THERMAL EXPOSURE OF AMMUNITION ON BOARD SHIP. PART 2. AIRCRAFT -- ETC(U)

OCT 79  S. MATSUDA, H. C. SCHAER

UNCLASSIFIED

MWC-4884-PT-2
FOREWORD

This report presents results of an investigation to determine the valid shipboard thermal environment of ammunition. The work was conducted by the Naval Weapons Center (NWC), China Lake, California and supported by the Naval Air Systems Command under AirTask A03W-3300/008B/F31300000.

This report, Part 2, covers the probable thermal exposure to be found on aircraft carriers. The previously published volume, Part 1, covers cruisers and large destroyers. Additional volumes covering other naval ship types will be published at a later date.

This report has been reviewed for technical accuracy by Warren Oshel.

Approved by
C. J. DiPol, Head
Range Department
29 June 1979

Released for publication by
R. M. HILLYER
Technical Director

Under authority of
W. B. HAFF
Capt., U.S. Navy
Commander

NWC Technical Publication 4824, Part 2

Published by . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . Range Department
Collation . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . Cover, 35 leaves
First printing . . . . . . . . . . . . . . . . . . . . . . . . . . . 620 unnumbered copies
DISCLAIMER NOTICE

THIS DOCUMENT IS BEST QUALITY PRACTICABLE. THE COPY FURNISHED TO DDC CONTAINED A SIGNIFICANT NUMBER OF PAGES WHICH DO NOT REPRODUCE LEGIBLY.
**Report Title:** Thermal Exposure of Ammunition on Board Ship

**Authors:**
S. Matsuda
H. C. Schafer

**Performing Organization:**
Naval Weapons Center
China Lake, CA 93555

**Report Date:**
October 1979

**Number of Pages:**
68

**Abstract:**
See back of form.

(U) The magazine air temperature records from CVS and CVA type ships have been statistically analyzed to obtain the probable thermal exposure to be found on these type ships. The information is divided into the temperature expectancies for the various deck levels as applicable. Effort has been made to eliminate information from compartments influenced by the engine room. This report includes more than 1.1 million data points from 17 ships. The ships were assigned to the 1st, 2nd, 6th and 7th Fleets in this time frame.

Accession For
NTIS GNSF
DDC TAB
Unannounced
Justification

By
Distribution/
Availability Codes
Dist. Available or special
A 25P
CONTENTS

Introduction ............................................. 3

Instrumentation .......................................... 6

Data Handling ............................................. 6

Results and Conclusions ................................. 7

Midway Class ............................................. 7

Enterprise Class .......................................... 8

Essex Class ............................................... 9

Forrestal Class ........................................... 9

Carrier Fleet ............................................. 10

Appendixes:
A. Data Handling ........................................... 41
B. Definitions of Data ..................................... 59
C. Explanation of Deck Level and Compartment Identifications .......................... 62

Figures:
1. Horseshoe Type Thermometer ........................... 12
2. U.S.S. Coral Sea (CVA-43), All Levels .................. 13
3. U.S.S. Coral Sea (CVA-43), All Levels Below Waterline ........ 14
4. U.S.S. Coral Sea (CVA-43), All Levels Above Waterline .......... 15
5. U.S.S. Coral Sea (CVA-43), Fantail Lockers ............... 16
6. U.S.S. Enterprise (CVAN-65), 03 Level .................. 17
7. U.S.S. Enterprise (CVAN-65), 02 Level .................. 18
8. U.S.S. Enterprise (CVAN-65), 01 Level .................. 19
9. U.S.S. Enterprise (CVAN-65), 1 Level .................. 20
10. U.S.S. Enterprise (CVAN-65), 2 Level .................. 21
11. U.S.S. Enterprise (CVAN-65), 4 Level .................. 22
12. U.S.S. Enterprise (CVAN-65), 5 Level .................. 23
15. U.S.S. Essex (CVS-9), Upper Levels - Consolidated ....... 26
16. U.S.S. Essex (CVS-9), Lower Levels - Consolidated ....... 27
17. U.S.S. Forrestal (CVA-59), Lower Levels - Consolidated .... 28
18. U.S.S. Forrestal (CVA-59), Upper Levels - Consolidated .... 29
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>19</td>
<td></td>
<td></td>
<td></td>
<td>20</td>
<td></td>
<td></td>
<td></td>
<td>21</td>
<td></td>
<td></td>
<td></td>
<td>22</td>
<td></td>
<td></td>
<td></td>
<td>23</td>
<td></td>
<td></td>
<td></td>
<td>24</td>
<td></td>
<td></td>
<td></td>
<td>25</td>
<td></td>
<td></td>
<td></td>
<td>26</td>
<td></td>
<td></td>
<td></td>
<td>27</td>
</tr>
</tbody>
</table>
INTRODUCTION

An important factor in designing a ship-launched weapon is the environmental temperature range the weapon will experience during storage and operation. As part of a larger program aimed at determining the stockpile-to-target environments that will be experienced by air-launched weapons, a study was undertaken to define the thermal regime as it pertains to shipboard storage and use.

Recording of the maximum and minimum air temperatures in each magazine on board every ship in all Fleets has been required for years. This requirement, however, was strictly for safety; the records were usually retained on board the ship for only 1 to 2 years and then destroyed. At the request of the Naval Weapons Center (NWC), the Chief of Naval Operations in 1967 instructed all Fleet elements to send their obsolete magazine records to NWC for use in this project. Ships from the 1st, 2nd, 6th and 7th Fleets responded to this request, and the information from the cruisers and newer destroyers was reported on in Part I of this report series.

This volume, Part 2, presents the data and results as they pertain to aircraft carriers. Eventually all ship classes will be divided into logical study units and similar reports detailing the storage temperatures for each group prepared and published.

More than one million maximum or minimum temperature data points collected from all compartments and lockers on all levels of 17 aircraft carriers have been integrated into this report. The data collection time frame for each ship ranged from a few months to 10 years (for the
U.S.S. (U.S.S. J.). Many of these ships are no longer in service; however, the data are considered valid since all aircraft carrier compartment temperatures tend to describe a very narrow band of exposure. Also, it was thought these obsolete ships data would detail any thermal differences that would exist in future aircraft carrier design, if such tend to exist.

A complete definition of the extreme temperature circumstances is not provided since the exact position of the ship, day by day, is not known. Therefore, it is possible that even with the mass of data presented a chance exposure to less moderate temperatures could be experienced. Also, there was no control over ship deployment or the personnel actually recording the individual temperature readings. The sources of error in the existing collection system, however, have been investigated and compensated for. For example, the measuring instrument, a "horse-shoe" thermometer equipped with maximum and minimum temperature tattletales, could be affected by ship vibration. If mounted on a resonating bulkhead, the vibration could shake the tattletales down to the menisci of the mercury. This is evidenced in the records by identical maximum and minimum temperature entries for an interval of several days.

The lack of ship location information for a given day does not invalidate the data obtained since a correlation was made during the investigation on the service temperature of the ASROC missile.\(^1\) In this correlation, the recorded sea water temperature was compared with the minimum recorded ASROC motor temperature for the same day. The

---


resulting readings were within a few degrees of each other. Since the data were from ships assigned to the 7th Fleet, and this Fleet's area of interest is the Western Pacific, given the month and minimum compartment temperatures, a good guess can be made as to where the ship was located. As indicated in footnotes 1 and 2, the Western Pacific could be the warmest area in which our ships will be required to be deployed. When considering the cold extreme situation, there is a logically self-limiting factor. For instance none of the carriers providing data were in the Beaufort Sea during winter. This sea is ice choked in winter and a carrier would quite possibly be stuck in the ice until the next summer.

During the data accrual period, the candidate ships were deployed between 9 and 20° North latitude in the South China Sea. Thus these data, though incomplete and imperfect, are of extreme value in determining the environmental temperature criteria to which a majority of ship-launched ordnance will be exposed. This work then lays a foundation for determining the aircraft carrier maximum and minimum temperature regime for any non-heat generating naval material so as to be in design compliance with DOD Directive series 4120 and 5000. In addition, these data can be indicative of the "ready strike" thermal regime of ordnance and external stores mounted on aircraft during a combat situation.

