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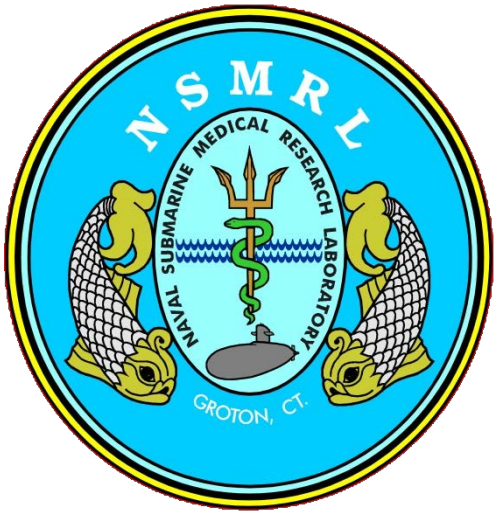

Disabled submarine (DISSUB) escape time calculations: A comparison of time and accuracy between the 2006 and 2020 Disabled Submarine Survival Guides

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commendations for reducing errors that emerged in the 2020 version thereby increasing the chance of survival in DISSUB scenario

14. ABSTRACT

During a disabled submarine (DISSUB) scenario, crew members must refer to the Disabled Submarine Survival Guide (also known as the Guard Book) to determine appropriate procedures for survival, including calculations for escape times. A pressing concern is that these critical calculations can be difficult to complete. In an attempt to address this issue, the method for completing escape time calculations has been revised in a new edition of the Guard Book. In the present study, thirty-four subjects completed both the older (2006) and revised (2020) versions of the Guard Book carbon dioxide and oxygen escape time calculations. Accuracy was low and did not significantly differ between versions (38.24% for the 2006 version vs. 41.18% for the 2020 version). Participants were significantly faster when completing the 2006 version and 50% of participants preferred the 2006 version over the 2020 version. The two calculation methods elicited different error types. Mathematical and instructional errors were most frequent for the 2006 version, inaccurate rounding on lookup tables and time conversion errors were most frequent for the 2020 version. We provide re-

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Abstract

During a disabled submarine (DISSUB) scenario, crew members must refer to the Disabled Submarine Survival Guide (also referred to as the DISSUB Guard Book) in order to determine appropriate procedures for survival, including the calculations for how long the crew can safely stay aboard the submarine before an escape is necessary. Because failure to accurately determine the necessary escape time could potentially cost the lives of the entire crew, it is a major cause of concern that the calculations can be extremely difficult to complete. In an attempt to address this issue, the method by which the calculations are completed has been revised in a new 2020 edition of the Guard Book. In the present study, thirty-four subjects were recruited to complete both the older (2006) and the revised (2020) versions of the Guard Book carbon dioxide and oxygen escape time calculations. The results showed that there was no significant difference in accuracy between the two Guard Book versions ($X^2(1, N = 34) = 0.08$, $p = 0.78$). 38.24% of participants reached the correct escape time for both carbon dioxide and oxygen on the 2006 version and 41.18% of participants reached the correct escape time for both carbon dioxide and oxygen on the 2020 version. Moreover, participants were significantly faster when completing the 2006 version than the 2020 version ($t(33) = 5.18$, $p < 0.001$) and 50% of participants preferred the 2006 version over the 2020 version. While the 2020 method does not reduce the number of errors made relative to the 2006 method, the types of errors that were made were very different. On the 2006 version of the calculations, the two most common errors were mathematical and instructional errors. On the 2020 version, nearly all of the mathematical and instructional errors were resolved, but errors such as rounding on lookup tables and time conversion errors emerged. We provide recommendations for how future Guard Book iterations can reduce these errors, thereby increasing the chances of survival for crew members in a DISSUB scenario.

Table of Contents

Introduction

In the unlikely event that a submarine becomes disabled, survivors may need to conduct an escape if the conditions aboard the boat deteriorate to a point that would not support human life. In order to make the critical decision of when to initiate an escape, crew members should refer to the Disabled Submarine (DISSUB) Survival Guide (also referred to as the DISSUB Guard Book), which contains all of the necessary steps and procedures for how to survive, escape, and be rescued from a disabled submarine, including calculations for determining carbon dioxide (CO_2) and oxygen (O_2) escape times. While multiple factors such as pressure, depth, and the presence of toxic gasses will influence escape time decisions, two of the largest threats are expected to be the accumulation of carbon dioxide and the depletion of oxygen in the submarine atmosphere (Horn, Benton, Hughes, Demers, Jankosky, Woodson, Lunney, Wagner, et al., 2009).

Unfortunately, the Guard Book calculations for determining carbon dioxide and oxygen escape times are not trivial. In addition to the current carbon dioxide and oxygen levels, survivors must consider factors such as the number of survivors fit and unfit[1] to escape, the percent of the compartment that is flooded, the number of carbon dioxide and oxygen countermeasures that are available, and more (NAVSEA, 2013b). The use of so many interrelated factors results in a complex series of steps that the user must follow in order to reach a final escape time. These steps often include long equations involving arithmetic such as addition, subtraction, multiplication, and division (requiring order of operations) that can easily result in errors (see Figure 1 for sample calculations from the 2006 Guard Book).

Waiting time after ExtendAir® LiOH used:

$$J = \frac{\{[D \times 0.06] - [(CO_2 \times C) / 100] - [G \times 0.85]\}}{[SURV \times 0.85]}$$

Figure 1. Sample equation from the 2006 Guard Book escape time calculations.

A second factor that adds further urgency to the need for simple calculation procedures is that crew members will likely face a number of stressors that could impair their ability to think clearly (Chabal, Bohnenkamper, Reinhart, & Quatroche, 2019). Stressors likely to impair cognition in a DISSUB scenario include increased temperature, toxic gasses, increased pressure, decreased oxygen levels, etc. (Behnke, Thomson, & Motley, 1935; Chabal, Bohnenkamper, Moslener, & Casper, 2020; Fowler, Prlic, & Brabant, 1994; Francis et al., 2002; Mendl, 1999; NAVSEA, 2013a; *Review of Submarine Escape Action Levels for Selected Chemicals*, 2002; Taylor, Watkins, Marshall, Dascombe, & Foster, 2016).

Recent revisions to the Guard Book, to be published in 2020, replace the long, complicated equations that were seen in the 2006 version of the Guard Book with look-up tables and simple addition and subtraction (see Figure 2 for a sample calculation box from a 2018 draft of the 2020 Guard Book). In theory, the elimination of complicated mathematical problems would be beneficial to crew members attempting to complete the escape time calculations during a DISSUB scenario because mathematical processing is likely to deteriorate while a person is under stress. This is especially true when the math being performed requires high working

[1] A fit survivor is defined as someone who is capable of conducting an escape from the submarine. In general, this means that they should have use of both arms and at least one leg.

memory demands and is practiced infrequently, as in the 2006 Guard Book calculations (Beilock, Kulp, Holt, & Carr, 2004). The replacement of complicated mathematical problems with lookup tables and simple addition and subtraction in the 2020 Guard Book should result in performance that is less likely to deteriorate under stress, which should therefore lead to an improvement in accuracy on the calculations. However, performance on this new Guard Book has yet to be tested. Testing of the new Guard Book is critical to verify that mathematical errors are indeed reduced and to ensure that additional errors are not introduced by the change in format.

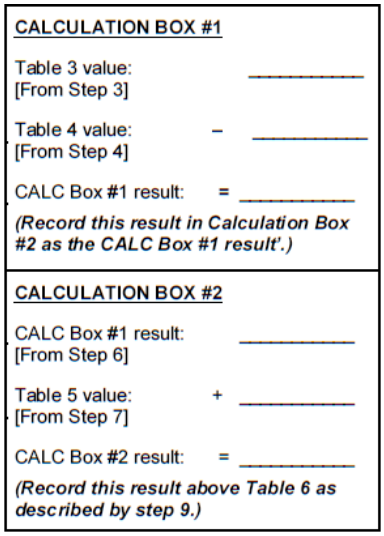

Figure 2: Sample calculation box from a draft (2018) of the 2020 Guard Book escape time calculations.

In order to simplify calculations, three major elements were changed in the 2020 Guard Book. First, complicated mathematical equations were replaced by look-up tables. While searching for values on a look-up table may seem like a simple task, it can become difficult if the value that the user is searching for does not appear on the table. Most of the values on the axes of the lookup tables are in multiples of either five or ten; if the value that the user is searching for is not a multiple of five or ten, they must round either up or down to reach a value that is on the table. The general rule for rounding is that the user should round in the more conservative direction (e.g., the number of survivors should be rounded up to account for a more conservative estimate of oxygen depletion, but the number of chlorate candles should be rounded down to account for a more conservative estimate of the available countermeasures). As a consequence, the direction of rounding changes with each look-up table, creating a potential for the user to round in the wrong direction and use an incorrect value.

The second element introduced in the 2020 Guard Book escape time calculations is the requirement for users to convert the number of hours until escape to an exact "start escape time" for carbon dioxide and oxygen; then the user must circle the earlier of the two escape times. These additional steps create the potential for time conversion errors. The 2006 Guard Book calculations do not contain these steps and only require calculation of the number of hours until escape for both carbon dioxide and oxygen.

Finally, the instructions in the 2020 Guard Book are much more detailed than the 2006 Guard Book. More detailed instructions are often beneficial, but they also create the potential for

important instructions (e.g., which direction to round on look-up tables or how to complete time conversions) to get lost if the user is distracted with other information.

With these changes, it is unknown whether the revisions in the 2020 Guard Book result in more accurate escape time calculations relative to the 2006 Guard Book. In the present study, we therefore compare performance on the old and revised Guard Book versions. We also characterize performance in order to identify where errors are being made. We make recommendations to improve the escape time calculation procedures, in order to maximize survival during a DISSUB event.

Methods

Participants

Thirty-six adults (18 females) between the ages of 20-57 (mean age = 34.82 years, SD = 10.48 years) were recruited through word-of-mouth to participate in the two-part study. Minimum sample size was determined using G*Power (Erdfelder, Faul, & Buchner, 1996) for two-tailed *t*-tests (matched samples) with an assumed medium effect size *f* of 0.5 and an alpha level of 0.05.

Subjects included seven active duty military, four former military, and 23 civilians. Of the 11 active duty military and former military participants, three were submarine qualified. One civilian participant had previously completed the Submarine Senior Survivor course.[2] Participants were highly educated, with 22 participants holding a bachelor's degree or higher. There were no exclusionary criteria and participants were not compensated for their time.

Materials

Guard Book calculations. Participants were tested on the carbon dioxide and oxygen escape time calculations from the older version and the revised version of the Forward Compartment SSN 774 Class Guard Book. Participants were given a calculation packet from the 2006 Guard Book and from a 2018 draft of the 2020 Guard Book (revisions to the Guard Book were not fully complete at the time of this study).[3]

For the purpose of this study, only the pages that were necessary for the calculations were included in the calculation packets. For example, in the 2006 version of the Guard Book, the calculations require the use of Cards 3A and 10A-E but not the cards in between; therefore, the unnecessary cards were excluded from the calculation packet. The 2006 calculation packet consisted of six pages and the 2020 calculation consisted of 19 pages.

Participants were given values for each of the variables that were required to complete the calculations (e.g., number of survivors, carbon dioxide and oxygen levels, number of lithium hydroxide curtains, etc.). The values provided remained consistent for every participant and were the same in each calculation packet.

See Appendices A and B for the full calculation packets provided to participants.

Subjective ratings. Following completion of the second set of Guard Book calculations, participants completed a post-study comparison sheet where they provided feedback on which

[2] Users who have taken the Submarine Senior Survivor course will have had previous experience completing the Guard Book escape time calculations.

[3] For descriptive purposes, we refer to the newest Guard Book packet used in the present study as the 2020 Guard Book. We will note where differences between the 2018 Guard Book draft and the final version of the 2020 Guard Book emerge.

method they felt was easier to complete, which method they felt was faster to complete, and which method they preferred overall.

Demographic information. Participants provided their gender, date of birth, education level, military experience, whether or not the participant was submarine qualified, and whether or not the participant had ever taken the Submarine Senior Survivor course. There were no significant effects of participant demographics on any of the measured metrics, therefore demographic information will not be discussed further.

Procedure

Data collection for each participant occurred during two separate sessions scheduled seven or more days apart. During each testing session, participants completed either the 2006 version or the 2020 version of the DISSUB Guard Book escape time calculations; order of testing was counterbalanced across participants and participants were blind to which version they were completing.

During each of the two testing sessions, participants sat in a quiet room with a standard calculator, a pen or pencil, and the assigned calculation packet. Participants were briefed as follows: "You are in a disabled submarine scenario and these are the calculations that you need to complete in order to determine what time you need to begin initiating an escape so that you are able to get your entire crew out of the submarine before the atmosphere becomes unsafe to breathe." Participants were instructed to take as much time as they needed to complete the calculations and to let the researcher know when they finished. Timing began when the participant started to read the first page of the packet and stopped when the participant indicated to the researcher that they were finished. Once the participant was finished, the researcher recorded the time taken to complete the calculations. Following the second session, participants completed the post-study comparison sheet.

Design

This study was designed as a two way, within-subjects experiment with Guard Book version (2006 vs. 2020) as the independent variable. Dependent variables were time (minutes, seconds) to complete the calculations, accuracy of the calculations, and subjective preference of the Guard Book version.

The types of errors that participants made were also categorized and counted. Errors were classified into seven types: instructional (following the instructions incorrectly), mathematical (incorrectly completing arithmetic or equations), table reading (reading the numbers on one or more table incorrectly), table rounding (rounding in the wrong direction on one or more of the table axes), transcription (incorrectly transferring numbers from one page to the next), time conversion (incorrectly converting the number of hours to escape to an exact date and time that an escape needs to be initiated), and other. If a participant committed more than one type of error, both types were counted, but each type of error was only counted one time per participant. For example, if a participant rounded incorrectly on two different tables in the revised version of the calculations, only one rounding error was counted; if a participant rounded incorrectly and also converted time incorrectly, both a rounding error and a time conversion error were counted.

Results

Analyses were conducted in order to determine which version of the DISSUB Guard Book escape time calculations was more accurate, which was faster to complete, and which was preferred by participants.

Accuracy

Accuracy was calculated in two ways: *absolute accuracy* required that participants reached the exact escape time with no margin for error; *target accuracy* required that participants responded within 30 minutes of the correct escape time.[4] Although the two versions used the same starting values for each variable, the final answers were slightly different between the 2006 and 2020 calculations due to calculation and rounding differences. The correct start escape time for each version was determined based on the answer reached when every step of that calculation packet was completed correctly. For both absolute and target analyses, accuracy was compared between the two Guard Book versions using McNemar's tests. Accuracy was considered both individually for CO_2 and O_2, and as an overall composite (overall accuracy required that participants reached the correct answer on both the O_2 and CO_2 calculations). See Figure 3 for all accuracy performance metrics.

