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(SL-7-20)

279

# MODIFIED RADAR AND STANDARD TUCKER WAVEMETER SL-7 CONTAINERSHIP DATA

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SHIP STRUCTURE COMMITTEE

1978

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SR-1221

**SEP 1978**

This report is one of a group of Ship Structure Committee Reports which describes the SL-7 Instrumentation Program. This program, a jointly funded undertaking of Sea-Land Service, Inc., the American Bureau of Shipping and the Ship Structure Committee, represents an excellent example of cooperation between private industry, regulatory authority and government. The goal of the program is to advance understanding of the performance of ships' hull structures and the effectiveness of the analytical and experimental methods used in their design. While the experiments and analyses of the program are keyed to the SL-7 Containership and a considerable body of the data developed relates specifically to that ship, the conclusions of the program will be completely general, and thus applicable to any surface ship structure.

The program includes measurement of hull stresses, accelerations and environmental and operating data on the S.S. Sea-Land McLean, development and installation of a microwave radar wavemeter for measuring the seaway encountered by the vessel, a wave tank model study and a theoretical hydrodynamic analysis which relate to the wave induced loads, a structural model study and a finite element structural analysis which relate to the structural response, and installation of long term stress recorders on each of the eight vessels of the class. In addition, work is underway to develop the initial correlations of the results of the several program elements.

Results of each of the program elements are being made available through the National Technical Information Service, each identified by an SL-7 number and an AD- number. A list of all SL-7 reports available to date is included in the back of this report.

This report documents the selection and calibration of the data set drawn from the measurements of waves, stress, roll, pitch and acceleration from the modified microwave radar and standard Tucker wavemeters. The reduction methods employed are identical to those documented in report SL-7-14.

Henry H. Bell
Rear Admiral, U. S. Coast Guard
Chairman, Ship Structure Committee

SSC-279

(SL-7-20)

TECHNICAL REPORT

on

Project SR-1221

"Correlation and Verification of

Wavemeter Data from the SL-7"

# MODIFIED RADAR AND STANDARD TUCKER WAVEMETER

# SL-7 CONTAINERSHIP DATA

by

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under

Department of the Navy
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U. S. Coast Guard Headquarters
Washington, D.C.
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ABSTRACT

So that more precise correlations between full scale observations and analytical and model results could be carried out, one of the objectives of the instrumentation program for the SL-7 class container ships was the provision of instrumental measures of the wave environment. To this end, two wave meter systems were installed on the S.S. SEA-LAND McLEAN. Raw data was collected from both systems during the second (1973-1974) and third (1974-1975) winter data collecting seasons.

It was the purpose of the present work to reduce this raw data, to develop and implement such corrections as were found necessary and feasible, and to correlate and evaluate the final results from the two wave meters. In carrying out this work it was necessary to at least partly reduce several other channels of recorded data, so that, as a by-product, reduced results were also obtained for midship bending stresses, roll, pitch, and two components of acceleration on the ship's bridge.

As the work progressed it became evident that the volume of documentation required would grow beyond the usual dimensions of a single technical report. For this reason the analyses, the methods, the detailed results, discussions, and conclusions are contained in a series of ten related reports.

The present report parallels the first report in the series in that it documents the sampling and calibration of data from the third (1974-1975) recording season, and presents a summary of initial results.

CONTENTS

## LIST OF FIGURES



## LIST OF TABLES

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# NOTES

# INTRODUCTION

In the analysis of the wave-induced ship hull strain data obtained by SSC in the 1960's it was necessary to infer the wave environment from estimated Beaufort wind speeds. An extraordinary amount of work was required to develop the inferential techniques. These techniques appear to suffice for valid prediction of long-term trends because a great deal of averaging is carried out. Unfortunately when verification of short-term statistical predictions is desired, the use of wind as a wave environment index appears to be less than satisfactory.

As a consequence it was one of the objectives of the SL-7 full-scale instrumentation program to provide a direct instrumental measure of the wave environment so that more precise correlations could be made between full-scale observations, and analytical and model results.