As stated above, the data presented herein do not permit the exact correlation of ship location at the time a given temperature was recorded. However, the modern aircraft carrier does not congregate in groups but is usually the sole or paired center of her own task force. Thus each carrier data record is, in fact, the record for a carrier task force. Herein we have a conglomerate record of many independent carrier task forces from which we can derive a good idea of the overwhelming use of carriers (and the resulting compartment temperatures) in both cold and hot extremes. Based on these considerations it can be stated that the probable chance of occurrence of the response temperature of aircraft carrier ordnance and material is herein displayed.
INSTRUMENTATION

The horseshoe-type mercury thermometer (Figure 1) was used to obtain the data. This type thermometer, equipped with a floating steel tattletale device, allows maximum and minimum temperatures to be recorded. The tattletale device rests on the menisci of the mercury and moves only in the upward direction. When a meniscus moves in the downward direction it leaves the tattletale at the departure point, thus indicating the maximum or minimum temperature for the measurement period. Using a magnet, the tattletales are reset to rest on the menisci after recording the maximum and minimum temperatures. These thermometers are generally mounted on the bulkhead of the ship or laid on top of the ordnance within the locker.

The thermometer manufacturers (Taylor, Weksler and Moeller) warrant that the temperature readings are accurate to within 2°F at the time of delivery.

DATA HANDLING

The raw data were received from the aircraft carriers in various forms, i.e., temperature logbooks, individual monthly magazine temperature record cards or individual temperature record sheets gathered together in an envelope. These records identified the month, day and year the temperatures were recorded as well as the magazine or compartment of data origin.

These raw data were keypunched, reduced, tabulated and plotted to yield meaningful statistics and significant points of interest for upper and lower deck levels of each aircraft carrier and groups of aircraft carriers. Upper deck level was defined as the second deck and above; the lower deck level was the third deck and below. This division of levels took into account the temperature data from above and below the waterline and their possible effects.
RESULTS AND CONCLUSIONS

In excess of 1.1 million data points were collected during this investigation. These data represent a composite of the 12 years from 1960 through 1972. The types of carriers providing these data can be divided into four classes according to hull design and characteristics: (1) Essex, (2) Midway, (3) Forrestal and (4) Enterprise. The following discussions of the specific carrier classes and the carrier fleet in general bear out that the thermal environment aboard such craft is truly moderate.

Though the data presented herein make it highly obvious, it must be stated that the old design values of -65 and 160°F never were experienced. Temperatures of these magnitudes simply are not in evidence on board an aircraft carrier. This fact was previously recognized in Part 1 of this report series as related to cruisers and guided missile frigates.

MIDWAY CLASS

Since the most contiguous data were received from the U.S.S. Coral (CVA-43), these data are presented first (Figures 2 through 5). It is believed that the following data will reinforce, in a more general format, the results from this single ship.

Figure 2 is the cumulative probability display for all the magazine temperature records from the U.S.S. Coral Sea. Notice that the maximum and minimum temperatures displayed are about 105 and 42°F, respectively. In essence, the temperature spread is about the same as that of free sea water. Even solar radiation loads of the tropical South Pacific and South China Sea do not seem to change this pattern of moderation. The far left cumulative probability curve in Figure 2 is that for all the low temperatures recorded; the right-hand line is for the daily high
temperatures. The center line is the most probable fit between the two lines. This is an attempt to provide a single line as it should look if all 24 hourly temperatures for each day were at hand instead of only the single hottest and coldest hour each day. (Note: Figures not specific to the U.S.S. Coral Sea data present only the center curve.) Since the moderate mid-range data are not available, the two curves (maximum and minimum cumulative probabilities) would tend to be extreme. In the overall terms of ordnance design, however, even this "extreme" data are rather benign compared to other events in the stock-pile-to-target sequence.

Figure 3 is the cumulative probability of occurrence curve for the ammunition magazines located below the main deck. The major ordnance items (and other materiel) are, in fact, stored below the main deck. Usually only pyrotechnics are stored above the main deck.

The above deck magazettes and pyrotechnic lockers display is shown in Figure 4. Keep in mind that during the Vietnam emergency the ordnance use and replenishment rates were such that iron bombs were not taken down to the magazines in the bottom of the aircraft carriers. Rather, these items were stored on the main deck for rapid access. Figure 5 could represent this type bomb storage situation, though in point of fact the bombs were not placed in these lockers. These lockers are, however, somewhat representative of the temperatures that existed in the areas where the bombs were consigned for short durations on Yankee Station.

ENTERPRISE CLASS

The U.S.S. Enterprise (CVAN-65) is a nuclear powered modern generation aircraft carrier. Figures 6 through 14 are the cumulative data for each deck or level on which ordnance is stored. (Keep in mind that the deck numbering system for aircraft carriers is such that a number by itself is indicative of the main deck (1) and below (2, 3, 4, etc.).
A number preceded by a zero is indicative of a deck location above the main deck (01, 02, 03, etc.). The highest zero numbered location is the top of the ship; the largest numbered deck is the bottom of the ship.

Figures 6 through 14 are arranged in sequence so that we start from the top of the ship, work down to the main deck, and on through to the bottom of the ship. Note that the temperature differences between the U.S.S. Coral Sea figures and the U.S.S. Enterprise are minor. In essence, one group tends to reinforce the other even though the size and structure of the two aircraft carriers are quite different.

ESSEX CLASS

Figures 15 and 16 represent the data from the U.S.S. Essex (CVS-9). This carrier was chosen because it is the named representative of the class and the oldest aircraft carrier from the class lot. Also, the bulk of the acquired data came from the CVS-9. Figures 15 and 16 display the reported data from the above deck's magazettes and lockers and the below waterline magazines, respectively. When compared with similar data from either the U.S.S. Enterprise or U.S.S. Coral Sea, these data fall right in line. Also, in the main, these data are truly moderate, even in the extreme.

FORRESTAL CLASS

The U.S.S. Forrestal (CVA-59) was arbitrarily chosen to represent its aircraft carrier class. Only 1 year's worth of data is integrated into the plots provided in Figures 17 and 18; however, a comparison of these figures with Figures 15 and 16 and those from the U.S.S. Coral Sea and U.S.S. Enterprise indicates that this newer class of ship seems to provide the same benign thermal environment for ordnance and materiel as the other three carrier types.
CARRIER FLEET

The following ships provided magazine temperature data:

<table>
<thead>
<tr>
<th>Ship</th>
<th>Hull No.</th>
<th>Data years</th>
</tr>
</thead>
<tbody>
<tr>
<td>U.S.S. Essex</td>
<td>CVS-9</td>
<td>1960-1964</td>
</tr>
<tr>
<td>U.S.S. Yorktown</td>
<td>CVS-10</td>
<td>1966</td>
</tr>
<tr>
<td>U.S.S. Ticonderoga</td>
<td>CVS-14</td>
<td>1966-1969</td>
</tr>
<tr>
<td>U.S.S. Wasp</td>
<td>CVS-18</td>
<td>1966</td>
</tr>
<tr>
<td>U.S.S. Oriskany</td>
<td>CVS-34</td>
<td>1967-1968</td>
</tr>
<tr>
<td>U.S.S. Franklin D. Roosevelt</td>
<td>CVA-42</td>
<td>1969</td>
</tr>
<tr>
<td>U.S. Coral Sea</td>
<td>CVA-43</td>
<td>1960-1970</td>
</tr>
<tr>
<td>U.S.S. Forrestal</td>
<td>CVA-59</td>
<td>1968</td>
</tr>
<tr>
<td>U.S.S. Saratoga</td>
<td>CVA-60</td>
<td>1965-1966</td>
</tr>
<tr>
<td>U.S.S. Kitty Hawk</td>
<td>CVA-63</td>
<td>1969</td>
</tr>
<tr>
<td>U.S.S. Constellation</td>
<td>CVA-64</td>
<td>1969-1970</td>
</tr>
<tr>
<td>U.S.S. America</td>
<td>CVA-66</td>
<td>1965-1967</td>
</tr>
</tbody>
</table>

Figures 19 through 35 indicate the differences in structure and size of these representative U.S. Navy aircraft carriers, both past and present.

An attempt was made to consolidate all the data from all the ships. Since the U.S.S. Coral Sea and U.S.S. Enterprise data were so similar, it was thought that the data from all the ships might conveniently group
to provide a truly universal display of magazine temperature data for any
given level in any carrier operating in any of the U.S. Navy fleets. Note
that at no time during the 12 calendar years of this data accumulation
effort was any aircraft carrier tasked to sail to a given area specifically
for this project. Rather, it can be assumed that sailing orders for any
carrier were typical of that particular fleet's mission during that period. Therefore, it seems logical that a random use population of mission induced magazine temperature information was indeed derived.