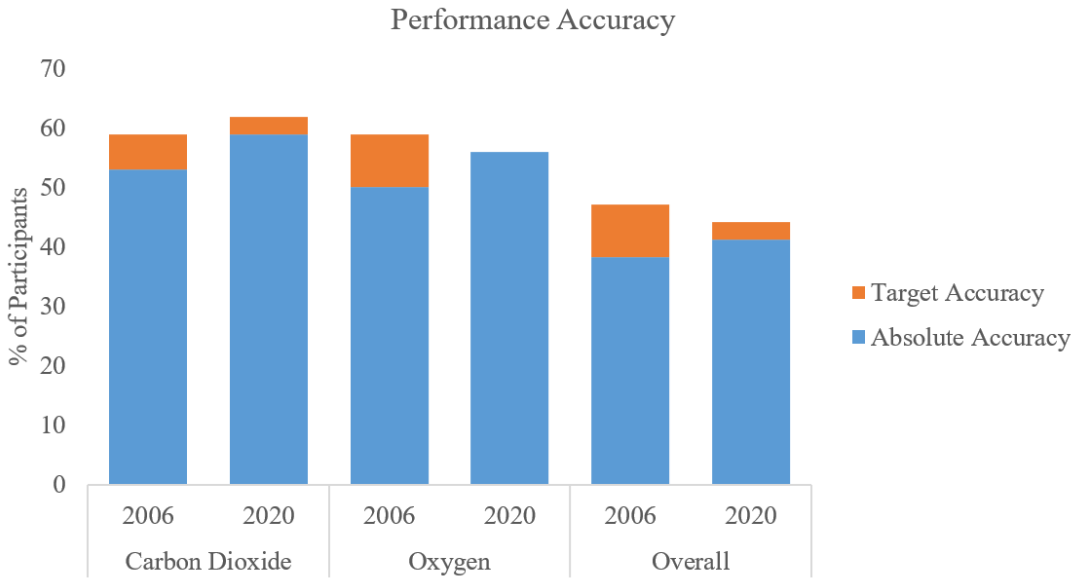

Figure 3. Performance on the 2006 and 2020 escape time calculations. Percent of participants with correct responses on carbon dioxide, oxygen, and overall escape time calculations. Absolute accuracy (blue) represents responses that matched the correct start escape time answer; target accuracy (orange) represents responses that fall within +/- 30 minutes of the correct answer.

[4] Thirty minutes was chosen after consulting a DISSUB subject matter expert. With the rate at which crew members are able to escape from the submarine (two members every 15 minutes), a 30-minute buffer would still allow enough time for all crew members to escape before the carbon dioxide or oxygen levels become unsafe (A. Quatroche, personal communication, December 3, 2019).

CO_2 calculations. There was no significant difference in absolute accuracy between the 2006 and the 2020 version of the Guard Book carbon dioxide escape time calculations ($X^2(1, N = 34) = 0.08$, $p = 0.78$, $\phi = 0.05$). 52.94% of participants reached the correct carbon dioxide escape time on the 2006 version and 58.82% of participants reached the correct carbon dioxide escape time on the 2020 version.

Target accuracy did not differ between versions ($X^2(1, N = 34) = 0.07$, $p = 0.79$, $\phi = 0.05$), with 58.82% and 61.76% reaching the correct carbon dioxide escape time on the 2006 and the 2020 versions, respectively.

O_2 calculations. There was no significant difference in absolute accuracy between the 2006 and the 2020 version of the Guard Book oxygen escape time calculations ($X^2(1, N = 34) = 0.08$, $p = 0.78$, $\phi = 0.05$). 50.00% of participants reached the correct oxygen escape time on the 2006 version and 55.88% of participants reached the correct oxygen escape time on the 2020 version.

Similarly, target accuracy did not differ between versions ($X^2(1, N = 34) = 0.07$, $p = 0.80$, $\phi = 0.05$), with 58.82% reaching the correct oxygen escape time on the 2006 version and 55.88% reaching the correct oxygen escape time on the 2020 version.

Overall accuracy. Due to the two-part nature of the calculations, it was possible for participants to reach the correct escape time for carbon dioxide but not oxygen, or vice versa. Therefore, a count of overall accuracy was calculated by including participants who responded correctly to both the CO_2 and the O_2 escape time calculations; no partial credit was given.[5]

There was no significant difference in overall absolute accuracy ($X^2(1, N = 34) = 0.08$, $p = 0.78$, $\phi = 0.05$; 2006 accuracy: 38.24%, 2020 accuracy: 41.18%) or overall target accuracy ($X^2(1, N = 34) = 0.07$, $p = 0.80$, $\phi = 0.05$; 2006 accuracy: 47.06%, 2020 accuracy: 44.12%) between the two versions.

In order to determine whether either Guard Book version resulted in escape time calculations that were "closer" to the correct response, a magnitude of difference variable was computed by subtracting participants' escape time response from the correct escape time response. Participants' answers were incorrect by 0 – 574,942.50 hours on the 2006 version and by 0 – 123.58 hours on the 2020 version of the calculations. As the number of hours until escape would not normally exceed 168 hours during a true DISSUB scenario with a full crew (A. Quatroche, personal communication, August 12, 2020), the range of responses on the 2006 version was un-realistically high. Some of the participants whose answers were extremely far from the correct answer expressed to the researchers that they knew their answer was incorrect, but they were not sure where they went wrong or how to fix it. Fortunately, the inclusion of lookup tables, whose largest value was 300 hours, eliminated these high-magnitude errors in the 2020 Guard Book.

Error types. Errors for each of the two sets of Guard Book calculations were counted and classified into one of seven categories. Even though participants committed similar numbers of errors in the two versions, the types of errors committed in the two versions were very different.

[5] The revised version has an extra step where participants must circle the earlier escape time between oxygen and carbon dioxide; this step was not included in the scoring process in order to maintain consistency between the two versions.

On the 2006 version, the two most common errors were mathematical and instructional errors. Mathematical errors most often involved solving long arithmetic; as each equation involves multiple facets, even a small mistake can lead to an incorrect answer. Instructional errors included mistakes such as using the wrong variable in an equation (e.g., both chlorate candles and lithium hydroxide (LiOH) canisters are recorded in "CANS," so some participants may have confused which variable to use) or converting values to different units when it was not necessary (e.g., a note reads: "[r]ead depth pressure at TD-510-GA-38 and convert to fsw (fsw=press/0.44)"; participants who did not realize that the pressure was already provided in fsw often completed the conversion, resulting in an incorrect answer to one or multiple equations).

On the 2020 version of the escape time calculations, nearly all of the mathematical and instructional errors were resolved, but new error types emerged. The most common errors were rounding on the lookup tables and time conversion. Rounding errors occurred because the lookup tables require participants to round the actual values they were working with to multiples of five or ten (e.g., if there are 62 survivors fit to escape, the user would have to round up to 65 in order to reach a value on the lookup table). Rounding rules on the lookup tables are constructed to be as conservative as possible (e.g., users round up for the number of survivors and down for the number of LiOH canisters). As a result, the rounding rules on each table are not always consistent, and participants would often round in the wrong direction. Time conversion errors occurred when participants had to take the number of hours until escape and the current date and time, and use that information to calculate the exact date and time of escape (e.g., if the current date and time is May 15 at 1300 and the user determines that they have to escape in 105 hours, he/she would have to calculate that the escape needs to be initiated on May 19 at 2200). See Table 1 for the number of times each error was counted in the 2006 and the 2020 version of the Guard Book escape time calculations.

Table 1
Classification of errors in the 2006 and 2020 Guard Book escape time calculations.

Error Type	2006	2020
Instructional	10	0
Mathematical	22	1
Table Reading	1	4
Table Rounding	0	11
Transcription	0	2
Time Conversion	N/A	11
Other	0	2

Calculation Time

As shown in Figure 4, participants were significantly faster at completing the 2006 version than the 2020 version of the calculations. Subjects took an average of 28.41 minutes (*SE* = 1.52) to complete the 2006 version of the calculations and an average of 37.65 minutes (*SE* = 2.37) to complete the 2020 version ($t(33) = 5.18$, $p < 0.001$, $d = 1.26$). Only six participants completed both the 2006 and the 2020 versions correctly, providing insufficient data for the computation of inferential statistics for overall accuracy. All response time statistical comparisons include all participants, regardless of accuracy.

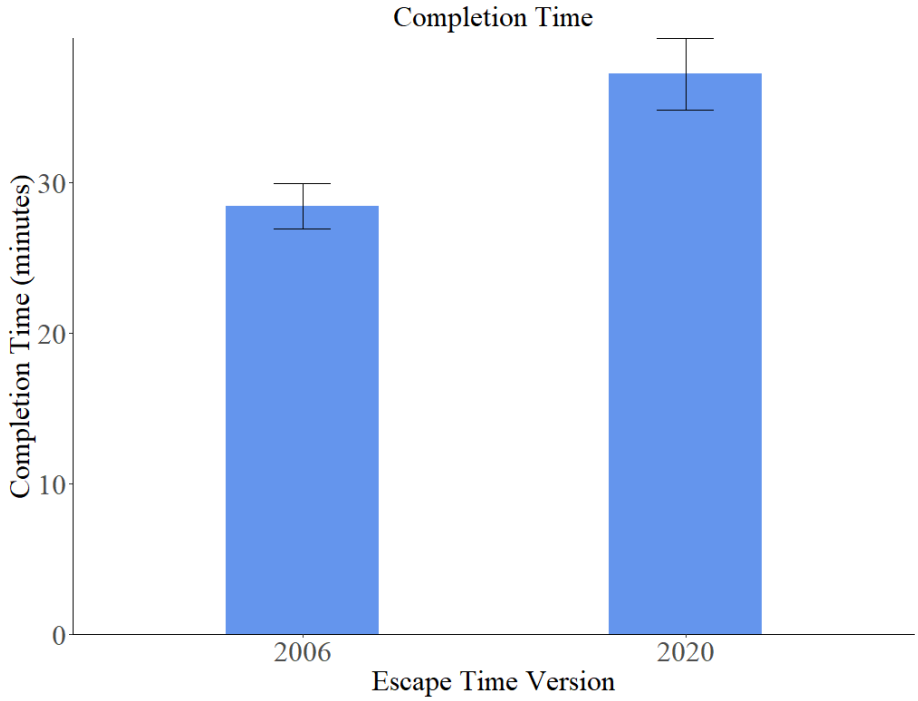

Figure 4. Completion time. Completion time (in minutes) for the 2006 version (left) and the 2020 version (right) of the Guard Book escape time calculations. Error bars represent standard error of the mean.

Preference

As seen in Figure 5, 55.90% of participants felt that the 2006 version was easier to complete (p = 0.61), 70.60% felt that the 2006 version was faster to complete (p = .02), and 50% of participants preferred the 2006 version overall (p = 1). Most participants (34/36) indicated that the version they felt was easier to complete was also the version that they preferred overall. Two participants preferred the 2020 version in spite of believing that the 2006 version of the calculations was easier to complete. These participants explained that, while they had an easier time completing the 2006 calculations, they thought that the 2020 calculations would result in a more accurate escape time and they were more confident in their answers.

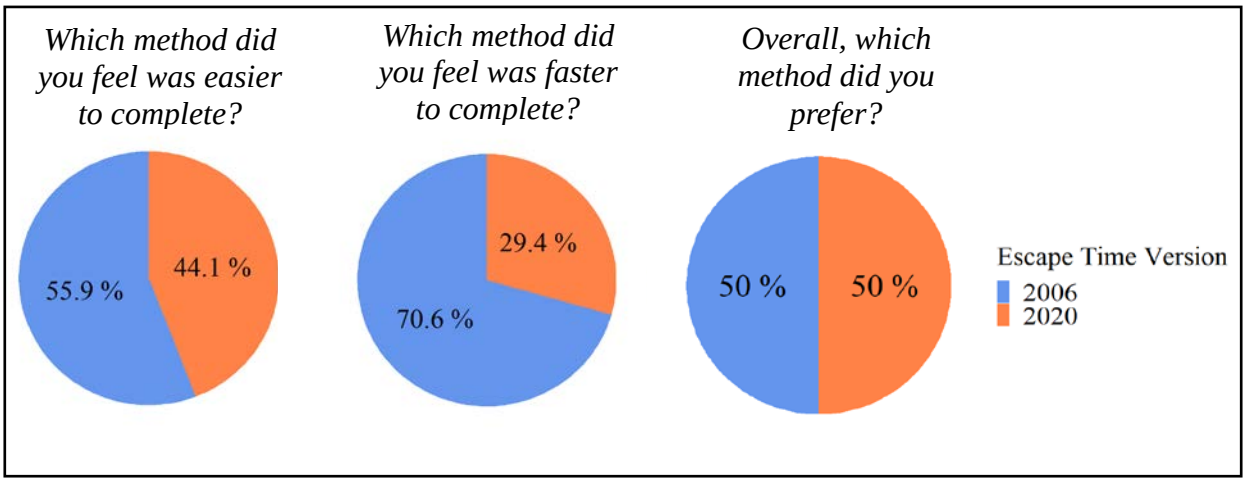

Figure 5. Participant response to post-study comparison sheet. The post-study comparison sheet was completed immediately after participants were finished with the second testing session. Participants were blind to which method was the older version and which method was the revised version.

Discussion

Despite recent revisions intended to make escape time calculations more accurate and easier to complete in the event of a disabled submarine, no differences in escape time accuracy were observed between the 2006 and the 2020 versions of the DISSUB Guard Book. Not only does accuracy remain low across both versions, but the newest escape time calculations actually result in slower response times and most participants felt that it was more difficult when compared to the 2006 version. Nevertheless, in spite of these deficiencies, revisions included in the 2020 Guard Book *do* eliminate the pervasive mathematical errors observed in earlier versions. The introduction of new error types (rounding and time conversion) is likely easily mitigated, and our recommendations for improvements to future Guard Book iterations are provided below.

Eliminating Guard Book Errors

Only approximately half of the participants in the present study were able to arrive at the correct escape time determination, despite performing the calculations under unrealistically stress-free conditions (Chabal et al., 2019). When confronted with a life-or-death, stressful environment, it is likely that this success rate would be much lower. Unfortunately, this implies that the crew of a submarine experiencing a DISSUB event would have about a 50/50 chance of correctly making the decision that supports their survival. The importance of simplifying the Guard Book procedures in order to decrease this error rate cannot be overstated.

In the present (2020) iteration of the Guard Book escape time calculations, a successful effort was made to eliminate complicated mathematical equations and reduce errors attributed to arithmetic miscalculations by over 95% when compared to the 2006 Guard Book. Unfortunately, however, while these changes result in reductions to mathematical and instructional errors, errors in rounding and time conversion were introduced. If these errors can be mitigated by modifying the layout of the escape time calculation cards, the Guard Book success rate is expected to be

much higher. In the current sample, the elimination of rounding and time conversion errors would have resulted in a successful completion rate of 73.53% on the 2020 Guard Book calculations.

Rounding errors in the 2020 Guard Book are most likely caused by two factors: 1. the direction of rounding (i.e., whether a value should be rounded up or down) is not consistent between tables; and 2. the instructions for each table are incredibly wordy, leading to participants overlooking the correct rounding direction. In an updated draft of the 2020 Guard Book sent to NSMRL after this study was completed, an arrow has been added to the axis of each table to indicate which direction to round in (see Figure 6). This addition will likely eliminate most of the errors that were due to rounding in the wrong direction on the lookup tables. Further research is required to test this.