To this end the ship was fitted with a micro-wave radar relative wave meter and various motion sensing devices. A "Tucker Meter" pressure actuated wave height sensing system was also installed.

The purpose of the present project is to reduce and analyze the resulting wave meter data obtained on the SEA-LAND McLEAN in the second (1973-1974) and third (1974-1975) winter recording seasons.

In the documentation of the present project it has been necessary for practical reasons to assume on the part of the reader a general familiarity with the Ship Structure Committee's SL-7 measurement program. The primary background references for the present project are References 1 through 4. Reference 1 is the basic documentation of the full-scale instrumentation system. References 2 and 3 contain, for both recording seasons in question, a quite full account of instrumentation, basic recording, and the nominal circumstances surrounding the present data. These references also contain results of analyses of longitudinal vertical midship bending stress which were carried out according to the methods of Reference 4.

The first report under the present project is Reference 5. This reference contains the detail of the selection of the data set for the 1973-1974 winter season, the methods utilized in the digitization, the calibration of the data, and results of a first analysis of the data.

The second report in the present series (Ref.6) deals with the analyses which were carried out so as to produce the basic data reduction system, and with a description of that system.

The third through sixth reports in the series (Refs. 7 through 10) taken together, are a presentation of reduced results from the 1973-1974 winter season.

The purpose of the present report is to document the selection and calibration of a digital data set drawn from the measurements obtained during the third (1974-1975) winter recording season. The reduction methods employed for the third season data were to be identical to those documented in Reference 5. It was thus the intent to include herein only items which specifically pertain to the third season data.

## THE AVAILABLE THIRD SEASON DATA

The third winter recording season was short relative to its predecessors, involving only three trans-Atlantic voyages during the period 17 January 1975 to 17 March 1975, Reference 3. As noted in Reference 5, the channels of interest in the present program were recorded on Recorder No. 1. Table I summarizes the voyage numbers, dates, and the applicable analog tape numbers for the entire season. Also shown is the number of intervals of longitudinal vertical bending stress reduced by Teledyne (Ref.3).

During the period shown in the table both wave measuring systems were operational. The number of intervals of longitudinal stress reduced in Reference 3 sums to 864. As far as distintly defined log-book conditions are concerned, 864 intervals correspond roughly to a sampling of 220 four-hour watches. In Reference 5, it was considered unreasonable to select for wave analysis more than one interval per watch, or to select intervals not initially reduced by Teledyne (because of the difficulty in retrieving the log-book data for intervals not processed by them). On this basis the entire available third season data could not involve much more than 200 watches.

The first stage in the present data reduction process, Reference 5, is to duplicate the original analog tapes for playback in intermediate band FM. This was carried out by Teledyne Engineering Services for all analog tapes noted in Table I. As in the case of the second season data, all thirteen data channels were reproduced against possible future use by others, though only seven were required for the present work.

## INITIAL SCREENING

There were two main points in expanding the present program to include third season data. The first was that a significant amount of new strain instrumentation had been added. According to Reference 3 the highest local stresses ever recorded on an SL-7 were recorded during the third season. Reduction of the corresponding wave data was clearly desirable. The second point was that a new radar unit had been installed for the third season. It was thus desirable to see if deficiencies noted in the second season data had been cleared up.

TABLE I

SUMMARY OF VOYAGE AND TAPE NUMBERS,
SEA-LAND McLEAN, 1974-1975
WINTER RECORDING SEASON

| Voyage | Dates: | Recorder No. 1 Tape Numbers | Number of Intervals Reduced by Teledyne, Ref. 3 |
|---|---|---|---|
| 59E | 1/17 - 1/24/75 | 201, 203, 205 | 54, 59, 41 |
| 59W | 1/28 - 2/2/75 | 207, 209 | 52, 64 |
| 60E | 2/7 - 2/15/75 | 211, 213, 215 | 52, 60, 52 |
| 60W | 2/18 - 2/24/75 | 217, 219, 221 | 60, 60, 13 |
| 61E | 2/28 - 3/7/75 | 223, 225, 227 | 56, 59, 33 |
| 61W | 3/11/75 - 3/17-75 | 229, 231, 233 | 64, 51, 34 |

The second season data set had been selected in part so that the set included all of the various nominal ship speeds, headings, and Beaufort winds. Accordingly, the second season data set was thought to reasonably represent the average as well as the severe conditions encountered by the ship.