Figure 36 provides a total accumulation of all ships composite data. This figure can be used, for all intents and purposes, as the thermal criteria for storage of ordnance munitions and materiel on board aircraft carriers. In fact, since the 03, 02 and 01 levels data are also incorporated in this figure, it can be used for the thermal criteria for all operations on board an aircraft carrier. Keep in mind, however, that this figure is only responsive to thermally quiescent circumstances. Any internally generated heat, such as in avionics or electrical equipment must be added to the value selected from Figure 36.

In Figure 36 the curve shape is very symmetrical. The symmetry is very similar to that of a Gaussian distribution. Because a Gaussian display more easily portrays the "extreme" or end point data, while fully portraying the central portion of the data population, an attempt was made to place Figure 36 in Gaussian format. Figure 37 is a replot of the Figure 36 data on Gaussian paper. The prime use of Figure 37 is that some reader may want to derive a quantification for even more "extreme" data than was measured during this project. Because there is no end point to a Gaussian distribution, the straight line of Figure 37 can be extended out to infinity if desired. By the statistical laws governing the Gaussian distribution, the probability of occurrence for any chosen temperature can be derived from the extension of the plot of Figure 37. However, moderation in all things should be the watchword. Remember that the area under a Gaussian curve between 3σ is 99.7% of the total population.
FIGURE 1. Horseshoe Type Thermometer.
FIGURE 2. U.S.S. Coral Sea (CVA-43), All Levels.
FIGURE 5. U.S.S. Coral Sea (CVA-43), Fantail Lockers.
FIGURE 7. U.S.S. Enterprise (CVAN-65), O2 Level.
FIGURE 8. U.S.S. Enterprise (CVAN-65), 01 Level.
FIGURE 15. U.S.S. Essex (CVS-9), Upper Levels - Consolidated.
FIGURE 16. U.S.S. Essex (CVS-9), Lower Levels - Consolidated.
FIGURE 17. U.S.S. Forrestal (CVA-59), Lower Levels - Consolidated.


FIGURE 27. U.S.S. Franklin D. Roosevelt (CVA-42).


FIGURE 30. U.S.S. Saratoga (CVA-60).

FIGURE 32. U.S.S. Kitty Hawk (CVA-63).
FIGURE 33. U.S.S. Constellation (CVA-64).

FIGURE 34. U.S.S. Enterprise (CVAN-65).
FIGURE 35. U.S.S. America (CVA-66).
FIGURE 36. Composite of All Ships, All Levels.
FIGURE 37. Composite of All Ships, All Levels, Gaussian.
Temperature data from logbooks, monthly cards, and daily sheets are keypunched in formats as shown in Figure A-1 and the flow of data handling is as shown in Figure A-2.

The keypunched temperature data cards are pre-sorted per ship identification, year of the data, and deck level of the compartment or magazine from which the temperature data were taken.

The data cards are prepared as input to Program TTAPE which reads the input and writes the temperature data onto a digital magnetic tape (TTAPE Raw Data) and also prints out a set of tabulations showing the files written on this tape via UNIVAC 1110 computer. Data from each deck level represents a file, and a sample of the tabulation is shown in Figure A-3. All manipulations and reductions of the raw temperature data are done using the tape TTAPE.

Program TTEMP is then prepared with TTAPE as input and via the computer it sorts and counts the minimum and maximum daily temperature data into stalls of temperature data from -20 to 120°F at a 1-degree increment. This program outputs the temperature frequency data on punched cards and tabulations as shown in Figure A-4.

The temperature frequency data cards are then checked for obvious bad data points, if any, and eliminated prior to being prepared as input to Program CTAPE or Program FCON.

When the Program CTAPE option is used, the temperature frequency card data are written on a digital magnetic tape (CTAPE Frequency Data) and a list of files of CTAPE is printed out via the computer showing what
data (i.e., ship hull number, level, year of data, etc.) were written on what file of CTAPE. A sample of this list is shown in Figure A-5.

Program CTAPE option is used when obtaining temperature frequency data which are summed or consolidated over many levels, many ships, and many years, such that manipulation of the tape input is more efficient and flexible in the computer usage than the handling of voluminous card input.

Program CCON is then prepared for the computer run using the magnetic tape CTAPE as input to compute the consolidated temperature frequency data. The computed data are similarly punched out on cards and printed out in tabulations as the Program TTEMP.

The consolidated temperature frequency data cards from Program CCON are then prepared as input to Program TEMPF, which takes this input and computes the cumulative frequency data and the cumulative probability data of the consolidated temperature data for minimum and maximum temperatures separately and for minimum and maximum temperatures combined. The program outputs plotted and tabulated data, as shown in Figure A-6.

Program FCON option is used when the temperature frequency data cards are relatively small in volume and the consolidation of the data is limited. The program then outputs the consolidated temperature frequency data cards and a set of tabulations listing the consolidated temperature frequency data.

The output cards from Program FCON are prepared as input to Program TEMPF to yield cumulative frequency and cumulative probability data of the consolidated temperature data as discussed above.

All plotted data presented in this publication are augmented with tabulated data and are available in the permanent file of the NWC Ordnance Test and Evaluation Division.
SAMPLE INPUT CARD
DATA FIELDS

FIGURE A-1.
<table>
<thead>
<tr>
<th>Degree Range</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>-20 to 0</td>
<td>0</td>
</tr>
<tr>
<td>0 to 10</td>
<td>10</td>
</tr>
<tr>
<td>10 to 20</td>
<td>40</td>
</tr>
<tr>
<td>20 to 30</td>
<td>70</td>
</tr>
<tr>
<td>30 to 40</td>
<td>100</td>
</tr>
</tbody>
</table>

**FIGURE A-6. (Contd.)**
<table>
<thead>
<tr>
<th>Degree</th>
<th>Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>-20</td>
<td>0.0000</td>
</tr>
<tr>
<td>-19</td>
<td>0.0000</td>
</tr>
<tr>
<td>-18</td>
<td>0.0000</td>
</tr>
<tr>
<td>-17</td>
<td>0.0000</td>
</tr>
<tr>
<td>-16</td>
<td>0.0000</td>
</tr>
<tr>
<td>-15</td>
<td>0.0000</td>
</tr>
<tr>
<td>-14</td>
<td>0.0000</td>
</tr>
<tr>
<td>-13</td>
<td>0.0000</td>
</tr>
<tr>
<td>-12</td>
<td>0.0000</td>
</tr>
<tr>
<td>-11</td>
<td>0.0000</td>
</tr>
<tr>
<td>-10</td>
<td>0.0000</td>
</tr>
<tr>
<td>-9</td>
<td>0.0000</td>
</tr>
<tr>
<td>-8</td>
<td>0.0000</td>
</tr>
<tr>
<td>-7</td>
<td>0.0000</td>
</tr>
<tr>
<td>-6</td>
<td>0.0000</td>
</tr>
<tr>
<td>-5</td>
<td>0.0000</td>
</tr>
<tr>
<td>-4</td>
<td>0.0000</td>
</tr>
<tr>
<td>-3</td>
<td>0.0000</td>
</tr>
<tr>
<td>-2</td>
<td>0.0000</td>
</tr>
<tr>
<td>-1</td>
<td>0.0000</td>
</tr>
<tr>
<td>0</td>
<td>0.0000</td>
</tr>
<tr>
<td>1</td>
<td>0.0000</td>
</tr>
<tr>
<td>2</td>
<td>0.0000</td>
</tr>
<tr>
<td>3</td>
<td>0.0000</td>
</tr>
<tr>
<td>4</td>
<td>0.0000</td>
</tr>
<tr>
<td>5</td>
<td>0.0000</td>
</tr>
<tr>
<td>6</td>
<td>0.0000</td>
</tr>
<tr>
<td>7</td>
<td>0.0000</td>
</tr>
<tr>
<td>8</td>
<td>0.0000</td>
</tr>
<tr>
<td>9</td>
<td>0.0000</td>
</tr>
<tr>
<td>10</td>
<td>0.0000</td>
</tr>
<tr>
<td>11</td>
<td>0.0000</td>
</tr>
<tr>
<td>12</td>
<td>0.0000</td>
</tr>
<tr>
<td>13</td>
<td>0.0000</td>
</tr>
<tr>
<td>14</td>
<td>0.0000</td>
</tr>
<tr>
<td>15</td>
<td>0.0000</td>
</tr>
<tr>
<td>16</td>
<td>0.0000</td>
</tr>
<tr>
<td>17</td>
<td>0.0000</td>
</tr>
<tr>
<td>18</td>
<td>0.0000</td>
</tr>
<tr>
<td>19</td>
<td>0.0000</td>
</tr>
<tr>
<td>20</td>
<td>0.0000</td>
</tr>
</tbody>
</table>