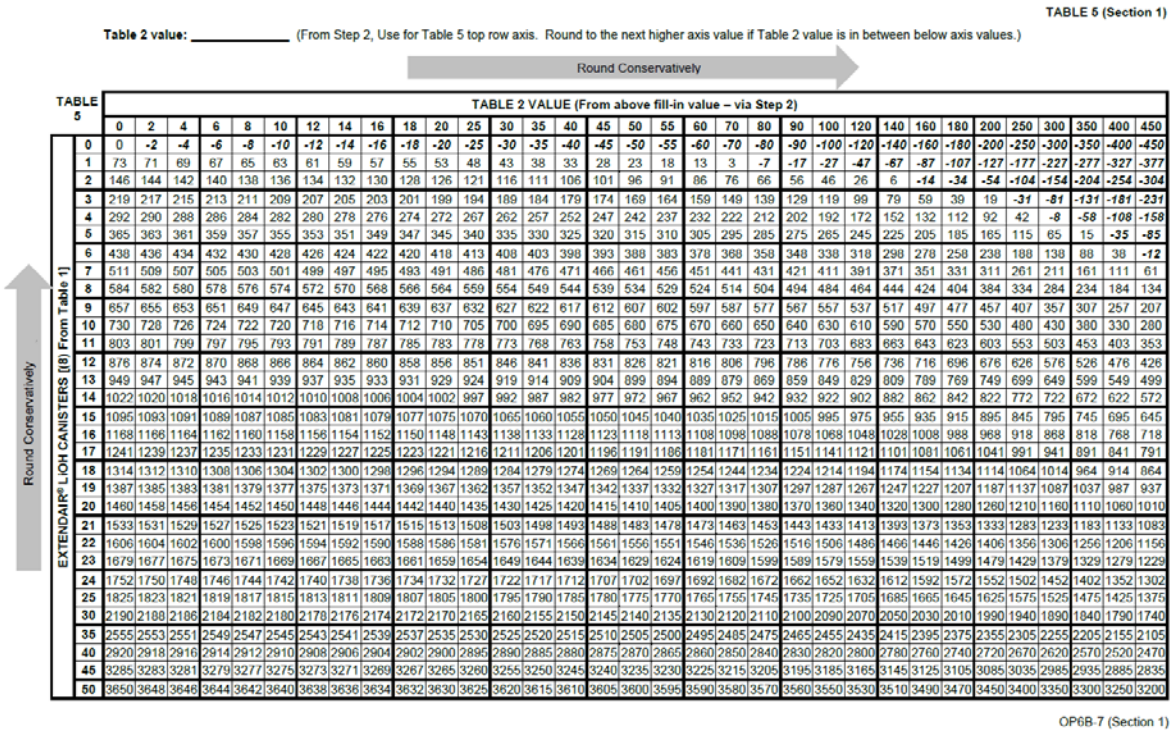

TABLE 5 (Section 1)

Table 2 value: _____ (From Step 2, Use for Table 5 top row axis. Round to the next higher axis value if Table 2 value is in between below axis values.)

Round Conservatively

TABLE 5	TABLE 2 VALUE (From above fill-in value – via Step 2)																																
	0	2	4	6	8	10	12	14	16	18	20	25	30	35	40	45	50	55	60	70	80	90	100	120	140	160	180	200	250	300	350	400	450
0	0	-2	-4	-6	-8	-10	-12	-14	-16	-18	-20	-25	-30	-35	-40	-45	-50	-55	-60	-70	-80	-90	-100	-120	-140	-160	-180	-200	-250	-300	-350	-400	-450
1	73	71	69	67	65	63	61	59	57	55	53	48	43	38	33	28	23	18	13	3	-7	-17	-27	-47	-67	-87	-107	-127	-177	-227	-277	-327	-377
2	146	144	142	140	138	136	134	132	130	128	126	121	116	111	106	101	96	91	86	76	66	56	46	26	6	-14	-34	-54	-104	-154	-204	-254	-304
3	219	217	215	213	211	209	207	205	203	201	199	194	189	184	179	174	169	164	159	149	139	129	119	99	79	59	39	19	-31	-81	-131	-181	-231
4	292	290	288	286	284	282	280	278	276	274	272	267	262	257	252	247	242	237	232	222	212	202	192	172	152	132	112	92	42	-8	-58	-108	-158
5	365	363	361	359	357	355	353	351	349	347	345	340	335	330	325	320	315	310	305	295	285	275	265	245	225	205	185	165	115	65	15	-35	-85
6	438	436	434	432	430	428	426	424	422	420	418	413	408	403	398	393	388	383	378	368	358	348	338	318	298	278	258	238	188	138	88	38	-12
7	511	509	507	505	503	501	499	497	495	493	491	486	481	476	471	466	461	456	451	441	431	421	411	391	371	351	331	311	261	211	161	111	61
8	584	582	580	578	576	574	572	570	568	566	564	559	554	549	544	539	534	529	524	514	504	494	484	464	444	424	404	384	334	284	234	184	134
9	657	655	653	651	649	647	645	643	641	639	637	632	627	622	617	612	607	602	597	587	577	567	557	537	517	497	477	457	407	357	307	257	207
10	730	728	726	724	722	720	718	716	714	712	710	705	700	695	690	685	680	675	670	660	650	640	630	610	590	570	550	530	480	430	380	330	280
11	803	801	799	797	795	793	791	789	787	785	783	778	773	768	763	758	753	748	743	733	723	713	703	683	663	643	623	603	553	503	453	403	353
12	876	874	872	870	868	866	864	862	860	858	856	851	846	841	836	831	826	821	816	806	796	786	776	756	736	716	696	676	626	576	526	476	426
13	949	947	945	943	941	939	937	935	933	931	929	924	919	914	909	904	899	894	889	879	869	859	849	829	809	789	769	749	699	649	599	549	499
14	1022	1020	1018	1016	1014	1012	1010	1008	1006	1004	1002	997	992	987	982	977	972	967	962	952	942	932	922	902	882	862	842	822	772	722	672	622	572
15	1095	1093	1091	1089	1087	1085	1083	1081	1079	1077	1075	1070	1065	1060	1055	1050	1045	1040	1035	1025	1015	1005	995	975	955	935	915	895	845	795	745	695	645
16	1168	1166	1164	1162	1160	1158	1156	1154	1152	1150	1148	1143	1138	1133	1128	1123	1118	1113	1108	1098	1088	1078	1068	1048	1028	1008	988	968	918	868	818	768	718
17	1241	1239	1237	1235	1233	1231	1229	1227	1225	1223	1221	1216	1211	1206	1201	1196	1191	1186	1181	1171	1161	1151	1141	1121	1101	1081	1061	1041	991	941	891	841	791
18	1314	1312	1310	1308	1306	1304	1302	1300	1298	1296	1294	1289	1284	1279	1274	1269	1264	1259	1254	1244	1234	1224	1214	1194	1174	1154	1134	1114	1064	1014	964	914	864
19	1387	1385	1383	1381	1379	1377	1375	1373	1371	1369	1367	1362	1357	1352	1347	1342	1337	1332	1327	1317	1307	1297	1287	1267	1247	1227	1207	1187	1137	1087	1037	987	937
20	1460	1458	1456	1454	1452	1450	1448	1446	1444	1442	1440	1435	1430	1425	1420	1415	1410	1405	1400	1390	1380	1370	1360	1340	1320	1300	1280	1260	1210	1160	1110	1060	1010
21	1533	1531	1529	1527	1525	1523	1521	1519	1517	1515	1513	1508	1503	1498	1493	1488	1483	1478	1473	1463	1453	1443	1433	1413	1393	1373	1353	1333	1283	1233	1183	1133	1083
22	1606	1604	1602	1600	1598	1596	1594	1592	1590	1588	1586	1581	1576	1571	1566	1561	1556	1551	1546	1536	1526	1516	1506	1486	1466	1446	1426	1406	1356	1306	1256	1206	1156
23	1679	1677	1675	1673	1671	1669	1667	1665	1663	1661	1659	1654	1649	1644	1639	1634	1629	1624	1619	1609	1599	1589	1579	1559	1539	1519	1499	1479	1429	1379	1329	1279	1229
24	1752	1750	1748	1746	1744	1742	1740	1738	1736	1734	1732	1727	1722	1717	1712	1707	1702	1697	1692	1682	1672	1662	1652	1632	1612	1592	1572	1552	1502	1452	1402	1352	1302
25	1825	1823	1821	1819	1817	1815	1813	1811	1809	1807	1805	1800	1795	1790	1785	1780	1775	1770	1765	1755	1745	1735	1725	1705	1685	1665	1645	1625	1575	1525	1475	1425	1375
30	2190	2188	2186	2184	2182	2180	2178	2176	2174	2172	2170	2165	2160	2155	2150	2145	2140	2135	2130	2120	2110	2100	2090	2070	2050	2030	2010	1990	1940	1890	1840	1790	1740
35	2555	2553	2551	2549	2547	2545	2543	2541	2539	2537	2535	2530	2525	2520	2515	2510	2505	2500	2495	2485	2475	2465	2455	2435	2415	2395	2375	2355	2305	2255	2205	2155	2105
40	2920	2918	2916	2914	2912	2910	2908	2906	2904	2902	2900	2895	2890	2885	2880	2875	2870	2865	2860	2850	2840	2830	2820	2800	2780	2760	2740	2720	2670	2620	2570	2520	2470
45	3285	3283	3281	3279	3277	3275	3273	3271	3269	3267	3265	3260	3255	3250	3245	3240	3235	3230	3225	3215	3205	3195	3185	3165	3145	3125	3105	3085	3035	2985	2935	2885	2835
50	3650	3648	3646	3644	3642	3640	3638	3636	3634	3632	3630	3625	3620	3615	3610	3605	3600	3595	3590	3580	3570	3560	3550	3530	3510	3490	3470	3450	3400	3350	3300	3250	3200

Round Conservatively

EXTENDAIR® LiOH CANISTERS (18) From Table 1)

OP6B-7 (Section 1)

Figure 6. Sample look-up table from a draft (2019) of the 2020 Guard Book. The arrows along each axis were not included in the 2018 draft that was used in the present study.

The second most common error on the 2020 version of the calculations occurred in the final steps where participants were asked to convert the number of hours until escape to an exact date and time that an escape needs to be initiated. Errors during this final step would likely be reduced with the inclusion of a simple formula or set of instructions walking participants through the conversion (e.g., see Figure 7), though further research is required to test this. Additionally, in the present version of the 2020 Guard Book, users are required to convert the number of hours until escape to an exact start escape time for both carbon dioxide and oxygen, then they must circle the earlier start escape time. In order to reduce the total amount of time it takes to complete the calculations and to reduce potential errors, the calculations could be adjusted so that the user first circles the shorter number of hours (oxygen or carbon dioxide) and then converts those

hours to an exact start escape time. This way, the user must only complete a single time conversion.

1. Enter the time and date (from Table 1)	_____; _____ - _____ / _____ Time (24hr) DD - MM / YY
2. Enter total number of hours until escape (Table 6 value)	T = _____(total hours)
3. Divide total number of hours by 24	T ÷ 24 = _____
4. Number of days until escape: Value from Step 3 rounded DOWN to the nearest whole number	DAYS = _____
5. Multiply number of days (Step 4 value) by 24	Days * 24 = _____
6. Number of hours until escape: Hours = Total hours (T) – Step 5 value	HOURS = _____

7. Transfer the number of DAYS (Step 4 value) and HOURS (Step 6 value) to their respective blanks in the statement below:

You must start to escape in _____ DAYS and _____HOURS.

Step 4 value Step 6 value

8. Circle the time (from Step 1) in the grey section of the number line below (exclude the minute's value; e.g., if the time is 0742, circle 0700).

9. Draw a horizontal line to the right of your circled time that spans the number of HOURS recorded in Step 6. Then, circle the time at the end of your line.

0000|0100|0200|0300|0400|0500|0600|0700|0800|0900|1000|1100|1200|1300|1400|1500|1600 →

1700|1800|1900|2000|1200|2200|2300 | 0000|0100|0200|0300|0400|0500|0600|0700|0800|0900 →

1000|1100|1200|1300|1400|1500|1600|1700|1800|1900|2000|2100|2200|2300

10. Add the minute's value from Step 1 to the time you circled at the END of your line and record the final time here: _____

Does your line cross the red bar?

YES

Escape Time = Step 10 value

Escape Date = Current date + DAYS (Step 4 value) + 1

NO

Escape Time = Step 10 value

Escape Date = Current date + DAYS (Step 4 value)

CO_2 Start Escape Time: _____ ; _____ - _____ / _____

Time (24hr) DD - MM / YY

NOTE: Pay attention to the current month and whether or not adding DAYS to the current date will lead you to a new month.

Months with 31 Days	Months with 30 Days	Months with 28 Days
January (01)	April (04)	February (02) *
March (03)	June (06)	
May (05)	September (09)	
July (07)	November (11)	
August (08)		
October (10)		
December (12)		

* If it is a Leap Year, there will be 29 days in February

Figure 7. Example of time conversion instructions. The inclusion of these instructions could direct users on how to convert the number of hours until escape to an exact Start Escape Time.

Testing of Future Guard Book Iterations

As noted above, testing is required to ensure that any future changes to the Guard Book (such as those implemented to reduce rounding or time conversion errors) successfully increase performance and do not inadvertently introduce new types of errors. As in the current study, future studies should consider not only accuracy and response time, but also the prevalence of different error types so that appropriate recommendations can be made. It would also likely be helpful to include a measure of participants' confidence in their responses, and to allow participants to make open-ended recommendations for improvements.

Assessments of new/ future Guard Book versions should also include all calculations that are required of survivors. Although the present study included only CO_2 and O_2 calculations (in order to allow for direct comparison with the 2006 version), the 2020 Guard Book also includes a start escape time calculation based on pressure. It is unknown whether performance on this calculation is sufficiently high to promote survival.

Once new versions of the Guard Book are tested under calm, laboratory conditions, it is crucial that they are also assessed under the stressful conditions likely to be present during a DISSUB event. Many of the stressors expected to be present during a DISSUB (e.g., increased temperature, decreased oxygen, increased carbon dioxide, fatigue; Chabal et al., 2019) have known effects on cognition (Chabal et al., 2020; Chapman, Stray-Gundersen, & Levine, 1998; Drummond et al., 1999; Gaoua, Racinais, Grantham, & El Massioui, 2011; Sayers, Smith, Holland, & Keatinge, 1987); therefore, the presence of these stressors would likely cause a decrease in performance. Testing under DISSUB-like conditions is also important because some cognitive processes are more sensitive to stressors and may be more likely to be degraded during a DISSUB scenario. For example, mathematical processing is negatively impacted by stress and anxiety, especially when the math problems are complex and require high levels of working memory (Beilock et al., 2004). Specifically, math that involves multiple subsystems (as seen in the 2006 Guard Book calculations) requires individuals to store interim results from different parts of the problem, increasing working memory demands (Ashcraft & Kirk, 2001; Fürst & Hitch, 2000). Simple math such as addition and subtraction (as seen in the 2020 Guard Book calculations) does not demand as much working memory, and should therefore be less sensitive to the stress and anxiety that will likely be present during a DISSUB scenario (Ashcraft, 2002; Ashcraft & Faust, 1994; Faust, Ashcraft, & Fleck, 1996; Maloney, Risko, Ansari, & Fugelsang, 2010). Testing the Guard Book escape time calculations under stressful conditions (e.g., limiting the amount of time given to complete the calculations) could reveal significant differences between the two versions that were not seen when the calculations were completed in a stress-free environment.

In addition to considering how changes to the Guard Book *structure* impact performance on escape time calculations, future research should also consider how changes to the Guard Book *format* might impact survival decisions. An electronic version of the Guard Book (E-Guard), which runs on Android-based tablets, is currently under development by researchers at NSMRL. The E-Guard provides a guide to submariners collecting crucial information in a DISSUB event (e.g., atmospheric conditions, number of survivors) and automatically generates start escape times based on the inputted values. The overall goal of the app is to increase the accuracy and decrease the time it takes to determine the start escape time in a DISSUB scenario (J.