It thus seemed reasonable to approach the selection of data from the third season from a different point of view; that is, to concentrate on conditions which appeared to be of interest in other aspects of the SL-7 measurement program.

From the point of view of the present objectives, correlation with the results presented in Reference 11 was of considerable interest. The work of Reference 11 involved reducing wave data taken by the SL-7 radar system and making comparisons with wave data obtained at roughly the same time by an airborne laser profilometer and an airborne nanosecond radar. The airborne measurements were taken between 0900 and 1000 (EST), 6 February 1975, and the shipboard radar measurements were taken more or less continuously from 0820 to 1400 the same day. It may be noted that the date of these experiments is not represented in Table I. The experiments in question were evidently done while the ship was on a coastwise run to Portsmouth, VA at the beginning of Voyage 60E. It appeared that the data were omitted in the Teledyne reduction of midship stress, Reference 3. The reason for the apparent omission was that the wavemeter data of 6 February 1975 were specially handled and are not included in the third season data library. Unfortunately, it was thus not possible to plan upon a correlation of present results with those of Reference 11.

The cases of high stress presented in Reference 3 involve a sampling from twenty-six watches in Voyages 60 and 61. The Recorder No. 1 tape and index numbers associated with these data are:

Voyage 60E, Tape 213, Index Numbers 19 through 28

Voyage 60W, Tape 219, Index Numbers 16 through 18

Voyage 61E, Tape 223, Index Numbers 6 through 12

Voyage 61W, Tape 233, Index Numbers 31 through 36

It was desirable to plan upon the inclusion of an interval from each of these watches in the third season data set.

Other projected overall plans for use of the SL-7 data involve correlations between stress data and analytical predictions of one sort or another. It would be anticipated that instances of relatively high midship bending stress would be of interest in this endeavor. With respect to comparisons of the behavior of the second and third season radar unit, the deficiencies noted in the second season data were associated with severe wave conditions. It thus appeared that interval selection, over and above the specific cases previously noted, could profitably be biased toward relatively severe conditions.

It is shown in Reference 3 that the overall sea and wind conditions experienced during the third measurement season were significantly milder than those experienced in the previous seasons, and in fact milder than what would be expected in mid-Atlantic in an average year. By the standards of the second season data set the "high stress" watches previously noted involve practically all the severe conditions experienced.

In the context of severe weather, Voyages 34 and 36E were the mildest of the second season voyages reduced in that no storms were evident, a consistent 32 knot ship speed could be maintained and visual wave and swell observations were typically 2 to 6 feet. Inspection of the visual wave, wind and stress data in Reference 3 indicated that Voyage 59 was of the same nature -- possibly even less eventful. (In fact at least a third of the intervals in Voyages 60 and 61 appear to involve extremely mild sea conditions.)

The conclusion from the general study just outlined was that the results of a reduction of data from Voyage 59 would be no more useful to other efforts within the SL-7 program than the results from Voyages 34 and 36E (Refs. 9,10) initially appeared to be. It seemed best to concentrate efforts on Voyages 60 and 61 where definite sampling requirements had been determined, and in which considerable relatively mild conditions were represented.

## INTERVAL SAMPLING

Compressed time scale oscillograph records were made of the tapes involved in Voyages 60 and 61 (the so-called "quick-look" records, Ref.5), and these were compared with the log-book data of Reference 3 to determine the final interval sampling plan.

It was apparent from the quick look records that the most serious radar problems of the second season persisted into the third season. In what appeared to be heavy weather, gross and sudden changes in the mean were apparent. As in the second season, these changes often occurred more than once in an interval, thus making the radar data in the interval of little practical use. In roughly 3/4 of the intervals corresponding to the high stress just noted, the radar signal was unusable. The signals of the other pertinent channels appeared to have few gross defects -- an occasional suspicious burst of noise was noted on the vertical bending stress intervals.