FIGURE A-6. (Contd.)
<table>
<thead>
<tr>
<th>TAKE NO.</th>
<th>FILE NO.: 19</th>
<th>PROBABILITY OF TLK SUB 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>0000</td>
<td></td>
<td>0000</td>
</tr>
<tr>
<td>001 D6</td>
<td></td>
<td>0000</td>
</tr>
<tr>
<td>002 D6</td>
<td></td>
<td>0000</td>
</tr>
<tr>
<td>003 D6</td>
<td></td>
<td>0000</td>
</tr>
<tr>
<td>004 D6</td>
<td></td>
<td>0000</td>
</tr>
<tr>
<td>005 D6</td>
<td></td>
<td>0000</td>
</tr>
<tr>
<td>006 D6</td>
<td></td>
<td>0000</td>
</tr>
<tr>
<td>007 D6</td>
<td></td>
<td>0000</td>
</tr>
<tr>
<td>008 D6</td>
<td></td>
<td>0000</td>
</tr>
<tr>
<td>009 D6</td>
<td></td>
<td>0000</td>
</tr>
<tr>
<td>010 D6</td>
<td></td>
<td>0000</td>
</tr>
<tr>
<td>011 D6</td>
<td></td>
<td>0000</td>
</tr>
<tr>
<td>012 D6</td>
<td></td>
<td>0000</td>
</tr>
<tr>
<td>013 D6</td>
<td></td>
<td>0000</td>
</tr>
<tr>
<td>014 D6</td>
<td></td>
<td>0000</td>
</tr>
<tr>
<td>015 D6</td>
<td></td>
<td>0000</td>
</tr>
<tr>
<td>016 D6</td>
<td></td>
<td>0000</td>
</tr>
<tr>
<td>017 D6</td>
<td></td>
<td>0000</td>
</tr>
<tr>
<td>018 D6</td>
<td></td>
<td>0000</td>
</tr>
<tr>
<td>019 D6</td>
<td></td>
<td>0000</td>
</tr>
<tr>
<td>020 D6</td>
<td></td>
<td>0000</td>
</tr>
<tr>
<td>021 D6</td>
<td></td>
<td>0000</td>
</tr>
<tr>
<td>022 D6</td>
<td></td>
<td>0000</td>
</tr>
<tr>
<td>023 D6</td>
<td></td>
<td>0000</td>
</tr>
<tr>
<td>024 D6</td>
<td></td>
<td>0000</td>
</tr>
<tr>
<td>025 D6</td>
<td></td>
<td>0000</td>
</tr>
<tr>
<td>026 D6</td>
<td></td>
<td>0000</td>
</tr>
<tr>
<td>027 D6</td>
<td></td>
<td>0000</td>
</tr>
<tr>
<td>028 D6</td>
<td></td>
<td>0000</td>
</tr>
<tr>
<td>029 D6</td>
<td></td>
<td>0000</td>
</tr>
<tr>
<td>030 D6</td>
<td></td>
<td>0000</td>
</tr>
<tr>
<td>031 D6</td>
<td></td>
<td>0000</td>
</tr>
<tr>
<td>032 D6</td>
<td></td>
<td>0000</td>
</tr>
<tr>
<td>033 D6</td>
<td></td>
<td>0000</td>
</tr>
<tr>
<td>034 D6</td>
<td></td>
<td>0000</td>
</tr>
<tr>
<td>035 D6</td>
<td></td>
<td>0000</td>
</tr>
<tr>
<td>036 D6</td>
<td></td>
<td>0000</td>
</tr>
<tr>
<td>037 D6</td>
<td></td>
<td>0000</td>
</tr>
<tr>
<td>038 D6</td>
<td></td>
<td>0000</td>
</tr>
<tr>
<td>039 D6</td>
<td></td>
<td>0000</td>
</tr>
<tr>
<td>040 D6</td>
<td></td>
<td>0000</td>
</tr>
<tr>
<td>041 D6</td>
<td></td>
<td>0000</td>
</tr>
<tr>
<td>042 D6</td>
<td></td>
<td>0000</td>
</tr>
<tr>
<td>043 D6</td>
<td></td>
<td>0000</td>
</tr>
<tr>
<td>044 D6</td>
<td></td>
<td>0000</td>
</tr>
<tr>
<td>045 D6</td>
<td></td>
<td>0000</td>
</tr>
<tr>
<td>046 D6</td>
<td></td>
<td>0000</td>
</tr>
<tr>
<td>047 D6</td>
<td></td>
<td>0000</td>
</tr>
<tr>
<td>048 D6</td>
<td></td>
<td>0000</td>
</tr>
<tr>
<td>049 D6</td>
<td></td>
<td>0000</td>
</tr>
<tr>
<td>050 D6</td>
<td></td>
<td>0000</td>
</tr>
<tr>
<td>051 D6</td>
<td></td>
<td>0000</td>
</tr>
<tr>
<td>052 D6</td>
<td></td>
<td>0000</td>
</tr>
<tr>
<td>053 D6</td>
<td></td>
<td>0000</td>
</tr>
<tr>
<td>054 D6</td>
<td></td>
<td>0000</td>
</tr>
<tr>
<td>055 D6</td>
<td></td>
<td>0000</td>
</tr>
<tr>
<td>056 D6</td>
<td></td>
<td>0000</td>
</tr>
<tr>
<td>057 D6</td>
<td></td>
<td>0000</td>
</tr>
<tr>
<td>058 D6</td>
<td></td>
<td>0000</td>
</tr>
<tr>
<td>059 D6</td>
<td></td>
<td>0000</td>
</tr>
<tr>
<td>060 D6</td>
<td></td>
<td>0000</td>
</tr>
<tr>
<td>061 D6</td>
<td></td>
<td>0000</td>
</tr>
<tr>
<td>062 D6</td>
<td></td>
<td>0000</td>
</tr>
<tr>
<td>063 D6</td>
<td></td>
<td>0000</td>
</tr>
<tr>
<td>064 D6</td>
<td></td>
<td>0000</td>
</tr>
<tr>
<td>065 D6</td>
<td></td>
<td>0000</td>
</tr>
<tr>
<td>066 D6</td>
<td></td>
<td>0000</td>
</tr>
<tr>
<td>067 D6</td>
<td></td>
<td>0000</td>
</tr>
<tr>
<td>068 D6</td>
<td></td>
<td>0000</td>
</tr>
<tr>
<td>069 D6</td>
<td></td>
<td>0000</td>
</tr>
<tr>
<td>070 D6</td>
<td></td>
<td>0000</td>
</tr>
<tr>
<td>071 D6</td>
<td></td>
<td>0000</td>
</tr>
<tr>
<td>072 D6</td>
<td></td>
<td>0000</td>
</tr>
<tr>
<td>073 D6</td>
<td></td>
<td>0000</td>
</tr>
<tr>
<td>074 D6</td>
<td></td>
<td>0000</td>
</tr>
<tr>
<td>075 D6</td>
<td></td>
<td>0000</td>
</tr>
<tr>
<td>076 D6</td>
<td></td>
<td>0000</td>
</tr>
<tr>
<td>077 D6</td>
<td></td>
<td>0000</td>
</tr>
<tr>
<td>078 D6</td>
<td></td>
<td>0000</td>
</tr>
<tr>
<td>079 D6</td>
<td></td>
<td>0000</td>
</tr>
<tr>
<td>080 D6</td>
<td></td>
<td>0000</td>
</tr>
<tr>
<td>081 D6</td>
<td></td>
<td>0000</td>
</tr>
<tr>
<td>082 D6</td>
<td></td>
<td>0000</td>
</tr>
<tr>
<td>083 D6</td>
<td></td>
<td>0000</td>
</tr>
<tr>
<td>084 D6</td>
<td></td>
<td>0000</td>
</tr>
<tr>
<td>085 D6</td>
<td></td>
<td>0000</td>
</tr>
<tr>
<td>086 D6</td>
<td></td>
<td>0000</td>
</tr>
<tr>
<td>087 D6</td>
<td></td>
<td>0000</td>
</tr>
<tr>
<td>088 D6</td>
<td></td>
<td>0000</td>
</tr>
<tr>
<td>089 D6</td>
<td></td>
<td>0000</td>
</tr>
<tr>
<td>090 D6</td>
<td></td>
<td>0000</td>
</tr>
<tr>
<td>091 D6</td>
<td></td>
<td>0000</td>
</tr>
<tr>
<td>092 D6</td>
<td></td>
<td>0000</td>
</tr>
<tr>
<td>093 D6</td>
<td></td>
<td>0000</td>
</tr>
<tr>
<td>094 D6</td>
<td></td>
<td>0000</td>
</tr>
<tr>
<td>095 D6</td>
<td></td>
<td>0000</td>
</tr>
<tr>
<td>096 D6</td>
<td></td>
<td>0000</td>
</tr>
<tr>
<td>097 D6</td>
<td></td>
<td>0000</td>
</tr>
<tr>
<td>098 D6</td>
<td></td>
<td>0000</td>
</tr>
<tr>
<td>099 D6</td>
<td></td>
<td>0000</td>
</tr>
<tr>
<td>100 D6</td>
<td></td>
<td>0000</td>
</tr>
<tr>
<td>101 D6</td>
<td></td>
<td>0000</td>
</tr>
<tr>
<td>102 D6</td>
<td></td>
<td>0000</td>
</tr>
<tr>
<td>103 D6</td>
<td></td>
<td>0000</td>
</tr>
<tr>
<td>104 D6</td>
<td></td>
<td>0000</td>
</tr>
<tr>
<td>105 D6</td>
<td></td>
<td>0000</td>
</tr>
<tr>
<td>106 D6</td>
<td></td>
<td>0000</td>
</tr>
<tr>
<td>107 D6</td>
<td></td>
<td>0000</td>
</tr>
<tr>
<td>108 D6</td>
<td></td>
<td>0000</td>
</tr>
<tr>
<td>109 D6</td>
<td></td>
<td>0000</td>
</tr>
<tr>
<td>110 D6</td>
<td></td>
<td>0000</td>
</tr>
<tr>
<td>111 D6</td>
<td></td>
<td>0000</td>
</tr>
<tr>
<td>112 D6</td>
<td></td>
<td>0000</td>
</tr>
<tr>
<td>113 D6</td>
<td></td>
<td>0000</td>
</tr>
<tr>
<td>114 D6</td>
<td></td>
<td>0000</td>
</tr>
<tr>
<td>115 D6</td>
<td></td>
<td>0000</td>
</tr>
<tr>
<td>116 D6</td>
<td></td>
<td>0000</td>
</tr>
<tr>
<td>117 D6</td>
<td></td>
<td>0000</td>
</tr>
<tr>
<td>118 D6</td>
<td></td>
<td>0000</td>
</tr>
<tr>
<td>119 D6</td>
<td></td>
<td>0000</td>
</tr>
<tr>
<td>120 D6</td>
<td></td>
<td>0000</td>
</tr>
</tbody>
</table>