Bolkhovsky, personal communication, June 1, 2020). While the E-Guard will likely never fully replace the paper version of the Guard Book because access to an electronic device can never be guaranteed during a DISSUB event, it is likely that the automated calculations will reduce human error and result in more accurate escape time decisions. This claim should be empirically tested.

Conclusions

Overall, results from this research demonstrate that the most recent revisions to Guard Book escape time calculations do not significantly improve performance. Even after substantial changes, performance remains at approximately 50% correct. This is problematic, as both staying on a disabled submarine too long and escaping too early have potentially-fatal consequences. A crew that decides to remain on the submarine for too long will likely be exposed to elevated atmospheric pressure, dangerous toxic gasses, elevated carbon dioxide levels, radiation, and insufficient oxygen levels (Chabal et al., 2019; Horn, Benton, Hughes, Demers, Jankosky, Woodson, Lunney, Wangner, et al., 2009; NAVSEA, 2013a). Conversely, a crew that decides to escape too early risks escape-based injury (e.g., decompression sickness or pulmonary over inflation syndrome; Bond, Workman, & Mazzone, 1960) and may reach the surface before rescue crews are available to provide evacuation and medical care (Bond et al., 1960; Parker, Ball, Tibbles, & Weathersby, 2000; Van Wijk, 2017). The accurate completion of the Guard Book escape time calculations is necessary for survival.

In spite of demonstrating sustained difficulties with the completion of DISSUB escape time calculations, this research also provides suggestions for how errors can be mitigated and performance can be enhanced in future Guard Book iterations. It is imperative that the escape time calculations, and all other Guard Book procedures, are written to be intuitive and easy to complete so that survivors are able to accurately complete the calculations even while experiencing decrements to their cognitive abilities. Future iterations of the DISSUB Guard Book must consider how best to minimize errors and increase performance on all sets of procedures and calculations in order to increase sailors' chances of survival during a disabled submarine event.

Appendices

Appendix A: 2006 Guard Book Calculation Packet

Training Day 1

Subj ID:_____ Date:_____ Time to complete: _____

START ESCAPE TIME DATA **CARD 3A**

COLLECT AND RECORD THE FOLLOWING INFORMATION

Total number of survivors	**SURV = 100 (men)**
Survivors fit to escape	**FIT = 80 (men)**
Internal pressure (see Note 1)	**PRESS = 4 (fsw)**
Escape depth of boat (see Note 2)	**DEPTH = 520 (fsw)**
Estimate the percentage of flooding in the compartment	**FLOOD = 0 (%)**
Carbon dioxide concentration (using Analox Analyzer or Dräger tube) (see Notes 3 and 4)	**CO_2 = 2 (% SEV)**
Oxygen concentration (see Notes 3 and 4)	**O_2 = 18 (% SEV)**
Number of ExtendAir® lithium hydroxide canisters	**LiOH = 140 (cans)**
Number of chlorate candles	**CANDLE = 50 (cndls)**
Ship's Service Air (SSA) pressure	**SSA = 3000 (psi)**

Note 1: Reading of internal pressure in fsw can be accomplished directly from the Analox Analyzer or by using the diver's depth gage found in the Crash Bag. See **CARD 4A** for trunk entry.

Note 2: Read depth pressure at TD-510-GA-38 and convert to fsw (fsw=press/0.44) See **CARD 4A** to line up valves.

Note 3: **If using Analox Analyzer, the O_2 and CO_2 readings are in % SEV (no correction required).** If using any non-pressure compensated analyzer at increased pressure, the reading must be converted;

O_2 SEV = (METER READING) x [1 + (PRESS/33)] CO_2 SEV = (METER READING/10,000) x [1 + (PRESS/33)]

where "PRESS" = value in third box above.

Caution: Readings converted from monitors other than the Analox can be suspect.

1 (1)

Change A

Subj ID:_____ Date:_____

STAY-TIME CALCULATIONS CARD 10A

PRESSURE CALCULATION (Note: **X / Y** = Divide X by Y)

Internal pressure in ATA: **A = (fsw / 33) + 1 (see Note 2)**	**A =_____(ATA)**
Escape depth in ATA: **B = (fsw escape depth / 33) + 1 or** **B = (psig escape depth / 14.7) + 1 (see Note 3)**	**B =_____(ATA)**
Volume of air in the compartment: **C = (100 – FLOOD) x 798**	**C =_____(cu ft)**
Volume of the compartment after escapes are made: **D = C – 1658 – [67.7 x (FIT – 2)]**	**D =_____(cu ft)**
Volume of air added by the escapes: **E = 108 x A x FIT**	**E =_____(cu ft)**
Internal pressure after escaping: **F = [(C x A) + E] / D**	**F =_____(ATA)**
Convert to fsw: = **ESC PRESS = (F – 1) x 33 (see Note 4)**	**ESC PRESS =_____(fsw)**

Note 1: Refer to **Card 3A** for data entry.

Note 2: Reading of internal pressure in fsw can be accomplished directly from the Analox Analyzer or by using the diver's depth gage found in the Crash Bag.

Note 3: Escape Depth pressure can be read at TD-510-GA-38 outside the LOT.e

Note 4: If internal pressure before or during escape exceeds 23 fsw, there is an increased risk of decompression sickness, which rises with increasing pressure and time. Wait for rescue unless there is a compelling reason to escape.

Subj ID:_____ Date:_____

CO_2 CALCULATION CARD 10B

This card provides a more accurate estimate than CARD 3C of the time Survivors can wait before starting escapes. Based on this calculation, the compartment atmosphere will be at 6% CO_2 SEV when the last Survivor escapes.

From the start of the first escape, **Table 2** (**CARD 10C**) provides the number of man- hours of breathing that will occur in the compartment during the escape process by survivors waiting to escape and those survivors not escaping. It assumes that the cycling time for the trunk is about 15 minutes and two survivors escape each time. **(Note that these values are not the same as the time taken for all the survivors to escape; that is calculated by dividing the number of escapers by 8 - the number who escape each hour.)**

Use **Table 2** on **CARD 10C or 10D** to determine man-hours of breathing while waiting to escape (**G**) and enter the result in the table below. Complete the two calculations for 'ExtendAir® LiOH duration' (**H**) and 'Waiting time after ExtendAir® LiOH' (**J**). Then add '**H**' and '**J**' to determine '**WAIT CO_2**' time in hours.

Enter breathing man-hours spent waiting to escape: (from Table 2 CARD 10C or 10D)	**G =_____(man-hrs)**
Time on ExtendAir® LiOH prior to start of escapes: $H = \frac{(LiOH \times 73)}{SURV}$ **NOTE: 'LiOH' is the number of ExtendAir® cans from CARD 3A (not to include Granular LiOH cans).**	**H =_____(hrs)**
Waiting time after ExtendAir® LiOH used: $J = \{[D \times 0.06] - [(CO_2 \times C) / 100] - [G \times 0.85]\} / [SURV \times 0.85]$	**J =_____(hrs)**
Total CO_2 waiting time: $WAIT\_CO_2 = H + J$	**$WAIT\_CO_2$ =_____(hrs)**

3(1)

Change A

18

Enter Table 2, **CARD 10C** and **10D**, with the number of Survivors **FIT** to Escape from **CARD 3A** and the number of survivors **NOT FIT** to Escape (NOT FIT = SURV – FIT). Circle the column with the number of Survivors FIT to Escape closest to the actual number of FIT Survivors from **CARD 3A**. Circle the horizontal row that is closest to the number of Survivors **NOT FIT** to Escape (SURV – FIT). The value at the intersection of the column and row circled is the number of man-hours of breathing (G) in the compartment during the escape process. (Example: If there are 60 Survivors FIT to Escape and 20 Survivors NOT FIT to Escape, then G = 368 man-hours.)

Table 2		Survivors FIT to Escape (FIT from CARD 3A)															
		5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80
Survivors NOT FIT to Escape (SURV – FIT)	0	1	5	12	23	36	53	72	95	121	150	182	218	256	298	342	390
	10	7	18	31	48	67	90	116	145	177	213	251	293	337	385	436	490
	20	13	30	50	73	98	128	160	195	233	275	320	368	418	473	530	590
	30	20	43	68	98	130	165	203	245	290	338	388	443	500	560	623	690
	40	26	55	87	123	161	203	247	295	346	400	457	518	581	648	717	790
	50	32	68	106	148	192	240	291	345	402	463	526	593	662	735	811	890
	60	38	80	125	173	223	278	335	395	458	525	595	668	743	823	905	990
	70	45	93	143	198	255	315	378	445	515	588	663	743	825	910	998	1090
	80	51	105	162	223	286	353	422	495	571	650	732	818	906	998	1092	1190
	90	57	118	181	248	317	390	466	545	627	713	801	893	987	1085	1186	1290
	100	63	130	200	273	348	428	510	595	683	775	870	968	1068	1173	1280	1390
	110	70	143	218	298	380	465	553	645	740	838	938	1043	1150	1260	1373	1490
	120	76	155	237	323	411	503	597	695	796	900	1007	1118	1231	1348	1467	1590
	130	82	168	256	348	442	540	641	745	852	963	1076	1193	1312	1435	1561	1690
	140	88	180	275	373	473	578	685	795	908	1025	1145	1268	1393	1523	1655	1790
	150	95	193	293	398	505	615	728	845	965	1088	1213	1343	1475	1610	1748	1890
	160	101	205	312	423	536	653	772	895	1021	1150	1282	1418	1556	1698	1842	1990

CARD 10C

Enter the value 'G' in **CARD 10B**

Change A

Table 2 (Cont)		Survivors FIT to Escape (FIT from CARD 3A)															
		85	90	95	100	105	110	115	120	125	130	135	140	145	150	155	160
Survivors NOT FIT to Escape (SURV – FIT)	0	441	495	552	613	676	743	812	885	961	1040	1122	1208	1296	1388	1482	1580
	10	547	608	671	738	807	880	956	1035	1117	1203	1291	1383	1477	1575	1676	1780
	20	653	720	790	863	938	1018	1100	1185	1273	1365	1460	1558	1658	1763	1870	1980
	30	760	833	908	988	1070	1155	1243	1335	1430	1528	1628	1733	1840	1950	2063	2180
	40	866	945	1027	1113	1201	1293	1387	1485	1586	1690	1797	1908	2021	2138	2257	2380
	50	972	1058	1146	1238	1332	1430	1531	1635	1742	1853	1966	2083	2202	2325	2451	2580
	60	1078	1170	1265	1363	1463	1568	1675	1785	1898	2015	2135	2258	2383	2513	2645	2780
	70	1185	1283	1383	1488	1595	1705	1818	1935	2055	2178	2303	2433	2565	2700	2838	2980
	80	1291	1395	1502	1613	1726	1843	1962	2085	2211	2340	2472	2608	2746	2888	3032	3180
	90	1397	1508	1621	1738	1857	1980	2106	2235	2367	2503	2641	2783	2927	3075	3226	3380
	100	1503	1620	1740	1863	1988	2118	2250	2385	2523	2665	2810	2958	3108	3263	3420	3580
	110	1610	1733	1858	1988	2120	2255	2393	2535	2680	2828	2978	3133	3290	3450	3613	3780
	120	1716	1845	1977	2113	2251	2393	2537	2685	2836	2990	3147	3308	3471	3638	3807	3980
	130	1822	1958	2096	2238	2382	2530	2681	2835	2992	3153	3316	3483	3652	3825	4001	4180
	140	1928	2070	2215	2363	2513	2668	2825	2985	3148	3315	3485	3658	3833	4013	4195	4380
	150	2035	2183	2333	2488	2645	2805	2968	3135	3305	3478	3653	3833	4015	4200	4388	4580
	160	2141	2295	2452	2613	2776	2943	3112	3285	3461	3640	3822	4008	4196	4388	4582	4780

CARD 10D

Enter the value 'G' in CARD 10B

Subj ID:_____ Date:_____

OXYGEN CALCULALTION CARD 10E

This card provides a more accurate estimate than CARD 3D of the time Survivors can wait before starting escapes. Based on this calculation for oxygen that is available in the compartment and oxygen from Chlorate Candles, the compartment atmosphere will be at 13% O_2 SEV when the last Survivor escapes. Oxygen at 13% SEV represents minimum available breathing oxygen before mental and physiological effects become significant.

Use **Table 2** on **CARD 10C or 10D** to determine man-hours of breathing while waiting to escape (**G**) and enter the result in the table below. Complete the two calculations for 'Time to breathe down oxygen to 13% SEV (accounts for escaping survivors no longer consuming O_2)' (**K**) and 'Time on Chlorate candles prior to start of escapes' (**M**). Then add '**K**' and '**M**' to determine '**WAIT_O_2**' time in hours.

OXYGEN CALCULATION

Enter breathing man-hours spent waiting to escape: (from Table 2 on CARD 10C or 10D):	**G =_____(man-hrs)**
Time to breathe down oxygen to 13% SEV (accounts for escaping survivors no longer consuming O_2): $K = \frac{\{[(O_2 \times C)/100 - (0.13 \times D)] - G\}}{SURV}$	**K =_____(hrs)**
Time on chlorate candles prior to start of escapes: $M = \frac{(CANDLE \times 115)}{SURV}$	**M =_____(hrs)**
Oxygen waiting time before starting escape: $WAIT\_O_2 = K + M$	**WAIT_O_2 =_____(hrs)**

NOTE 1: For the purposes of these calculations survivors are assumed to consume 1 scf O2 per hour and produce 0.85 scf per hour CO2. Minimizing survivor activity will prolong survival time by minimizing O2 consumption and CO2 production.

6(1)

Appendix B: 2020 Guard Book Calculation Packet

Training Day 1

Subj ID:_____ Date:_____ Time to complete: _____

OP6B

ASSESS CARBON DIOXIDE & OXYGEN START ESCAPE TIME

EQUIPMENT/TOOLS

NONE

OPERATIONS

_____ **1. Determine start escape times.**

_✓_ a. Fill-in Table 1 using previously recorded Table 1 (OP6) information or as updated since OP6 completion. Complete step 1 of section 1 (OP6B-3).