The final interval sampling scheme was thus similar to that outlined in detail in Reference 5. For each watch (index number) of interest according to the previously outlined criteria, there were four intervals available. One of these was selected for digitization according to relative freedom from the problems just discussed. In addition, a sampling of intervals involving mild sea conditions was selected so as to be representative of all headings and ship speeds available. The result was a list of 80 specific intervals to be digitized from the roughly 150 watches in which recordings were made during Voyages 60 and 61.

The filtering of analog signals, the sampling interval, and the digitization process was exactly the same as that described in Reference 5. Analog tape tracks 1, 3 through 7, and 12 were digitized (longitudinal vertical bending stress, radar, roll, pitch, vertical and lateral accelerations at the radar pedestal, and the Tucker Meter).

## ASSEMBLY OF OTHER PARAMETERS

The raw digitization files contain little more information than the original magnetic tape. Quite a number of other pieces of information are needed for analysis and for correlation.

All the readily available information about the general circumstances associated with each tape and interval is contained in Reference 3. This information is a tabulation from the TMR log-books of time, ships position, speed, draft, visual observations of weather and wave conditions, general comments, and the results of the TMR analysis of midship vertical bending stress. All of the data summarized by TMR for the particular intervals which had been digitized is contained in a digital summary tape. A copy of this tape was acquired, and the information required for the present project was abstracted and reformatted for the Stevens PDP-10 system.

Table II contains a track description for Tapes 201 through 233, and the values and senses of the pertinent TMR calibration signals. The values of calibration signals and their senses were established in conferences with both TMR and the designers of the radar.

## TABLE II

## ANALOG MAGNETIC TAPE TRACK DESCRIPTION, TAPES 201 THROUGH 233

| Track | Item | Calibration Signal Value and Sense |
|---|---|---|
| 1 | Longitudinal Vertical Bending | 8214 psi (Tension) |
| 2 | Midship Torsional Shear | |
| 3 | Radar | 46 ft. (Range decreasing) |
| 4 | Roll | $10^{\circ}$ (Starboard side down) |
| 5 | Pitch | $10^{\circ}$ (Bow up) |
| 6 | Radar Antenna Acceleration, Vertical | 0.5 g (Same sense as gravity component of accelerometer output) |
| 7 | Radar Antenna Acceleration, Transverse | 0.5 g (In opposite sense to gravity component of accelerometer signal for steady heel, starboard side down) |
| 8 | Hull Forward Acceleration, Vertical | |
| 9 | Hull Forward Acceleration, Transverse | |
| 10 | Rudder Angle | |
| 11 | Longitudinal Horizontal Bending | |
| 12 | Tucker Meter | 10 ft. (sense not documented) |
| 13 | Longitudinal Vertical Bending (Fwd Qtr.) | |
| 14 | Shorted Input | |

The values of the calibration signals are used directly in the calibration of the data. Two sign inversions were necessary. Positive roll starboard side down, positive pitch bow up, and positive transverse acceleration in a sense opposite to the gravity signal for a steady heel to starboard all suit a coordinate system in which the x axis is positive forward, the y axis is positive to starboard and the z axis is positive downward. In this coordinate system positive vertical acceleration is an acceleration down so that the sign of the calibration signal was reversed for Track 6, the vertical accelerometer. In the corrections to radar range, the range itself is considered positive, so that the sign of the radar calibration signal needed to be reversed also.

It should be noted that the sense of pitch relative to the nominal shown in Table II is reversed in the data reduction system, Reference 6, and that a positive Tucker meter signal corresponds to a trough. All sense conventions were checked relative to those established for the second season data, Reference 5, by comparing typical oscillograph records for low ship speed.

In the present case the radar and the accelerometer package were assumed coincident. Accordingly the location parameters $Q_x$, $Q_y$ and $Q_z$ called for in Reference 6 were all taken equal to zero.

The radar was aimed relative to ship coordinates at an azimuth of $90^{\circ}$ and depression from horizontal of $75^{\circ}$; that is, the radar was oriented in a plane normal to the ship centerline, pointing down and slightly to starboard.