FIGURE A-6. (Concl.)
<table>
<thead>
<tr>
<th>DEG</th>
<th>PROB</th>
</tr>
</thead>
<tbody>
<tr>
<td>-20</td>
<td>0.000</td>
</tr>
<tr>
<td>-19</td>
<td>0.000</td>
</tr>
<tr>
<td>-18</td>
<td>0.000</td>
</tr>
<tr>
<td>-17</td>
<td>0.000</td>
</tr>
<tr>
<td>-16</td>
<td>0.000</td>
</tr>
<tr>
<td>-15</td>
<td>0.000</td>
</tr>
<tr>
<td>-14</td>
<td>0.000</td>
</tr>
<tr>
<td>-13</td>
<td>0.000</td>
</tr>
<tr>
<td>-12</td>
<td>0.000</td>
</tr>
<tr>
<td>-11</td>
<td>0.000</td>
</tr>
<tr>
<td>-10</td>
<td>0.000</td>
</tr>
<tr>
<td>-9</td>
<td>0.000</td>
</tr>
<tr>
<td>-8</td>
<td>0.000</td>
</tr>
<tr>
<td>-7</td>
<td>0.000</td>
</tr>
<tr>
<td>-6</td>
<td>0.000</td>
</tr>
<tr>
<td>-5</td>
<td>0.000</td>
</tr>
<tr>
<td>-4</td>
<td>0.000</td>
</tr>
<tr>
<td>-3</td>
<td>0.000</td>
</tr>
<tr>
<td>-2</td>
<td>0.000</td>
</tr>
<tr>
<td>-1</td>
<td>0.000</td>
</tr>
<tr>
<td>0</td>
<td>0.000</td>
</tr>
<tr>
<td>1</td>
<td>0.000</td>
</tr>
<tr>
<td>2</td>
<td>0.000</td>
</tr>
<tr>
<td>3</td>
<td>0.000</td>
</tr>
<tr>
<td>4</td>
<td>0.000</td>
</tr>
<tr>
<td>5</td>
<td>0.000</td>
</tr>
<tr>
<td>6</td>
<td>0.000</td>
</tr>
<tr>
<td>7</td>
<td>0.000</td>
</tr>
<tr>
<td>8</td>
<td>0.000</td>
</tr>
<tr>
<td>9</td>
<td>0.000</td>
</tr>
</tbody>
</table>

FIGURE A-6. (Contd.)
### Figure A-6 (Contd.)