_____ b. Perform remaining section 1 steps, for results to avoid **high limit 6% SEV Carbon Dioxide (CO_2)** being exceeded before all escapes are complete; record below:

CO_2 START ESCAPE TIME: _____ ____ - ____ / ____
Time (24Hr) (DD - MM / YY)

_____ c. Perform section 2 (OP6B-12) steps, for results to avoid **low limit 13% SEV Oxygen (O_2)** being exceeded before all escapes are complete; record below:

O_2 START ESCAPE TIME: _____ ____ - ____ / ____
Time (24Hr) (DD - MM / YY)

_____ d. Circle the earliest START ESCAPE TIME in 1.b or 1.c above.

TABLE 1
DISSUB CONDITIONS DATA

Data Time and Date Table 1 information was gathered: *Transfer to Calculation Box #3 (OP6B-4) and Calculation Box #6 (OP6B-14).*	**1436 19 - 03 / 19** **Time (24Hr) (DD - MM / YY)**	
---NOTE--- *This Time/Date shall represent only one point-in-time for all Table 1 information.*		
Number of Survivors (FWD): Transfer to Tables 6A, 6B, 6C, 10A, 10B & 10C.	100 Survivor Total	**(2)**
Survivors FIT to escape (FWD): Transfer to Tables 2A, 2B, 3 & 8.	80 FIT to Escape	**(3)**
---NOTE--- *A FIT survivor is defined as having full use of both arms and able to stand upright in the escape trunk while it is being flooded. Personnel unable to perform this task due to injury, nausea or convulsions are UNFIT and not included.*		
Survivors UNFIT to escape (FWD): *Transfer to Table 2A or 2B (as applicable).*	20 UNFIT to Escape	**(4)**
Percent FWD compartment is flooded (rounded to nearest 20%): *Transfer to Tables 3, 4, 7A, 7B & 8.*	0 % Flooded	**(5)**
FWD compartment CO_2 concentration in %SEV as read from ANALOX Monitor or alternate method: *Transfer to Table 4.*	2 % SEV CO_2 Analox	**(6)**
FWD compartment O_2 concentration in %SEV as read from ANALOX Monitor or alternate method: *Transfer to page OP6B-12 & Tables 7A or B.*	18 % SEV O_2 Analox	**(7)**
Number of ExtendAir® Lithium Hydroxide (LiOH) Canisters with ExtendAir® Deployment Kit: (One ExtendAir® DISSUB LiOH Deployment Kit per 60 ExtendAir® LiOH Canisters is required) **(FWD):** *Transfer to Table 5.*	140 Cans (ExtendAir® LiOH with enough ExtendAir® DISSUB LiOH Deployment Kits)	**(8)**
Number of oxygen candles with at least half as many igniters available (FWD): *Transfer to Table 9.*	50 Cans O_2 Candles	**(9)**

SECTION 1
CARBON DIOXIDE TIME TO ESCAPE CALCULATIONS

---NOTE---

Calculations of Section 1 provide an estimated time when escapes should commence to prevent exceeding high limit 6% SEV Carbon Dioxide (CO_2) before all escapes are completed.

☐ **STEP 1:** Transfer Table 1 recorded values into Sections 1 and 2 as indicated in the first column of Table 1.

---NOTE---

When transferring these recorded values to other areas, look for blanks to be filled-in or, 'circle' applicable 'table Left (Column) or Top (Row) axis' quantity that is marked with a corresponding number in parenthesis (e.g., (2) = Survivor Total). If the Table 1 value transferred is not equal to the higher or lower value on the Table it is being transferred into, select the more conservative higher or lower axis value.

☐ **STEP 2:** In Table 2A or 2B (as applicable), circle the intersecting value to the previously circled Table 1 axis values **(3)** and **(4)**. Record the Table 2 intersecting value below. Record this value above Table 5 and Table 9 in the 'Table 2 value' spaces provided above these Tables. Use the Table 2 value to circle its 'equal or greater' value on Table 5 and Table 9 top row axis's.

Table 2 value: _____

☐ **STEP 3:** In Table 3, circle the intersecting value to the previously circled Table 1 values **(3)** and **(5)**; Record the Table 3 intersecting value in the Calculation Box #1 'Table 3 value' space at right.

☐ **STEP 4:** In Table 4, circle the intersecting value to the previously circled Table 1 values **(6)** and **(5)**; Record the Table 4 intersecting value in the Calculation Box #1 'Table 4 value' space.

☐ **STEP 5:** If the 'Table 4 value' is equal to or larger than the 'Table 3 value' recorded in Calculation Box #1, Record '0' in the Calculation Box #3 'Table 6 value' space, then skip to step 12. Otherwise, continue to step 6.

☐ **STEP 6:** In Calculation Box #1, ***subtract*** the 'Table 4 value' from the 'Table 3 value' as indicated. Record in Calculation Box #1 and in Calculation Box #2 as the 'CALC Box #1 result'.

CALCULATION BOX #1

Table 3 value: _____
[From Step 3]

Table 4 value: – _____
[From Step 4]

CALC Box #1 result: = _____

(Record this result in Calculation Box #2 as the CALC Box #1 result'.)

CALCULATION BOX #2

CALC Box #1 result: _____
[From Step 6]

Table 5 value: + _____
[From Step 7]

CALC Box #2 result: = _____

(Record this result above Table 6 as described by step 9.)

☐ **STEP 7:** In Table 5, circle the intersecting value to the previously circled Table 1 axis value **(8)** and the 'Table 2 value' recorded above Table 5 (by step 2). Record the Table 5 intersecting value in the Calculation Box #2 'Table 5 value' space.

---NOTE---

*Table 5 values in some columns of the top three rows are **NEGATIVE NUMBERS** (as indicated by a preceding dash) and must be recorded with its 'preceding dash' in Calculation Box #2 to represent a negative number.*

☐ **STEP 8:** In Calculation Box #2, **add** the 'Table 5 value' to the 'CALC Box #1 result'.

---NOTE---

*If the 'Table 5 value' was recorded with a preceding dash copied from Table 5, this **NEGATIVE NUMBER** must be **SUBTRACTED** instead of **ADDED** from the 'CALC Box #1 result' in Calculation Box #2.*

☐ **STEP 9:** Record 'CALC Box #2 result' above Table 6A, 6B, or 6C (as applicable) in the 'CALC Box #2 result' space provided.

☐ **STEP 10:** Use 'CALC Box #2 result' to circle its 'equal or lesser' value on the applicable Table 6 top row axis.

☐ **STEP 11:** Determine (& circle) the Table 6 intersecting value for the axis values previously circled
(i.e., use Table 1 value **(2)** for far left column axis and 'CALC Box #2 result' for top row axis of Table 6).
Record this value in the Calculation Box #3 'Table 6 value' space at right.

☐ **STEP 12:** In Calculation Box #3, use the 'Table 6 value' to convert the 'Data Time/Date values' to a 'CO_2 Start Escape Time'. This is the time/date escapes must start to prevent exceeding high limit 6% SEV CO_2 before all escapes are completed. Record this result on OP6B-1 under 1.b '***CO_2 START ESCAPE TIME***'. This completes OP6B Section 1. Continue to step 13 (Section 2, OP6B-12).

CALCULATION BOX #3

Data Time/Date: _____ ____ - ____ / ____
[**(1)** From Table 1] **Time (24Hr) (DD - MM / YY)**

Table 6 value: **+** _____
[From Step 11] **Hrs (Stay Time)**

CO_2
Start Escape Time: = _____ ____ - ____ / ____
Time (24Hr) (DD - MM / YY)

(Record this result on OP6B-1 under 1.b.)

TABLE 2A (Section 1)

TABLE 2A	UNFIT to ESCAPE [(4) From Table 1]																	*(1/ - For an UNFIT number 90 or greater, use Table 2B.)*
FIT to ESCAPE [(3) From Table 1]	0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85 1/
5	1	4	7	10	13	16	20	23	26	29	32	35	38	41	45	48	51	54
10	5	11	18	24	30	36	43	49	55	61	68	74	80	86	93	99	105	111
15	12	21	31	40	50	59	68	78	87	96	106	115	125	134	143	153	162	171
20	23	35	48	60	73	85	98	110	123	135	148	160	173	185	198	210	223	235
25	36	51	67	83	98	114	130	145	161	176	192	208	223	239	255	270	286	301
30	53	71	90	109	128	146	165	184	203	221	240	259	278	296	315	334	353	371
35	72	94	116	138	160	181	203	225	247	269	291	313	335	356	378	400	422	444
40	95	120	145	170	195	220	245	270	295	320	345	370	395	420	445	470	495	520
45	121	149	177	205	233	261	290	318	346	374	402	430	458	486	515	543	571	599
50	150	181	213	244	275	306	338	369	400	431	463	494	525	556	588	619	650	681
55	182	216	251	285	320	354	388	423	457	491	526	560	595	629	663	698	732	766
60	218	255	293	330	368	405	443	480	518	555	593	630	668	705	743	780	818	855
65	256	296	337	378	418	459	500	540	581	621	662	703	743	784	825	865	906	946
70	298	341	385	429	473	516	560	604	648	691	735	779	823	866	910	954	998	1041
75	342	389	436	483	530	576	623	670	717	764	811	858	905	951	998	1045	1092	1139
80	390	440	490	540	590	640	690	740	790	840	890	940	990	1040	1090	1140	1190	1240
85	441	494	547	600	653	706	760	813	866	919	972	1025	1078	1131	1185	1238	1291	1344
90	495	551	608	664	720	776	833	889	945	1001	1058	1114	1170	1226	1283	1339	1395	1451
95	552	611	671	730	790	849	908	968	1027	1086	1146	1205	1265	1324	1383	1443	1502	1561
100	613	675	738	800	863	925	988	1050	1113	1175	1238	1300	1363	1425	1488	1550	1613	1675
105	676	741	807	873	938	1004	1070	1135	1201	1266	1332	1398	1463	1529	1595	1660	1726	1791
110	743	811	880	949	1018	1086	1155	1224	1293	1361	1430	1499	1568	1636	1705	1774	>1800	>1800
115	812	884	956	1028	1100	1171	1243	1315	1387	1459	1531	1603	1675	1746	>1800	>1800	>1800	>1800
120	885	960	1035	1110	1185	1260	1335	1410	1485	1560	1635	1710	1785	>1800	>1800	>1800	>1800	>1800
125	961	1039	1117	1195	1273	1351	1430	1508	1586	1664	1742	>1800	>1800	>1800	>1800	>1800	>1800	>1800
130	1040	1121	1203	1284	1365	1446	1528	1609	1690	1771	>1800	>1800	>1800	>1800	>1800	>1800	>1800	>1800
135	1122	1206	1291	1375	1460	1544	1628	1713	1797	>1800	>1800	>1800	>1800	>1800	>1800	>1800	>1800	>1800
140	1208	1295	1383	1470	1558	1645	1733	>1800	>1800	>1800	>1800	>1800	>1800	>1800	>1800	>1800	>1800	>1800
145	1296	1386	1477	1568	1658	1749	>1800	>1800	>1800	>1800	>1800	>1800	>1800	>1800	>1800	>1800	>1800	>1800
150	1388	1481	1575	1669	1763	>1800	>1800	>1800	>1800	>1800	>1800	>1800	>1800	>1800	>1800	>1800	>1800	>1800
155	1482	1579	1676	1773	>1800	>1800	>1800	>1800	>1800	>1800	>1800	>1800	>1800	>1800	>1800	>1800	>1800	>1800
160	1580	1680	1780	>1800	>1800	>1800	>1800	>1800	>1800	>1800	>1800	>1800	>1800	>1800	>1800	>1800	>1800	>1800

TABLE 2B		UNFIT to ESCAPE [(4) From Table 1] *continued from Table 2A*														
		90	**95**	**100**	**105**	**110**	**115**	**120**	**125**	**130**	**135**	**140**	**145**	**150**	**155**	**160**
FIT to ESCAPE [(3) From Table 1]	**5**	57	60	63	66	70	73	76	79	82	85	88	91	95	98	101
	10	118	124	130	136	143	149	155	161	168	174	180	186	193	199	205
	15	181	190	200	209	218	228	237	246	256	265	275	284	293	303	312
	20	248	260	273	285	298	310	323	335	348	360	373	385	398	410	423
	25	317	333	348	364	380	395	411	426	442	458	473	489	505	520	536
	30	390	409	428	446	465	484	503	521	540	559	578	596	615	634	653
	35	466	488	510	531	553	575	597	619	641	663	685	706	728	750	772
	40	545	570	595	620	645	670	695	720	745	770	795	820	845	870	895
	45	627	655	683	711	740	768	796	824	852	880	908	936	965	993	1021
	50	713	744	775	806	838	869	900	931	963	994	1025	1056	1088	1119	1150
	55	801	835	870	904	938	973	1007	1041	1076	1110	1145	1179	1213	1248	1282
	60	893	930	968	1005	1043	1080	1118	1155	1193	1230	1268	1305	1343	1380	1418
	65	987	1028	1068	1109	1150	1190	1231	1271	1312	1353	1393	1434	1475	1515	1556
	70	1085	1129	1173	1216	1260	1304	1348	1391	1435	1479	1523	1566	1610	1654	1698
	75	1186	1233	1280	1326	1373	1420	1467	1514	1561	1608	1655	1701	1748	1795	>1800
	80	1290	1340	1390	1440	1490	1540	1590	1640	1690	1740	1790	>1800	>1800	>1800	>1800
	85	1397	1450	1503	1556	1610	1663	1716	1769	>1800	>1800	>1800	>1800	>1800	>1800	>1800
	90	1508	1564	1620	1676	1733	1789	>1800	>1800	>1800	>1800	>1800	>1800	>1800	>1800	>1800
	95	1621	1680	1740	1799	>1800	>1800	>1800	>1800	>1800	>1800	>1800	>1800	>1800	>1800	>1800
	100	1738	1800	>1800	>1800	>1800	>1800	>1800	>1800	>1800	>1800	>1800	>1800	>1800	>1800	>1800

TABLE 3	PERCENT (%) COMPARTMENT FLOODED [(5) From TABLE 1]				
FIT to ESCAPE [(3) From Table 1]	0	20	40	60	80
5	5316	4227	3137	2048	959
10	5299	4209	3120	2031	941
15	5272	4183	3094	2004	915
20	5255	4165	3076	1987	897
25	5228	4139	3050	1960	871
30	5211	4121	3032	1943	853
35	5185	4095	3006	1916	827
40	5167	4078	2988	1899	809
45	5141	4051	2962	1872	783
50	5123	4034	2944	1855	765
55	5097	4007	2918	1828	739
60	5079	3990	2900	1811	721
65	5053	3963	2874	1784	695
70	5035	3946	2856	1767	678
75	5009	3919	2830	1741	651
80	4991	3902	2812	1723	634
85	4965	3875	2786	1697	607
90	4947	3858	2768	1679	590
95	4921	3831	2742	1653	563
100	4903	3814	2725	1635	546
105	4877	3788	2698	1609	519
110	4859	3770	2681	1591	502
115	4833	3744	2654	1565	475
120	4815	3726	2637	1547	458
125	4789	3700	2610	1521	431
130	4772	3682	2593	1503	414
135	4745	3656	2566	1477	388
140	4728	3638	2549	1459	370
145	4701	3612	2522	1433	344
150	4684	3594	2505	1415	326
155	4657	3568	2478	1389	300
160	4640	3550	2461	1371	282

TABLE 4	PERCENT (%) COMPARTMENT FLOODED [(5) From TABLE 1]				
COMPARTMENT CO_2 CONCENTRATION (% SEV) [(6) From Table 1]	0	20	40	60	80
0.00	0	0	0	0	0
0.20	182	145	109	73	36
0.40	363	291	218	145	73
0.60	545	436	327	218	109
0.80	726	581	436	291	145
1.00	908	726	545	363	182
1.20	1089	872	654	436	218
1.40	1271	1017	763	508	254
1.60	1453	1162	872	581	291
1.80	1634	1307	980	654	327
2.00	1816	1453	1089	726	363
2.20	1997	1598	1198	799	399
2.40	2179	1743	1307	872	436
2.60	2360	1888	1416	944	472
2.80	2542	2034	1525	1017	508
3.00	2724	2179	1634	1089	545
3.20	2905	2324	1743	1162	581
3.40	3087	2469	1852	1235	617
3.60	3268	2615	1961	1307	654
3.80	3450	2760	2070	1380	690
4.00	3631	2905	2179	1453	726
4.20	3813	3050	2288	1525	763
4.40	3994	3196	2397	1598	799
4.60	4176	3341	2506	1670	835
4.80	4358	3486	2615	1743	872
5.00	4539	3631	2724	1816	908
5.20	4721	3777	2832	1888	944
5.40	4902	3922	2941	1961	980
5.60	5084	4067	3050	2034	1017
5.80	5265	4212	3159	2106	1053
6.00	5447	4358	3268	2179	1089

Table 2 value: _____ (From Step 2, Use for Table 5 top row axis. Round to the next higher axis value if Table 2 value is in between below axis values.)