#### Cumulative Probability Up to (Vmin and Vmax) Sub 1

<table>
<thead>
<tr>
<th>Degree</th>
<th>Cumulative Probability</th>
<th>Degree</th>
<th>Cumulative Probability</th>
<th>Degree</th>
<th>Cumulative Probability</th>
<th>Degree</th>
<th>Cumulative Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>-20</td>
<td>0.0000</td>
<td>10</td>
<td>0.0000</td>
<td>70</td>
<td>0.1208</td>
<td>100</td>
<td>0.9917</td>
</tr>
<tr>
<td>-19</td>
<td>0.0000</td>
<td>11</td>
<td>0.0000</td>
<td>71</td>
<td>0.1208</td>
<td>101</td>
<td>0.9917</td>
</tr>
<tr>
<td>-18</td>
<td>0.0000</td>
<td>12</td>
<td>0.0000</td>
<td>72</td>
<td>0.1708</td>
<td>102</td>
<td>0.9958</td>
</tr>
<tr>
<td>-17</td>
<td>0.0000</td>
<td>13</td>
<td>0.0000</td>
<td>73</td>
<td>0.1750</td>
<td>103</td>
<td>0.9958</td>
</tr>
<tr>
<td>-16</td>
<td>0.0000</td>
<td>14</td>
<td>0.0000</td>
<td>74</td>
<td>0.2167</td>
<td>104</td>
<td>0.9958</td>
</tr>
<tr>
<td>-15</td>
<td>0.0000</td>
<td>15</td>
<td>0.0000</td>
<td>75</td>
<td>0.2292</td>
<td>105</td>
<td>1.0000</td>
</tr>
<tr>
<td>-14</td>
<td>0.0000</td>
<td>16</td>
<td>0.0000</td>
<td>76</td>
<td>0.2750</td>
<td>106</td>
<td>1.0000</td>
</tr>
<tr>
<td>-13</td>
<td>0.0000</td>
<td>17</td>
<td>0.0000</td>
<td>77</td>
<td>0.2875</td>
<td>107</td>
<td>1.0000</td>
</tr>
<tr>
<td>-12</td>
<td>0.0000</td>
<td>18</td>
<td>0.0030</td>
<td>78</td>
<td>0.3542</td>
<td>108</td>
<td>1.0000</td>
</tr>
<tr>
<td>-11</td>
<td>0.0000</td>
<td>19</td>
<td>0.0000</td>
<td>79</td>
<td>0.4042</td>
<td>109</td>
<td>1.0000</td>
</tr>
<tr>
<td>-10</td>
<td>0.0000</td>
<td>20</td>
<td>0.0000</td>
<td>80</td>
<td>0.5167</td>
<td>110</td>
<td>1.0000</td>
</tr>
<tr>
<td>-9</td>
<td>0.0000</td>
<td>21</td>
<td>0.0000</td>
<td>81</td>
<td>0.5417</td>
<td>111</td>
<td>1.0000</td>
</tr>
<tr>
<td>-8</td>
<td>0.0000</td>
<td>22</td>
<td>0.0000</td>
<td>82</td>
<td>0.6375</td>
<td>112</td>
<td>1.0000</td>
</tr>
<tr>
<td>-7</td>
<td>0.0000</td>
<td>23</td>
<td>0.0000</td>
<td>83</td>
<td>0.6917</td>
<td>113</td>
<td>1.0000</td>
</tr>
<tr>
<td>-6</td>
<td>0.0000</td>
<td>24</td>
<td>0.0000</td>
<td>84</td>
<td>0.7375</td>
<td>114</td>
<td>1.0000</td>
</tr>
<tr>
<td>-5</td>
<td>0.0000</td>
<td>25</td>
<td>0.0000</td>
<td>85</td>
<td>0.8575</td>
<td>115</td>
<td>1.0000</td>
</tr>
<tr>
<td>-4</td>
<td>0.0000</td>
<td>26</td>
<td>0.0000</td>
<td>86</td>
<td>0.8708</td>
<td>116</td>
<td>1.0000</td>
</tr>
<tr>
<td>-3</td>
<td>0.0000</td>
<td>27</td>
<td>0.0000</td>
<td>87</td>
<td>0.8958</td>
<td>117</td>
<td>1.0000</td>
</tr>
<tr>
<td>-2</td>
<td>0.0000</td>
<td>28</td>
<td>0.0000</td>
<td>88</td>
<td>0.9125</td>
<td>118</td>
<td>1.0000</td>
</tr>
<tr>
<td>-1</td>
<td>0.0000</td>
<td>29</td>
<td>0.0000</td>
<td>89</td>
<td>0.9208</td>
<td>119</td>
<td>1.0000</td>
</tr>
<tr>
<td>0</td>
<td>0.0042</td>
<td>30</td>
<td>0.0000</td>
<td>90</td>
<td>0.9542</td>
<td>120</td>
<td>1.0000</td>
</tr>
<tr>
<td>1</td>
<td>0.0042</td>
<td>31</td>
<td>0.0000</td>
<td>91</td>
<td>0.9542</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>0.0042</td>
<td>32</td>
<td>0.0000</td>
<td>92</td>
<td>0.9607</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>0.0042</td>
<td>33</td>
<td>0.0000</td>
<td>93</td>
<td>0.9708</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>0.0042</td>
<td>34</td>
<td>0.0000</td>
<td>94</td>
<td>0.9708</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>0.0042</td>
<td>35</td>
<td>0.0000</td>
<td>95</td>
<td>0.9875</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>0.0125</td>
<td>36</td>
<td>0.0000</td>
<td>96</td>
<td>0.9917</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>0.0125</td>
<td>37</td>
<td>0.0000</td>
<td>97</td>
<td>0.9917</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>0.0458</td>
<td>38</td>
<td>0.0000</td>
<td>98</td>
<td>0.9917</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>0.0458</td>
<td>39</td>
<td>0.0000</td>
<td>99</td>
<td>0.9917</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Appendix B
DEFINITIONS OF DATA

Data presented in Figure A-3 are defined in the following:

TAPE NO. is the tape number identifying the tape that temperature data are written on.

FILE NO. is the file number of the tape that the data are written on.

IDENTIFICATION gives the deck level of the ship from which the data were obtained, the year of the data, the hull number of the ship, and the date the data were written on this tape.

MIN column gives the daily minimum temperature data.

MAX column gives the daily maximum temperature data.

TMIN TOTAL DATA PTS gives the total number of daily minimum temperature data available on this file.

TMAX TOTAL DATA PTS gives the total number of daily maximum temperature data available on this file.

NO. OF BAD PTS gives the number of daily minimum or maximum temperature data that were lower than -20°F or greater than 120°F.

NO. OF DATA PTS USED gives the number of daily minimum or maximum temperature data that were used in the compilation of the frequency data.

FREQUENCY OF TMIN SUB I gives the frequencies of the daily minimum temperature data from -20 to 120°F at 1-degree intervals and denoted $N_{\text{min}_1}$.
FREQUENCY OF TMAX SUB I gives the frequencies of the daily maximum temperature data from -20 to 120°F at 1-degree intervals and denoted \( N_{t_{\text{max}}^i} \).

FREQUENCY OF (TMAX AND TMIN) SUB I gives the frequencies of the daily minimum and maximum, combined, temperature data from -20 to 120°F at 1-degree intervals and denoted \( N_{(t_{\text{min}}^i \text{ and } t_{\text{max}}^i)} \).

Data presented in Figure A-6 are defined in the following:

CUMULATIVE FREQUENCY UP TO TMIN SUB I gives the cumulative frequencies of the daily minimum temperature from -20°F up to minimum temperature of interest and denoted \( N_{t_{\text{min}}^i} \).

\[
N_{t_{\text{min}}^i} = \sum_{j} N_{t_{\text{min}}^i}, \text{ where } N_{t_{\text{min}}^i} \text{ is the frequency of -20°F temperature and } N_{t_{\text{min}}^i} \text{ is the frequency of temperature of interest.}
\]

CUMULATIVE FREQUENCY UP TO TMAX SUB I denoted \( N_{t_{\text{max}}^i} \) is defined as follows:

\[
N_{t_{\text{max}}^i} = \sum_{j} N_{(t_{\text{min}}^i \text{ and } t_{\text{max}}^i)}
\]

PROBABILITY OF TMIN SUB I denoted \( P(t_{\text{max}}^i) \) defined as follows:

\[
P(t_{\text{min}}^i) = \frac{N_{t_{\text{min}}^i}}{N_{t_{\text{min}}^\text{total}}}, \text{ where } N_{t_{\text{min}}^\text{total}} \text{ is the total number of daily minimum temperature data used.}
\]

60
PROBABILITY OF TMAX SUB I denoted \( P(t_{\text{max}}) \) is defined as follows:

\[
P(t_{\text{max}}) = \frac{N_{t_{\text{max}}}}{N_{t_{\text{max}} \text{total}}}
\]

PROBABILITY OF (TMIN AND TMAX) SUB I denoted \( P(t_{\text{min}} \text{ and } t_{\text{max}}) \) is defined as follows:

\[
P(t_{\text{min}} \text{ and } t_{\text{max}}) = \frac{N(t_{\text{min}} \text{ and } t_{\text{max}})}{N_{t_{\text{min}} \text{ total}} + N_{t_{\text{max}} \text{ total}}}
\]

CUMULATIVE PROBABILITY UP TO TMIN SUB I denoted \( P_c(t_{\text{min}}) \) gives the cumulative probabilities of the daily minimum temperature from \(-20^\circ\) up to minimum temperature of interest. It is defined as follows:

\[
P_c(t_{\text{min}}) = \sum_{j} \frac{N_{t_{\text{min}}}}{N_{t_{\text{min}} \text{ total}}}
\]

CUMULATIVE PROBABILITY UP TO TMAX SUB I denoted \( P_c(t_{\text{max}}) \) is defined as follows:

\[
P_c(t_{\text{max}}) = \sum_{j} \frac{N_{t_{\text{max}}}}{N_{t_{\text{max}} \text{ total}}}
\]

CUMULATIVE PROBABILITY UP TO (TMIN AND TMAX) SUB I denoted \( P_c(t_{\text{min}} \text{ and } t_{\text{max}}) \) is defined as follows:

\[
P_c(t_{\text{min}} \text{ and } t_{\text{max}}) = \sum_{j} \frac{N(t_{\text{min}} \text{ and } t_{\text{max}})}{N_{t_{\text{min}} \text{ total}} + N_{t_{\text{max}} \text{ total}}}
\]
Appendix C

EXPLANATION OF DECK LEVEL AND COMPARTMENT IDENTIFICATIONS

The various decks of a ship are numbered, using the main deck as a baseline. On all ships except aircraft carriers, the main deck is the upper most deck that runs the length of the ship; on aircraft carriers the hangar deck is the baseline. Below the main deck are the second deck, third deck, etc. Above the main deck are the 01 (pronounced oh one) level, 02 level, etc.

Two systems of compartment numbering are presently in use, but only the newer system (begun in March 1949) is described here. Compartments are designated by a grouping of various letters and numbers, separated by hyphens. Each compartment is designated by its deck number, frame number (starting at zero at the bow and increasing towards aft), relation to ship's centerline, and usage. An example of this numbering system is 3-75-4-M. The 3 indicates the third deck; the 75 indicates that the forward boundary of the compartment is at frame 75; the 4 indicates that it is on the port of the ship (an odd number would indicate starboard side); and the M indicates that the compartment is used as a magazine. Other compartment designations are A for storage spaces, C for control spaces (areas normally manned, such as CIC communications spaces, and the pilot house), E for engineering spaces, F for fuel storage, Q for miscellaneous spaces (shops, offices, laundry, and galley), T for vertical access trunks, and L for living (berthing) spaces.

---

3 General Guide for Shipboard Visitors, Naval Weapons Center, China Lake, Calif.
INITIAL DISTRIBUTION

83 Naval Air Systems Command
AIR-00X (1) AIR-360 (1) AIR-5202 (1) AIR-53661B (1)
AIR-00XC (1) AIR-370C (1) AIR-5205 (2) AIR-53662 (1)
AIR-03 (1) AIR-410 (1) AIR-5205A (1) AIR-53662A (1)
AIR-03E (1) AIR-510 (1) AIR-5.05B (1) AIR-53662B (1)
AIR-03P1 (1) AIR-510B (1) AIR-532 (1) AIR-53663 (1)
AIR-03P2 (1) AIR-5102 (1) AIR-5321 (1) AIR-954 (2)
AIR-03P22 (1) AIR-5102A (1) AIR-5322 (1) PMA-241A (1)
AIR-03P23 (1) AIR-5105 (1) AIR-5323 (1) PMA-242 (1)
AIR-03P24 (1) AIR-5105A (1) AIR-5323A (2) PMA-242-1 (1)
AIR-04 (1) AIR-5105B (1) AIR-5323C (1) PMA-242-2 (1)
AIR-04A (1) AIR-5105C (1) AIR-5324 (1) PMA-259 (1)
AIR-05 (1) AIR-5105F (1) AIR-533 (1) PMA-259B (1)
AIR-05B (1) AIR-5105G (1) AIR-536 (1) PMA-262 (1)
AIR-09E1A (1) AIR-5105G1 (1) AIR-53603 (1) PMA-262-2 (1)
AIR-09E3 (1) AIR-5106 (1) AIR-53613 (1) PMA-264 (1)
AIR-330 (3) AIR-520 (1) AIR-5364 (1) PMA-264 (1)
AIR-330D (3) AIR-520A (1) AIR-53661 (3) PMA-266 (1)
AIR-340 (1) AIR-5201 (3) AIR-53661A (1) PMA-266 (1)
AIR-350 (1)

6 Chief of Naval Operations
OP-009D2 (1)
OP-009V (1)
OP-098 (1)
OP-0982E21 (1)
OP-0982E4 (1)
OP-506F (1)

10 Chief of Naval Material
MAT-00 (1)
MAT-04 (1)
MAT-0423 (1)
MAT-08 (1)
MAT-08E (2)
NSP-26 (1)
NSP-43 (2)
JCM-00 (1)

15 Naval Electronics Systems Command
NELEX-00B (1) NELEX-4702 (1)
NELEX-00M (1) NELEX-510A (1)
NELEX-03 (1) NELEX-52041 (1)
NELEX-05 (1) NELEX-5402 (1)
NELEX-05E (1) NELEX-9053 (1)
NELEX-30412 (1) PME-117-242 (1)
NELEX-350 (1) PME-121 (1)
NELEX-470 (1)

3 Naval Facilities Engineering Command
NFAC-03 (1)
NFAC-09M22C (2)

63
42 Naval Sea Systems Command

SEA-00 (1)   SEA-04K (1)   SEA-94 (2)   SEA-992E (1)
SEA-011 (1)  SEA-06G2 (1)  SEA-942 (2)  SEA-992L (1)
SEA-0151 (1) SEA-06G3, Mustin (1) SEA-98 (1)  SEA-9921B (1)
SEA-03 (1)   SEA-06M (1)   SEA-981 (1)  SEA-993 (1)
SEA-033 (1)  SEA-0633 (1)  SEA-982 (1)  SEA-9931G (1)
SEA-0331 (1) SEA-08 (1)    SEA-99 (1)   PMS-266 (1)
SEA-0351 (1) SEA-09G32 (2) SEA-9911 (1) PMS-392 (1)
SEA-04E (1)  SEA-661D-22 (1) SEA-9911D (1) PMS-39232 (1)
SEA-04H (1)  SEA-93H (1)   SEA-992 (1)  PMA-392AD11 (1)
SEA-04H3 (3)

4 Chief of Naval Research

ONR-100 (1)
ONR-200 (1)
Technical Library (1)

1 Assistant Secretary of the Navy (Research and Development)

2 Fleet Analyses Center, Naval Weapons Station, Seal Beach

GIDEP Office, Code 862 (1)
Technical Library (1)

5 Naval Air Engineering Center, Lakehurst

Code 93 (1)
D. Broude (1)
G. Walker (1)
Technical Library (2)

3 Naval Air Test Center (CT-176), Patuxent River

Service Test Divisions, D. Preston (1)
Technical Library (2)

2 Naval Avionics Center, Indianapolis

R. D. Stone (1)
Technical Library (1)

7 Naval Ocean Systems Center, San Diego

Code 133 (1)
Code 603 (1)

26 Naval Ordnance Station, Indian Head

Code EST, A. T. Camp (1)
Code FSC (1)
Code FS11C (1)
Code FS12A1 (1)
Code FS12A2 (1)
Code FS12A6 (1)
Code FS12B (1)
Code FS12D (1)
Code FS13, G. A. Bornstein (1)
Code FS13A (1)
Code FS13C (1)
Code FS14 (1)
Code FS15A (1)

1 Naval Postgraduate School, Monterey (Technical Library)
2 Naval Research Laboratory
   R. Volin (1)
   Technical Library (1)
4 Naval Ship Engineering Center, Hyattsville
   Code 6100 (1)
   Code 6105B (1)
   Code 6181B (1)  
   Technical Library (1)
1 Naval Ship Missile Systems Engineering Station, Port Hueneme
13 Naval Surface Weapons Center, Dahlgren Laboratory, Dahlgren
   Code D (1)
   Code T (1)  
   Code TEE (1)  
   Code TI, Jim Hurtt (2)  
   Code WXA, G. W. Allison (1)
   Code WXO (1)  
   Code WXR (1)
   Code WXS (1)
   Code WXT (1)
   Code WXV (1)
   Jim Horten (1)  
   Technical Library (1)
9 Naval Surface Weapons Center, White Oak
   Code 702
   C. V. Vickers (1)
   V. Yarow (1)
   Code KM (1)
   Code LX-1, Doyle (1)
   Code NO, French (1)
   Code WE (2)
   Code XWF, Parker (1)  
   Technical Library (1)
1 Naval Underwater Systems Center, Newport
2 Naval Weapons Evaluation Facility, Kirtland Air Force Base
   APM-4, G. V. Binns (1)
   AT-2, J. L. Abbott (1)
4 Naval Weapons Handling Center, Colts Neck
   Code NWHI, C. P. Troutman (1)
   Code 805, R. E. Seely (1)  
   Technical Library (2)
2 Naval Weapons Quality Assurance Office
   Director (1)
   Technical Library (1)
1 Naval Weapons Station, Concord (Technical Library)
5 Naval Weapons Station, Seal Beach
   Environmental Test Branch (1)
   QE Department (1)
   Code QESX (1)
   Code QESX-3 (1)
   T. B. Linton (1)
2 Naval Weapons Station, Yorktown
   Code 3032, Smith (1)  
   Technical Library (1)
7 Naval Weapons Support Center, Crane
   NAPEC, J. R. Stokinger (1)
   Code RD (1)
   Code QETE (1)
   Code 30331, Lawson (1)
   R. F. Karcher (2)
   Technical Library (1)

8 Pacific Missile Test Center, Point Mugu
   Code N314, C. V. Ryden (1)
   Code N3153, R. W. Villers (1)
   Code 5711, Sparrow Office (1)
   Code 5718, F. J. Brennan (1)
   Code 5719
   T. Elliott (1)
   L. Matthews (1)
   E. P. Olsen (1)
   Technical Library (1)

2 Office Chief of Research and Development
   Dr. Leo Alpert (1)
   Technical Library (1)

1 Army Training and Doctrine Command (ATCD-T)

4 Aberdeen Proving Ground
   AMSTE-TA
   Goddard (1)
   Peterson (1)
   STEAP-MT-M, J. A. Feroli (1)
   Technical Library (1)