TABLE 5	TABLE 2 VALUE (From above fill-in value – via Step 2)																				
EXTENDAIR® LiOH CANISTERS [(8) From Table 1]	25	50	75	100	200	300	400	500	600	700	800	900	1000	1100	1200	1300	1400	1500	1600	1700	1800
0	***-25***	***-50***	***-75***	***-100***	***-200***	***-300***	***-400***	***-500***	***-600***	***-700***	***-800***	***-900***	***-1000***	***-1100***	***-1200***	***-1300***	***-1400***	***-1600***	***-1700***	***-1800***	***-1800***
10	705	680	655	630	530	430	330	230	130	30	***-70***	***-170***	***-270***	***-370***	***-470***	***-570***	***-670***	***-870***	***-970***	***-1070***	***-1070***
20	1435	1410	1385	1360	1260	1160	1060	960	860	760	660	560	460	360	260	160	60	***-140***	***-240***	***-340***	***-340***
30	2165	2140	2115	2090	1990	1890	1790	1690	1590	1490	1390	1290	1190	1090	990	890	790	590	490	390	390
40	2895	2870	2845	2820	2720	2620	2520	2420	2320	2220	2120	2020	1920	1820	1720	1620	1520	1320	1220	1120	1120
50	3625	3600	3575	3550	3450	3350	3250	3150	3050	2950	2850	2750	2650	2550	2450	2350	2250	2050	1950	1850	1850
60	4355	4330	4305	4280	4180	4080	3980	3880	3780	3680	3580	3480	3380	3280	3180	3080	2980	2780	2680	2580	2580
70	5085	5060	5035	5010	4910	4810	4710	4610	4510	4410	4310	4210	4110	4010	3910	3810	3710	3510	3410	3310	3310
80	5815	5790	5765	5740	5640	5540	5440	5340	5240	5140	5040	4940	4840	4740	4640	4540	4440	4240	4140	4040	4040
90	6545	6520	6495	6470	6370	6270	6170	6070	5970	5870	5770	5670	5570	5470	5370	5270	5170	4970	4870	4770	4770
100	7275	7250	7225	7200	7100	7000	6900	6800	6700	6600	6500	6400	6300	6200	6100	6000	5900	5700	5600	5500	5500
110	8005	7980	7955	7930	7830	7730	7630	7530	7430	7330	7230	7130	7030	6930	6830	6730	6630	6430	6330	6230	6230
120	8735	8710	8685	8660	8560	8460	8360	8260	8160	8060	7960	7860	7760	7660	7560	7460	7360	7160	7060	6960	6960
130	9465	9440	9415	9390	9290	9190	9090	8990	8890	8790	8690	8590	8490	8390	8290	8190	8090	7890	7790	7690	7690
140	10195	10170	10145	10120	10020	9920	9820	9720	9620	9520	9420	9320	9220	9120	9020	8920	8820	8620	8520	8420	8420
150	10925	10900	10875	10850	10750	10650	10550	10450	10350	10250	10150	10050	9950	9850	9750	9650	9550	9350	9250	9150	9150
160	11655	11630	11605	11580	11480	11380	11280	11180	11080	10980	10880	10780	10680	10580	10480	10380	10280	10080	9980	9880	9880
170	12385	12360	12335	12310	12210	12110	12010	11910	11810	11710	11610	11510	11410	11310	11210	11110	11010	10810	10710	10610	10610
180	13115	13090	13065	13040	12940	12840	12740	12640	12540	12440	12340	12240	12140	12040	11940	11840	11740	11540	11440	11340	11340
190	13845	13820	13795	13770	13670	13570	13470	13370	13270	13170	13070	12970	12870	12770	12670	12570	12470	12270	12170	12070	12070
200	14575	14550	14525	14500	14400	14300	14200	14100	14000	13900	13800	13700	13600	13500	13400	13300	13200	13000	12900	12800	12800
210	15305	15280	15255	15230	15130	15030	14930	14830	14730	14630	14530	14430	14330	14230	14130	14030	13930	13730	13630	13530	13530
220	16035	16010	15985	15960	15860	15760	15660	15560	15460	15360	15260	15160	15060	14960	14860	14760	14660	14460	14360	14260	14260
230	16765	16740	16715	16690	16590	16490	16390	16290	16190	16090	15990	15890	15790	15690	15590	15490	15390	15190	15090	14990	14990
240	17495	17470	17445	17420	17320	17220	17120	17020	16920	16820	16720	16620	16520	16420	16320	16220	16120	15920	15820	15720	15720
250	18225	18200	18175	18150	18050	17950	17850	17750	17650	17550	17450	17350	17250	17150	17050	16950	16850	16650	16550	16450	16450
260	18955	18930	18905	18880	18780	18680	18580	18480	18380	18280	18180	18080	17980	17880	17780	17680	17580	17480	17380	17280	17180
270	19685	19660	19635	19610	19510	19410	19310	19210	19110	19010	18910	18810	18710	18610	18510	18410	18310	18210	18110	18010	17910
280	20415	20390	20365	20340	20240	20140	20040	19940	19840	19740	19640	19540	19440	19340	19240	19140	19040	18940	18840	18740	18640

TABLE 6A (Section 1)

PRE-ESCAPE 'CO₂' STAY TIME (Hrs)

CALC Box #2 result: _____ (From Step 9, use for Table 6A top row axis, if applicable. For a CALC Box #2 result 5,250 or greater, use Table 6B.)

TABLE 6A	CALC BOX #2 RESULT [From above fill-in value – via Step 9]																											
	0	**50**	**100**	**200**	**300**	**400**	**500**	**600**	**700**	**800**	**900**	**1000**	**1250**	**1500**	**1750**	**2000**	**2250**	**2500**	**2750**	**3000**	**3250**	**3500**	**3750**	**4000**	**4250**	**4500**	**4750**	**5000**
SURVIVOR TOTAL [(2) from Table 1]																												
5	0	10	20	40	60	80	100	120	140	160	180	200	250	300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300
10	0	5	10	20	30	40	50	60	70	80	90	100	125	150	175	200	225	250	275	300	>300	>300	>300	>300	>300	>300	>300	>300
15	0	3	7	13	20	27	33	40	47	53	60	67	83	100	117	133	150	167	183	200	217	233	250	267	283	300	>300	>300
20	0	3	5	10	15	20	25	30	35	40	45	50	63	75	88	100	113	125	138	150	163	175	188	200	213	225	238	250
25	0	2	4	8	12	16	20	24	28	32	36	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200
30	0	2	3	7	10	13	17	20	23	27	30	33	42	50	58	67	75	83	92	100	108	117	125	133	142	150	158	167
35	0	1	3	6	9	11	14	17	20	23	26	29	36	43	50	57	64	71	79	86	93	100	107	114	121	129	136	143
40	0	1	3	5	8	10	13	15	18	20	23	25	31	38	44	50	56	63	69	75	81	88	94	100	106	113	119	125
45	0	1	2	4	7	9	11	13	16	18	20	22	28	33	39	44	50	56	61	67	72	78	83	89	94	100	106	111
50	0	1	2	4	6	8	10	12	14	16	18	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100
55	0	1	2	4	5	7	9	11	13	15	16	18	23	27	32	36	41	45	50	55	59	64	68	73	77	82	86	91
60	0	1	2	3	5	7	8	10	12	13	15	17	21	25	29	33	38	42	46	50	54	58	63	67	71	75	79	83
65	0	1	2	3	5	6	8	9	11	12	14	15	19	23	27	31	35	38	42	46	50	54	58	62	65	69	73	77
70	0	1	1	3	4	6	7	9	10	11	13	14	18	21	25	29	32	36	39	43	46	50	54	57	61	64	68	71
75	0	1	1	3	4	5	7	8	9	11	12	13	17	20	23	27	30	33	37	40	43	47	50	53	57	60	63	67
80	0	1	1	3	4	5	6	8	9	10	11	13	16	19	22	25	28	31	34	38	41	44	47	50	53	56	59	63
85	0	1	1	2	4	5	6	7	8	9	11	12	15	18	21	24	26	29	32	35	38	41	44	47	50	53	56	59
90	0	1	1	2	3	4	6	7	8	9	10	11	14	17	19	22	25	28	31	33	36	39	42	44	47	50	53	56
95	0	1	1	2	3	4	5	6	7	8	9	11	13	16	18	21	24	26	29	32	34	37	39	42	45	47	50	53
100	0	1	1	2	3	4	5	6	7	8	9	10	13	15	18	20	23	25	28	30	33	35	38	40	43	45	48	50
105	0	0	1	2	3	4	5	6	7	8	9	10	12	14	17	19	21	24	26	29	31	33	36	38	40	43	45	48
110	0	0	1	2	3	4	5	5	6	7	8	9	11	14	16	18	20	23	25	27	30	32	34	36	39	41	43	45
115	0	0	1	2	3	3	4	5	6	7	8	9	11	13	15	17	20	22	24	26	28	30	33	35	37	39	41	43
120	0	0	1	2	3	3	4	5	6	7	8	8	10	13	15	17	19	21	23	25	27	29	31	33	35	38	40	42
125	0	0	1	2	2	3	4	5	6	6	7	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40
130	0	0	1	2	2	3	4	5	5	6	7	8	10	12	13	15	17	19	21	23	25	27	29	31	33	35	37	38
135	0	0	1	1	2	3	4	4	5	6	7	7	9	11	13	15	17	19	20	22	24	26	28	30	31	33	35	37
140	0	0	1	1	2	3	4	4	5	6	6	7	9	11	13	14	16	18	20	21	23	25	27	29	30	32	34	36
145	0	0	1	1	2	3	3	4	5	6	6	7	9	10	12	14	16	17	19	21	22	24	26	28	29	31	33	34
150	0	0	1	1	2	3	3	4	5	5	6	7	8	10	12	13	15	17	18	20	22	23	25	27	28	30	32	33
155	0	0	1	1	2	3	3	4	5	5	6	6	8	10	11	13	15	16	18	19	21	23	24	26	27	29	31	32
160	0	0	1	1	2	3	3	4	4	5	6	6	8	9	11	13	14	16	17	19	20	22	23	25	27	28	30	31

TABLE 6B (Section 1)

PRE-ESCAPE 'CO_2' STAY TIME (Hrs)

CALC Box #2 result: _____ (From Step 9, use for Table 6B top row axis, if applicable. For a CALC Box #2 result 13,000 or greater, use Table 6C.)

TABLE 6B	CALC BOX #2 RESULT [From above fill-in value – via Step 9]																									
SURVIVOR TOTAL [(2) from Table 1]	5250	5500	5750	6000	6250	6500	6750	7000	7250	7500	7750	8000	8250	8500	8750	9000	9250	9500	9750	10000	10500	11000	11500	12000	12500
5	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300
10	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300
15	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300
20	263	275	288	300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300
25	210	220	230	240	250	260	270	280	290	300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300
30	175	183	192	200	208	217	225	233	242	250	258	267	275	283	292	300	>300	>300	>300	>300	>300	>300	>300	>300	>300
35	150	157	164	171	179	186	193	200	207	214	221	229	236	243	250	257	264	271	279	286	300	>300	>300	>300	>300
40	131	138	144	150	156	163	169	175	181	188	194	200	206	213	219	225	231	238	244	250	263	275	288	300	>300
45	117	122	128	133	139	144	150	156	161	167	172	178	183	189	194	200	206	211	217	222	233	244	256	267	278
50	105	110	115	120	125	130	135	140	145	150	155	160	165	170	175	180	185	190	195	200	210	220	230	240	250
55	95	100	105	109	114	118	123	127	132	136	141	145	150	155	159	164	168	173	177	182	191	200	209	218	227
60	88	92	96	100	104	108	113	117	121	125	129	133	138	142	146	150	154	158	163	167	175	183	192	200	208
65	81	85	88	92	96	100	104	108	112	115	119	123	127	131	135	138	142	146	150	154	162	169	177	185	192
70	75	79	82	86	89	93	96	100	104	107	111	114	118	121	125	129	132	136	139	143	150	157	164	171	179
75	70	73	77	80	83	87	90	93	97	100	103	107	110	113	117	120	123	127	130	133	140	147	153	160	167
80	66	69	72	75	78	81	84	88	91	94	97	100	103	106	109	113	116	119	122	125	131	138	144	150	156
85	62	65	68	71	74	76	79	82	85	88	91	94	97	100	103	106	109	112	115	118	124	129	135	141	147
90	58	61	64	67	69	72	75	78	81	83	86	89	92	94	97	100	103	106	108	111	117	122	128	133	139
95	55	58	61	63	66	68	71	74	76	79	82	84	87	89	92	95	97	100	103	105	111	116	121	126	132
100	53	55	58	60	63	65	68	70	73	75	78	80	83	85	88	90	93	95	98	100	105	110	115	120	125
105	50	52	55	57	60	62	64	67	69	71	74	76	79	81	83	86	88	90	93	95	100	105	110	114	119
110	48	50	52	55	57	59	61	64	66	68	70	73	75	77	80	82	84	86	89	91	95	100	105	109	114
115	46	48	50	52	54	57	59	61	63	65	67	70	72	74	76	78	80	83	85	87	91	96	100	104	109
120	44	46	48	50	52	54	56	58	60	63	65	67	69	71	73	75	77	79	81	83	88	92	96	100	104
125	42	44	46	48	50	52	54	56	58	60	62	64	66	68	70	72	74	76	78	80	84	88	92	96	100
130	40	42	44	46	48	50	52	54	56	58	60	62	63	65	67	69	71	73	75	77	81	85	88	92	96
135	39	41	43	44	46	48	50	52	54	56	57	59	61	63	65	67	69	70	72	74	78	81	85	89	93
140	38	39	41	43	45	46	48	50	52	54	55	57	59	61	63	64	66	68	70	71	75	79	82	86	89
145	36	38	40	41	43	45	47	48	50	52	53	55	57	59	60	62	64	66	67	69	72	76	79	83	86
150	35	37	38	40	42	43	45	47	48	50	52	53	55	57	58	60	62	63	65	67	70	73	77	80	83
155	34	35	37	39	40	42	44	45	47	48	50	52	53	55	56	58	60	61	63	65	68	71	74	77	81
160	33	34	36	38	39	41	42	44	45	47	48	50	52	53	55	56	58	59	61	63	66	69	72	75	78

PRE-ESCAPE 'CO₂' STAY TIME (Hrs)

CALC Box #2 result: _____ (From Step 9, use for Table 6C top row axis, if applicable).

TABLE 6C		CALC BOX #2 RESULT [From above fill-in value – via Step 9] *(K = x(1,000); e.g., 13K = 13,000 and 13.5K = 13,500)*																								
		13K	**13.5K**	**14K**	**14.5K**	**15K**	**15.5K**	**16K**	**16.5K**	**17K**	**17.5K**	**18K**	**18.5K**	**19K**	**19.5K**	**20K**	**20.5K**	**21K**	**21.5K**	**22K**	**22.5K**	**23K**	**23.5K**	**24K**	**24.5K**	**25K**
SURVIVOR TOTAL [(2) from Table 1]	**5**	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300
	10	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300
	15	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300
	20	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300
	25	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300
	30	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300
	35	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300
	40	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300
	45	289	300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300
	50	260	270	280	290	300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300
	55	236	245	255	264	273	282	291	300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300
	60	217	225	233	242	250	258	267	275	283	292	300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300
	65	200	208	215	223	231	238	246	254	262	269	277	285	292	300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300
	70	186	193	200	207	214	221	229	236	243	250	257	264	271	279	286	293	300	>300	>300	>300	>300	>300	>300	>300	>300
	75	173	180	187	193	200	207	213	220	227	233	240	247	253	260	267	273	280	287	293	300	>300	>300	>300	>300	>300
	80	163	169	175	181	188	194	200	206	213	219	225	231	238	244	250	256	263	269	275	281	288	294	300	>300	>300
	85	153	159	165	171	176	182	188	194	200	206	212	218	224	229	235	241	247	253	259	265	271	276	282	288	294
	90	144	150	156	161	167	172	178	183	189	194	200	206	211	217	222	228	233	239	244	250	256	261	267	272	278
	95	137	142	147	153	158	163	168	174	179	184	189	195	200	205	211	216	221	226	232	237	242	247	253	258	263
	100	130	135	140	145	150	155	160	165	170	175	180	185	190	195	200	205	210	215	220	225	230	235	240	245	250
	105	124	129	133	138	143	148	152	157	162	167	171	176	181	186	190	195	200	205	210	214	219	224	229	233	238
	110	118	123	127	132	136	141	145	150	155	159	164	168	173	177	182	186	191	195	200	205	209	214	218	223	227
	115	113	117	122	126	130	135	139	143	148	152	157	161	165	170	174	178	183	187	191	196	200	204	209	213	217
	120	108	113	117	121	125	129	133	138	142	146	150	154	158	163	167	171	175	179	183	188	192	196	200	204	208
	125	104	108	112	116	120	124	128	132	136	140	144	148	152	156	160	164	168	172	176	180	184	188	192	196	200
	130	100	104	108	112	115	119	123	127	131	135	138	142	146	150	154	158	162	165	169	173	177	181	185	188	192
	135	96	100	104	107	111	115	119	122	126	130	133	137	141	144	148	152	156	159	163	167	170	174	178	181	185
	140	93	96	100	104	107	111	114	118	121	125	129	132	136	139	143	146	150	154	157	161	164	168	171	175	179
	145	90	93	97	100	103	107	110	114	117	121	124	128	131	134	138	141	145	148	152	155	159	162	166	169	172
	150	87	90	93	97	100	103	107	110	113	117	120	123	127	130	133	137	140	143	147	150	153	157	160	163	167
	155	84	87	90	94	97	100	103	106	110	113	116	119	123	126	129	132	135	139	142	145	148	152	155	158	161
	160	81	84	88	91	94	97	100	103	106	109	113	116	119	122	125	128	131	134	138	141	144	147	150	153	156

SECTION 2
OXYGEN TIME TO ESCAPE CALCULATIONS

---NOTE---

Calculations of Section 2 provide an estimated time when escapes should commence to prevent exceeding low limit 13% SEV Oxygen before all escapes are completed.

☐ **STEP 13:** Record the FWD Compartment O_2 concentration from Table 1 value **(7)** in the below box.

FWD Compartment O_2 concentration [(7) From Table 1]: _____ % SEV O_2

☐ **STEP 14:** If above FWD compartment O_2 concentration is 26% SEV or less, continue to step 15. If FWD compartment O_2 concentration is greater than 26% SEV, skip to step 16.

☐ **STEP 15:** In Table 7A, circle the intersecting value to the previously circled Table 1 axis values **(7)** and **(5)**. Record the Table 7A intersecting value in the Calculation Box #4 'Table 7 value' space at right. Skip to step 17.

☐ **STEP 16:** In Table 7B, circle the intersecting value to the previously circled Table 1 axis values **(7)** and **(5)**. Record the Table 7B intersecting value in the Calculation Box #4 'Table 7 value' space at right. Continue to step 17.

☐ **STEP 17:** In Table 8, circle the intersecting value to the previously circled Table 1 values **(3)** and **(5)**. Record the Table 8 intersecting value in the Calculation Box #4 'Table 8 value' space.

CALCULATION BOX #4

Table 7 value: _____
[From Steps 15 or 16]

Table 8 value: – _____
[From Step 17]

CALC Box #4 result: = _____

(Record this result in Calculation Box #5 on next page as the 'CALC Box #4 result'.)

☐ **STEP 18:** In Calculation Box #4, ***subtract*** the 'Table 8 value' from the 'Table 7 value' as indicated. Record in Calculation Box #4 and in Calculation Box #5 (next page) as the 'CALC Box #4 result'.

☐ **STEP 19:** In Table 9, circle the intersecting value to the previously circled Table 1 value **(9)** and the 'Table 2 value' recorded above Table 9 (by step 2 in Section 1). Record the Table 9 intersecting value in the Calculation Box #5 'Table 9 value' space below.

---NOTE---

*Table 9 values in some columns of the top two rows are **NEGATIVE NUMBERS** (as indicated by a preceding dash) and must be recorded with its 'preceding dash' in Calculation Box #5 to represent a negative number.*

☐ **STEP 20:** In Calculation Box #5, ***add*** the 'Table 9 value' to the 'CALC Box #4 result' to get a 'CALC Box #5 result'.

---NOTE---

*If the 'Table 9 value' was recorded with a preceding dash copied from Table 9, this **NEGATIVE NUMBER** must be **SUBTRACTED** instead of **ADDED** from the 'CALC Box #4 result' in Calculation Box #5.*

☐ **STEP 21:** Record 'CALC Box #5 result' above Table 10A, 10B, or 10C (as applicable) in the 'CALC Box #5 result' space provided.

☐ **STEP 22:** Use 'CALC Box #5 result' to circle its 'equal or lesser' value on the applicable Table 10 top row axis.

CALCULATION BOX #5

CALC Box #4 result: _____
[From Step 18]

Table 9 value: + _____
[From Step 19]

CALC Box #5 result: = _____

(Record this result* above Table 10 *as the 'CALC Box #5 result'.)

☐ **STEP 23:** Determine (& circle) the Table 10 intersecting value for the axis values previously circled. (i.e., use Table 1 value **(2)** for far left column axis & 'CALC Box #5 result' for top row axis of Table 10.) Record this value in the Calculation Box #6 'Table 10 value' space below.

☐ **STEP 24:** In Calculation Box #6, use the 'Table 10 value' to convert the 'Data Time/Date values' to an 'O_2 Start Escape Time'. This is the time/date escapes must start to prevent exceeding low limit 13% SEV O_2 before all escapes are completed. Record this result on OP6B-1 under 1.c ***'O_2 START ESCAPE TIME'***. This completes OP6B.

CALCULATION BOX #6

Data Time/Date: [**(1)** From Table 1] _____ Time (24Hr) ____ - ____ / ____ (DD - MM / YY)

Table 10 value [From Step 23] + _____ **Hrs (Stay Time)**

O_2 Start Escape Time: = _____ **Time (24Hr)** ____ - ____ / ____ **(DD - MM / YY)**

(Record this result on OP6B-1 under 1.c.)

TABLE 7A	PERCENT (%) COMPARTMENT FLOODED [(5) From Table 1]				
OXYGEN CONCENTRATION (% SEV) [(7) From Table 1]	0	20	40	60	80
13.0	10242	8194	6145	4097	2048
13.5	10636	8509	6382	4255	2127
14.0	11030	8824	6618	4412	2206
14.5	11424	9139	6855	4570	2285
15.0	11818	9455	7091	4727	2364
15.5	12212	9770	7327	4885	2442
16.0	12606	10085	7564	5042	2521
16.5	13000	10400	7800	5200	2600
17.0	13394	10715	8036	5358	2679
17.5	13788	11030	8273	5515	2758
18.0	14182	11346	8509	5673	2836
18.5	14576	11661	8745	5830	2915
19.0	14970	11976	8982	5988	2994
19.5	15364	12291	9218	6145	3073
20.0	15758	12606	9455	6303	3152
20.5	16152	12921	9691	6461	3230
21.0	16546	13236	9927	6618	3309
21.5	16939	13552	10164	6776	3388
22.0	17333	13867	10400	6933	3467
22.5	17727	14182	10636	7091	3545
23.0	18121	14497	10873	7249	3624
23.5	18515	14812	11109	7406	3703
24.0	18909	15127	11346	7564	3782
24.5	19303	15443	11582	7721	3861
25.0	19697	15758	11818	7879	3939
25.5	20091	16073	12055	8036	4018
26.0	20485	16388	12291	8194	4097

TABLE 7B	PERCENT (%) COMPARTMENT FLOODED [(5) From Table 1]				
OXYGEN CONCENTRATION (% SEV) [(7) From Table 1]	0	20	40	60	80
26.5	20879	16703	12527	8352	4176
27.0	21273	17018	12764	8509	4255
27.5	21667	17333	13000	8667	4333
28.0	22061	17649	13236	8824	4412
28.5	22455	17964	13473	8982	4491
29.0	22849	18279	13709	9139	4570
29.5	23243	18594	13946	9297	4649
30.0	23636	18909	14182	9455	4727
30.5	24030	19224	14418	9612	4806
31.0	24424	19539	14655	9770	4885
31.5	24818	19855	14891	9927	4964
32.0	25212	20170	15127	10085	5042
32.5	25606	20485	15364	10242	5121
33.0	26000	20800	15600	10400	5200
33.5	26394	21115	15836	10558	5279
34.0	26788	21430	16073	10715	5358
34.5	27182	21746	16309	10873	5436
35.0	27576	22061	16546	11030	5515
35.5	27970	22376	16782	11188	5594
36.0	28364	22691	17018	11346	5673
36.5	28758	23006	17255	11503	5752
37.0	29152	23321	17491	11661	5830
37.5	29546	23636	17727	11818	5909
38.0	29940	23952	17964	11976	5988
38.5	30333	24267	18200	12133	6067
39.0	30727	24582	18436	12291	6145
39.5	31121	24897	18673	12449	6224
40.0	31515	25212	18909	12606	6303

TABLE 8	PERCENT (%) COMPARTMENT FLOODED [(5) From Table 1]				
FIT to ESCAPE [(3) From Table 1]	0	20	40	60	80
5	9997	7948	5900	3851	1803
10	9964	7915	5867	3818	1770
15	9914	7866	5817	3769	1720
20	9881	7833	5784	3736	1687
25	9831	7783	5734	3686	1637
30	9798	7750	5701	3653	1604
35	9749	7700	5652	3603	1555
40	9716	7667	5619	3570	1522
45	9666	7618	5569	3521	1472
50	9633	7585	5536	3488	1439
55	9584	7535	5487	3438	1390
60	9551	7502	5454	3405	1357
65	9501	7452	5404	3356	1307
70	9468	7419	5371	3322	1274
75	9418	7370	5321	3273	1224
80	9385	7337	5288	3240	1191
85	9336	7287	5239	3190	1142
90	9303	7254	5206	3157	1109
95	9253	7205	5156	3108	1059
100	9220	7172	5123	3075	1026
105	9171	7122	5074	3025	977
110	9137	7089	5040	2992	944
115	9088	7039	4991	2942	894
120	9055	7006	4958	2909	861
125	9005	6957	4908	2860	811
130	8972	6924	4875	2827	778
135	8923	6874	4826	2777	729
140	8890	6841	4793	2744	696
145	8840	6792	4743	2695	646
150	8807	6759	4710	2662	613
155	8757	6709	4660	2612	563
160	8724	6676	4627	2579	530

Table 2 value: _____ (From Step 2, Use for Table 5 top row axis. Round to the next higher axis value if Table 2 value is in between below axis values.)

TABLE 9	TABLE 2 VALUE (From above fill-in value – via Step 2)																				
	25	**50**	**75**	**100**	**200**	**300**	**400**	**500**	**600**	**700**	**800**	**900**	**1000**	**1100**	**1200**	**1300**	**1400**	**1500**	**1600**	**1700**	**1800**
0	***-25***	***-50***	***-75***	***-100***	***-200***	***-300***	***-400***	***-500***	***-600***	***-700***	***-750***	***-800***	***-900***	***-1100***	***-1200***	***-1300***	***-1400***	***-1500***	***-1600***	***-1700***	***-1800***
10	1125	1100	1075	1050	950	850	750	650	550	450	400	350	250	50	***-50***	***-150***	***-250***	***-350***	***-450***	***-550***	***-650***
20	2275	2250	2225	2200	2100	2000	1900	1800	1700	1600	1550	1500	1400	1200	1100	1000	900	800	700	600	500
30	3425	3400	3375	3350	3250	3150	3050	2950	2850	2750	2700	2650	2550	2350	2250	2150	2050	1950	1850	1750	1650
40	4575	4550	4525	4500	4400	4300	4200	4100	4000	3900	3850	3800	3700	3500	3400	3300	3200	3100	3000	2900	2800
50	5725	5700	5675	5650	5550	5450	5350	5250	5150	5050	5000	4950	4850	4650	4550	4450	4350	4250	4150	4050	3950
60	6875	6850	6825	6800	6700	6600	6500	6400	6300	6200	6150	6100	6000	5800	5700	5600	5500	5400	5300	5200	5100
70	8025	8000	7975	7950	7850	7750	7650	7550	7450	7350	7300	7250	7150	6950	6850	6750	6650	6550	6450	6350	6250
80	9175	9150	9125	9100	9000	8900	8800	8700	8600	8500	8450	8400	8300	8100	8000	7900	7800	7700	7600	7500	7400
90	10325	10300	10275	10250	10150	10050	9950	9850	9750	9650	9600	9550	9450	9250	9150	9050	8950	8850	8750	8650	8550
100	11475	11450	11425	11400	11300	11200	11100	11000	10900	10800	10750	10700	10600	10400	10300	10200	10100	10000	9900	9800	9700
110	12625	12600	12575	12550	12450	12350	12250	12150	12050	11950	11900	11850	11750	11550	11450	11350	11250	11150	11050	10950	10850
120	13775	13750	13725	13700	13600	13500	13400	13300	13200	13100	13050	13000	12900	12700	12600	12500	12400	12300	12200	12100	12000
130	14925	14900	14875	14850	14750	14650	14550	14450	14350	14250	14200	14150	14050	13850	13750	13650	13550	13450	13350	13250	13150
140	16075	16050	16025	16000	15900	15800	15700	15600	15500	15400	15350	15300	15200	15000	14900	14800	14700	14600	14500	14400	14300
150	17225	17200	17175	17150	17050	16950	16850	16750	16650	16550	16500	16450	16350	16150	16050	15950	15850	15750	15650	15550	15450
160	18375	18350	18325	18300	18200	18100	18000	17900	17800	17700	17650	17600	17500	17300	17200	17100	17000	16900	16800	16700	16600
170	19525	19500	19475	19450	19350	19250	19150	19050	18950	18850	18800	18750	18650	18450	18350	18250	18150	18050	17950	17850	17750
180	20675	20650	20625	20600	20500	20400	20300	20200	20100	20000	19950	19900	19800	19600	19500	19400	19300	19200	19100	19000	18900
190	21825	21800	21775	21750	21650	21550	21450	21350	21250	21150	21050	20950	20850	20750	20650	20550	20450	20350	20250	20150	20050
200	22975	22950	22925	22900	22800	22700	22600	22500	22400	22300	22200	22100	22000	21900	21800	21700	21600	21500	21400	21300	21200
210	24125	24100	24075	24050	23950	23850	23750	23650	23550	23450	23350	23250	23150	23050	22950	22850	22750	22650	22550	22450	22350
220	25275	25250	25225	25200	25100	25000	24900	24800	24700	24600	24500	24400	24300	24200	24100	24000	23900	23800	23700	23600	23500
230	26425	26400	26375	26350	26250	26150	26050	25950	25850	25750	25650	25550	25450	25350	25250	25150	25050	24950	24850	24750	24650
240	27575	27550	27525	27500	27400	27300	27200	27100	27000	26900	26800	26700	26600	26500	26400	26300	26200	26100	26000	25900	25800
250	28725	28700	28675	28650	28550	28450	28350	28250	28150	28050	27950	27850	27750	27650	27550	27450	27350	27250	27150	27050	26950
260	29875	29850	29825	29800	29700	29600	29500	29400	29300	29200	29100	29000	28900	28800	28700	28600	28500	28400	28300	28200	28100
270	31025	31000	30975	30950	30850	30750	30650	30550	30450	30350	30250	30150	30050	29950	29850	29750	29650	29550	29450	29350	29250
280	32175	32150	32125	32100	32000	31900	31800	31700	31600	31500	31400	31300	31200	31100	31000	30900	30800	30700	30600	30500	30400
290	33325	33300	33275	33250	33150	33050	32950	32850	32750	32650	32550	32450	32350	32250	32150	32050	31950	31850	31750	31650	31550
300	34475	34450	34425	34400	34300	34200	34100	34000	33900	33800	33700	33600	33500	33400	33300	33200	33100	33000	32900	32800	32700
310	35625	35600	35575	35550	35450	35350	35250	35150	35050	34950	34850	34750	34650	34550	34450	34350	34250	34150	34050	33950	33850
320	36775	36750	36725	36700	36600	36500	36400	36300	36200	36100	36000	35900	35800	35700	35600	35500	35400	35300	35200	35100	35000
330	37925	37900	37875	37850	37750	37650	37550	37450	37350	37250	37150	37050	36950	36850	36750	36650	36550	36450	36350	36250	36150
340	39075	39050	39025	39000	38900	38800	38700	38600	38500	38400	38300	38200	38100	38000	37900	37800	37700	37600	37500	37400	37300
350	40225	40200	40175	40150	40050	39950	39850	39750	39650	39550	39450	39350	39250	39150	39050	38950	38850	38750	38650	38550	38450
360	41375	41350	41325	41300	41200	41100	41000	40900	40800	40700	40600	40500	40400	40300	40200	40100	40000	39900	39800	39700	39600
370	42525	42500	42475	42450	42350	42250	42150	42050	41950	41850	41750	41650	41550	41450	41350	41250	41150	41050	40950	40850	40750