1 Army Armament Research and Development Center, Dover (Technical Library)

1 Army Chemical Research and Development Laboratories, Edgewood Arsenal (Technical Library)

1 Army Chemical Warfare Laboratories, Edgewood Arsenal (Technical Library)

4 Army Engineer Topographic Laboratories, Fort Belvoir
   ETL-GS-EA (1)
   ETL-GS-EC, H. McPhilimy (2)
   Technical Library (1)

1 240 ATC CO (2nd PLT., SP/4, K. R. S. Polley)

4 Harry Diamond Laboratories
   Technical Director (1)
   R. Hoff (1)
   R. Smith (1)
   Technical Library (1)

3 Headquarters, U.S. Air Force
   AF/RDC (1)
   AF/RDPS, Allen Eaffy (1)
   AF/RST (1)

1 Air Force Systems Command, Andrews Air Force Base (Technical Library)

1 Strategic Air Command, Offutt Air Force Base (Technical Library)

1 Tactical Air Command, Langely Air Force Base (Technical Library)

2 Ogden Air Materiel Area, Hill Air Force Base
   Munitions Safety (1)
   Technical Library (1)
1 Sacramento Air Materiel Area, McClellan Air Force Base (Technical Library)
1 Warner Robins Air Materiel Area, Robins Air Force Base (Technical Library)
1 Air Force Avionics Laboratory, Wright-Patterson Air Force Base
2 Air Force Cambridge Research Laboratories, Laurence G. Hanscom Field
   Code LKI, P. Tattleman (1)
   Technical Library (1)
3 Air Force Environmental Technical Applications Center
   Technical Director (1)
   O. E. Richards (1)
   Technical Library (1)
4 Air Force Office of Scientific Research (Dr. J. F. Masi)
1 Air Force Rocket Propulsion Laboratory, Edwards Air Force Base (Technical Director)
4 Air Force Rocket Propulsion Laboratory, Edwards Air Force Base (Dr. Trout)
1 Air Force Rocket Propulsion Laboratory, Edwards Air Force Base (RKMA, L. Meyer)
1 Air Force Rocket Propulsion Laboratory, Edwards Air Force Base (Technical Library)
11 Armament Development and Test Center, Eglin Air Force Base
   AFATL (1)
   DL (1)
   SD (1)
   SD102 (1)
   SD15 (1)
   SD2 (1)
   SD3 (1)
   SD7 (1)
   SD9 (1)
   SDM (1)
   Technical Library (1)
1 Nellis Air Force Base (Technical Library)
2 Rome Air Development Center, Griffiss Air Force Base
   Code RCRM (1)
   Technical Library (1)
4 Wright-Patterson Air Force Base
   Director of Flight Dynamics Laboratory (1)
   Head, Research and Technology Division (1)
   FEE (1)
   Technical Library (1)
7 Assistant Secretary of Defense
   DMSSO
   Allen (1)
   Moses (1)
   J. A. Mittino (1)
   F. W. Myers (1)
   Explosives Safety Board (3)
10 Director of Defense Research and Engineering
   AD(ET), G. R. Makepeace (1)
   OAD(ET), R. Thorkildsen (1)
   OAD(T), Col. B. Swett (2)
   DD(T&E) (1)
   AMRAD Committee (2)
   Capt. J. Bres, USN (1)
   Col. H. Strickland, USA (1)
   Col. M. Weber, USAF (1)
5 Defense Advanced Research Project Agency, Arlington
   Technical Director (1) Technical Library (1)
   Strategic Tech (1)
   Tactical Tech (1)
   Tech Assessments (1)
3 Deputy Director for Operations
   Chairmans Staff Group (1)
   Director J-3 (1)
   Standards Branch (1)
12 Defense Documentation Center
3 Library of Congress
   1 Aerojet-General Corporation, Azusa, CA (Technical Library)
   3 Aerojet Liquid Rocket Co., Sacramento, CA (via AFPRO)
      Bert Loehr (1)
      Technical Library (2)
1 Allegany Ballistics Laboratory, Cumberland, MD (Technical Library)
2 Applied Physics Laboratory, Johns Hopkins University, Laurel, MD
   Dr. D. W. Avery (1)
   Technical Library (1)
1 ARINC Research Corporation, Santa Ana, CA
2 Bell Aerospace Textron, Ft. Worth, TX
   Technical Library (1)
   D. L. Kidd (1)
1 Booze Allen, Bethesda, MD
2 Chemical Propulsion Information Agency, Applied Physics Laboratory, Laurel, MD
   Sid Solomon (1)
   Technical Library (1)
1 Cushing Neveil Incorporated of California, Los Angeles, CA
2 Dayton T. Brown, Inc., Bohemia, LI, NY
   Technical Library (1)
   F. Gerber (1)
2 Ford Aerospace and Communications Corporation, Newport Beach, CA
   R. Elston (1)
   Technical Library (1)
2 General Dynamics, Pomona Division, Pomona, CA
   6-42, H. B. Godwin (1)
   Technical Library (1)
1 Governors State University, Park Forest, IL (Dr. T. Andrews)
1 Hercules, Inc., Bacchus Works, Magna, UT
2 Hughes Aircraft Company, Canoga Park, CA
   C. Clapp (1)
   Technical Library (1)
1 Institute for Defense Analyses, Arlington, VA (Technical Library)
2 Institute of Environmental Sciences, Mt. Prospect, IL
2 Lockheed Aircraft Corporation, Marietta, GA
   E. H. Parker (1)
   Technical Library (1)
1 Lockheed-California Company, Burbank, CA
1 McDonnell Astronautics Company, Florida Division, Titusville, FL
1 McDonnell Douglas Astronautics, Huntington Beach, CA
2 McDonnell Douglas Corporation, Long Beach, CA
   Pabat (1)
   Technical Library (1)
1 McDonnell Douglas Corporation, Santa Monica, CA
12 McDonnell Douglas Corporation, St. Louis, MO
   Aircraft Division, Technical Library (1)
   Harpoon Project Office (1)
   Missile Division Technical Library (1)
   J. Gubser (2)
   F-18 Program Engineering (1)
   A. S. Torgerson (1)
   B. Dighton (1)
   W. J. Stampley (1)
   J. P. Capellupo (1)
   L. W. Guenther (1)
   GIDEP Representative (1)
1 Marquardt Corporation, Van Nuys, CA
2 Martin-Marietta Corporation, Denver, CO
   Reliability (1)
   Technical Library (1)
2 North American Rockwell Corporation, Columbus, OH
   Engineering Development Laboratories (1)
   Technical Library (1)
2 Raytheon Company, Waltham, MA
   Missile Systems (1)
   Technical Library (1)
2 Rocketdyne International Corporation, Rocketdyne Division, Canoga Park, CA
   A. Kohl (1)
   Technical Library (1)
1 Rocketdyne, A Division of North American Rockwell Corporation, McGregor, TX (Technical Library)
1 Rockwell International Corporation, Los Angeles, CA (Technical Library)
1 Rohm and Haas Company, Huntsville, AL
3 Sandia Corporation, Albuquerque, NM
   Section 1541, Jerry T. Foley (2)
   Section 1543, Mark B. Gens (1)
3 Sandia Corporation, Livermore, CA
   C. A. Scott (2)
   Technical Library (1)
4 Texas Instruments, Inc., Dallas, TX
   B. Hatfield (1)
   J. Leslie (1)
   P. Watts, MS 296 (1)
   Technical Library (1)
4 The Boeing Company, Seattle, WA
   S. Barber, MS 8609 (1)
   J. Stuart, MS 47-06 (1)
   F. P. Stevens, Standards Control (1)
   Technical Library (1)
4 The Martin-Marietta Corporation, Newton, PA
   Engineering Library MP-30 (2)
   Technical Library (1)
   Code 143, J. A. Roy (1)
1 Thiokol Chemical Corporation, Newton, PA
1 Thiokol Chemical Corporation, Wasatch Division, Brigham City, UT
1 United Technologies, Chemical Systems Division, Sunnyvale, CA
2 Value Engineering Company, Alexandria, VA
   J. Toomey (1)
   Oxnard Plant (1)
4 Vought Corporation, Systems Division, Dallas, TX
   R. N. Hancock, Unit 2-53483 (2)
   C. T. Morrow, P. O. Box 6144 (1)
   Technical Library (1)