OXYGEN CANDLES [(9) from Table 1]

TABLE 10A (Section 2)

PRE-ESCAPE 'O_2' STAY TIME (Hrs)

CALC Box #5 result: _____ (From Step 21, use for Table 10A top row axis, if applicable. For a CALC Box #5 result 5,250 or greater, use Table 10B.)

TABLE 10A	CALC BOX #5 RESULT [From above fill-in value – via Step 21]																												
SURVIVOR TOTAL [(2) from Table 1]	0	50	100	200	300	400	500	600	700	800	900	1000	1250	1500	1750	2000	2250	2500	2750	3000	3250	3500	3750	4000	4250	4500	4750	5000
5	0	10	20	40	60	80	100	120	140	160	180	200	250	300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300
10	0	5	10	20	30	40	50	60	70	80	90	100	125	150	175	200	225	250	275	300	>300	>300	>300	>300	>300	>300	>300	>300	>300
15	0	3	7	13	20	27	33	40	47	53	60	67	83	100	117	133	150	167	183	200	217	233	250	267	283	300	>300	>300	>300
20	0	3	5	10	15	20	25	30	35	40	45	50	63	75	88	100	113	125	138	150	163	175	188	200	213	225	238	250	
25	0	2	4	8	12	16	20	24	28	32	36	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200	
30	0	2	3	7	10	13	17	20	23	27	30	33	42	50	58	67	75	83	92	100	108	117	125	133	142	150	158	167	
35	0	1	3	6	9	11	14	17	20	23	26	29	36	43	50	57	64	71	79	86	93	100	107	114	121	129	136	143	
40	0	1	3	5	8	10	13	15	18	20	23	25	31	38	44	50	56	63	69	75	81	88	94	100	106	113	119	125	
45	0	1	2	4	7	9	11	13	16	18	20	22	28	33	39	44	50	56	61	67	72	78	83	89	94	100	106	111	
50	0	1	2	4	6	8	10	12	14	16	18	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100	
55	0	1	2	4	5	7	9	11	13	15	16	18	23	27	32	36	41	45	50	55	59	64	68	73	77	82	86	91	
60	0	1	2	3	5	7	8	10	12	13	15	17	21	25	29	33	38	42	46	50	54	58	63	67	71	75	79	83	
65	0	1	2	3	5	6	8	9	11	12	14	15	19	23	27	31	35	38	42	46	50	54	58	62	65	69	73	77	
70	0	1	1	3	4	6	7	9	10	11	13	14	18	21	25	29	32	36	39	43	46	50	54	57	61	64	68	71	
75	0	1	1	3	4	5	7	8	9	11	12	13	17	20	23	27	30	33	37	40	43	47	50	53	57	60	63	67	
80	0	1	1	3	4	5	6	8	9	10	11	13	16	19	22	25	28	31	34	38	41	44	47	50	53	56	59	63	
85	0	1	1	2	4	5	6	7	8	9	11	12	15	18	21	24	26	29	32	35	38	41	44	47	50	53	56	59	
90	0	1	1	2	3	4	6	7	8	9	10	11	14	17	19	22	25	28	31	33	36	39	42	44	47	50	53	56	
95	0	1	1	2	3	4	5	6	7	8	9	11	13	16	18	21	24	26	29	32	34	37	39	42	45	47	50	53	
100	0	1	1	2	3	4	5	6	7	8	9	10	13	15	18	20	23	25	28	30	33	35	38	40	43	45	48	50	
105	0	0	1	2	3	4	5	6	7	8	9	10	12	14	17	19	21	24	26	29	31	33	36	38	40	43	45	48	
110	0	0	1	2	3	4	5	5	6	7	8	9	11	14	16	18	20	23	25	27	30	32	34	36	39	41	43	45	
115	0	0	1	2	3	3	4	5	6	7	8	9	11	13	15	17	20	22	24	26	28	30	33	35	37	39	41	43	
120	0	0	1	2	3	3	4	5	6	7	8	8	10	13	15	17	19	21	23	25	27	29	31	33	35	38	40	42	
125	0	0	1	2	2	3	4	5	6	6	7	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40	
130	0	0	1	2	2	3	4	5	5	6	7	8	10	12	13	15	17	19	21	23	25	27	29	31	33	35	37	38	
135	0	0	1	1	2	3	4	4	5	6	7	7	9	11	13	15	17	19	20	22	24	26	28	30	31	33	35	37	
140	0	0	1	1	2	3	4	4	5	6	6	7	9	11	13	14	16	18	20	21	23	25	27	29	30	32	34	36	
145	0	0	1	1	2	3	3	4	5	6	6	7	9	10	12	14	16	17	19	21	22	24	26	28	29	31	33	34	
150	0	0	1	1	2	3	3	4	5	5	6	7	8	10	12	13	15	17	18	20	22	23	25	27	28	30	32	33	
155	0	0	1	1	2	3	3	4	5	5	6	6	8	10	11	13	15	16	18	19	21	23	24	26	27	29	31	32	
160	0	0	1	1	2	3	3	4	4	5	6	6	8	9	11	13	14	16	17	19	20	22	23	25	27	28	30	31	

PRE-ESCAPE 'O_2' STAY TIME (Hrs)

CALC Box #5 result: _____ (From Step 21, use for Table 10B top row axis, if applicable. For a CALC Box #5 result 13,000 or greater, use Table 10C.)

TABLE 10B	CALC BOX #5 RESULT [From above fill-in value – via Step 21]																								
SURVIVOR TOTAL [(2) from Table 1]	5250	5500	5750	6000	6250	6500	6750	7000	7250	7500	7750	8000	8250	8500	8750	9000	9250	9500	9750	10000	10500	11000	11500	12000	12500
5	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300
10	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300
15	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300
20	263	275	288	300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300
25	210	220	230	240	250	260	270	280	290	300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300
30	175	183	192	200	208	217	225	233	242	250	258	267	275	283	292	300	>300	>300	>300	>300	>300	>300	>300	>300	>300
35	150	157	164	171	179	186	193	200	207	214	221	229	236	243	250	257	264	271	279	286	300	>300	>300	>300	>300
40	131	138	144	150	156	163	169	175	181	188	194	200	206	213	219	225	231	238	244	250	263	275	288	300	>300
45	117	122	128	133	139	144	150	156	161	167	172	178	183	189	194	200	206	211	217	222	233	244	256	267	278
50	105	110	115	120	125	130	135	140	145	150	155	160	165	170	175	180	185	190	195	200	210	220	230	240	250
55	95	100	105	109	114	118	123	127	132	136	141	145	150	155	159	164	168	173	177	182	191	200	209	218	227
60	88	92	96	100	104	108	113	117	121	125	129	133	138	142	146	150	154	158	163	167	175	183	192	200	208
65	81	85	88	92	96	100	104	108	112	115	119	123	127	131	135	138	142	146	150	154	162	169	177	185	192
70	75	79	82	86	89	93	96	100	104	107	111	114	118	121	125	129	132	136	139	143	150	157	164	171	179
75	70	73	77	80	83	87	90	93	97	100	103	107	110	113	117	120	123	127	130	133	140	147	153	160	167
80	66	69	72	75	78	81	84	88	91	94	97	100	103	106	109	113	116	119	122	125	131	138	144	150	156
85	62	65	68	71	74	76	79	82	85	88	91	94	97	100	103	106	109	112	115	118	124	129	135	141	147
90	58	61	64	67	69	72	75	78	81	83	86	89	92	94	97	100	103	106	108	111	117	122	128	133	139
95	55	58	61	63	66	68	71	74	76	79	82	84	87	89	92	95	97	100	103	105	111	116	121	126	132
100	53	55	58	60	63	65	68	70	73	75	78	80	83	85	88	90	93	95	98	100	105	110	115	120	125
105	50	52	55	57	60	62	64	67	69	71	74	76	79	81	83	86	88	90	93	95	100	105	110	114	119
110	48	50	52	55	57	59	61	64	66	68	70	73	75	77	80	82	84	86	89	91	95	100	105	109	114
115	46	48	50	52	54	57	59	61	63	65	67	70	72	74	76	78	80	83	85	87	91	96	100	104	109
120	44	46	48	50	52	54	56	58	60	63	65	67	69	71	73	75	77	79	81	83	88	92	96	100	104
125	42	44	46	48	50	52	54	56	58	60	62	64	66	68	70	72	74	76	78	80	84	88	92	96	100
130	40	42	44	46	48	50	52	54	56	58	60	62	63	65	67	69	71	73	75	77	81	85	88	92	96
135	39	41	43	44	46	48	50	52	54	56	57	59	61	63	65	67	69	70	72	74	78	81	85	89	93
140	38	39	41	43	45	46	48	50	52	54	55	57	59	61	63	64	66	68	70	71	75	79	82	86	89
145	36	38	40	41	43	45	47	48	50	52	53	55	57	59	60	62	64	66	67	69	72	76	79	83	86
150	35	37	38	40	42	43	45	47	48	50	52	53	55	57	58	60	62	63	65	67	70	73	77	80	83
155	34	35	37	39	40	42	44	45	47	48	50	52	53	55	56	58	60	61	63	65	68	71	74	77	81
160	33	34	36	38	39	41	42	44	45	47	48	50	52	53	55	56	58	59	61	63	66	69	72	75	78

PRE-ESCAPE 'O_2' STAY TIME (Hrs)

CALC Box #5 result: _____ (From Step 21, use for Table 10C top row axis, if applicable).

TABLE 10C		CALC BOX #5 RESULT [From above fill-in value – via Step 21] *(K = x(1,000); e.g., 13K = 13,000 and 13.5K = 13,500)*																								
		13K	**13.5K**	**14K**	**14.5K**	**15K**	**15.5K**	**16K**	**16.5K**	**17K**	**17.5K**	**18K**	**18.5K**	**19K**	**19.5K**	**20K**	**20.5K**	**21K**	**21.5K**	**22K**	**22.5K**	**23K**	**23.5K**	**24K**	**24.5K**	**25K**
SURVIVOR TOTAL [(2) from Table 1]	**5**	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300
	10	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300
	15	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300
	20	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300
	25	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300
	30	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300
	35	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300
	40	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300
	45	289	300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300
	50	260	270	280	290	300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300
	55	236	245	255	264	273	282	291	300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300
	60	217	225	233	242	250	258	267	275	283	292	300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300
	65	200	208	215	223	231	238	246	254	262	269	277	285	292	300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300
	70	186	193	200	207	214	221	229	236	243	250	257	264	271	279	286	293	300	>300	>300	>300	>300	>300	>300	>300	>300
	75	173	180	187	193	200	207	213	220	227	233	240	247	253	260	267	273	280	287	293	300	>300	>300	>300	>300	>300
	80	163	169	175	181	188	194	200	206	213	219	225	231	238	244	250	256	263	269	275	281	288	294	300	>300	>300
	85	153	159	165	171	176	182	188	194	200	206	212	218	224	229	235	241	247	253	259	265	271	276	282	288	294
	90	144	150	156	161	167	172	178	183	189	194	200	206	211	217	222	228	233	239	244	250	256	261	267	272	278
	95	137	142	147	153	158	163	168	174	179	184	189	195	200	205	211	216	221	226	232	237	242	247	253	258	263
	100	130	135	140	145	150	155	160	165	170	175	180	185	190	195	200	205	210	215	220	225	230	235	240	245	250
	105	124	129	133	138	143	148	152	157	162	167	171	176	181	186	190	195	200	205	210	214	219	224	229	233	238
	110	118	123	127	132	136	141	145	150	155	159	164	168	173	177	182	186	191	195	200	205	209	214	218	223	227
	115	113	117	122	126	130	135	139	143	148	152	157	161	165	170	174	178	183	187	191	196	200	204	209	213	217
	120	108	113	117	121	125	129	133	138	142	146	150	154	158	163	167	171	175	179	183	188	192	196	200	204	208
	125	104	108	112	116	120	124	128	132	136	140	144	148	152	156	160	164	168	172	176	180	184	188	192	196	200
	130	100	104	108	112	115	119	123	127	131	135	138	142	146	150	154	158	162	165	169	173	177	181	185	188	192
	135	96	100	104	107	111	115	119	122	126	130	133	137	141	144	148	152	156	159	163	167	170	174	178	181	185
	140	93	96	100	104	107	111	114	118	121	125	129	132	136	139	143	146	150	154	157	161	164	168	171	175	179
	145	90	93	97	100	103	107	110	114	117	121	124	128	131	134	138	141	145	148	152	155	159	162	166	169	172
	150	87	90	93	97	100	103	107	110	113	117	120	123	127	130	133	137	140	143	147	150	153	157	160	163	167
	155	84	87	90	94	97	100	103	106	110	113	116	119	123	126	129	132	135	139	142	145	148	152	155	158	161
	160	81	84	88	91	94	97	100	103	106	109	113	116	119	122	125	128	131	134	138	141	144	147	150	153	156

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