The nominal distance of the radar above the departure waterline was established with recorded departure drafts furnished by the owners. The vertical position of radar antenna above baseline was computed from plans to be 106.5 feet, its longitudinal position 123 feet aft of FP. The departure drafts and the result of the computation of initial vertical position of the radar are given in Table III.

TABLE III

| Voyage | Mean Draft, Departure (feet-inches) | Vertical Position of Radar (feet) |
|---|---|---|
| 59E | 28-8 | 78.4 |
| 59W | 32-10 | 74.2 |
| 60E | 30-10 | 76.2 |
| 60W | 31-3 | 75.8 |
| 61E | 33-5 | 73.6 |
| 61W | 33-10 | 73.2 |

## FIRST ANALYSIS OF DIGITIZED RESULTS FROM THE THIRD SEASON

### Content

The first analysis of digitized results had the same objectives as noted in Reference 5; that is, to develop the calibration, a few simple indices of the content of each sample, and a general check on the results of the digitizing process. The procedures and programs used were the same as that for the second season data, Reference 5.

### Values of the Calibration Steps

It was evident from the first pass calibration analysis (Ref.5) that the pitch calibrations were the strongest and most consistently applied, and the position of the calibration steps was determined from this channel (the transverse acceleration channel had been used for the second season).

Before indicating the calibration results for the various channels the various sensitivities of the elements of the digitization process should be noted. The nominal voltage sensitivity of the reproduce electronics in the analog tape recorder is 1.414 volts output for a 40% of center-frequency frequency deviation on the FM tape. The D.C. gain of the analog filters (Ref.5) is unity ± .5%. The computer was set to resolve 2-1/2 volts input into 1024 parts. The net sensitivity from magnetic tape output through filter and computer A/D was nearly nominal, ranging from 410 to 413 cu/volt* depending on the channel. In round numbers, 411 cu indicated by the computer corresponded to 1 volt out of the tape recorder or a 28.2% frequency deviation on the tape.

The calibration steps are superimposed upon the signal for the longitudinal bending stress channel. As described in the TMR reports, the average of the 10 cal steps and the average of the nine pieces of signal between the cal steps is computed. The indicated cal step for each interval is the average of the cal steps minus the average of the intermediate pieces of signal. These average indicated steps were computed and listed for all the digitized intervals. Because the signal is mixed up with the calibration step in this channel, the typical interval to interval scatter in what should be a constant is often 15%. However the average result at the beginning and end of voyages correlated quite well over the data set. It was concluded best not to believe the indicated fluctuations and a final cal step of + 420 cu was used for both voyages. This corresponds to a positive 1.03 volt step or a 29% deviation, both figures nearly exactly the values set up by TMR.

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*The abbreviation "cu" stands for computer units; that is, roughly 1/411 volts into the A/D.

In the radar calibrations the 10 square waves are imposed with reference to electrical zero and the signal is suppressed while the step is imposed. The indicated cal step is thus the average of the 10 individual steps minus electrical zero. This calibration was quite steady from interval to interval and tape to tape, the typical variation being 1%. The cal step was taken as constant over both voyages and equal to + 407 cu. This is equivalent to + .99 volts or a 28% deviation, and is equal to the values which were setup by TMR.

The cal steps applied to the roll and pitch tracks were similar to that for the radar. The signal is suppressed while the steps are on, and the reference for the signal is electrical zero. Again the indicated average cal step is the average of the 10 individual steps minus electrical zero. The indicated cal steps for both channels were quite steady, typical fluctuations from interval to interval being 1-1/2%. The cal steps for roll and pitch were taken constant and equal to + 187 cu (+.46 volts, 13% deviation) for roll and + 405 cu (+.98 volts, 28% deviation) for pitch. Both these values are as expected.

The cal steps applied to the acceleration channels were effectively superimposed on the mean signal level, though the signal was suppressed. Accordingly, the average cal step was derived by averaging the 10 individual steps from each interval and subtracting from this result the mean of the first 4 minutes of signal which was felt to be a slightly better estimator of the mean signal level during the calibration than the short pieces of signal between cal steps. The stability of these results from interval to interval was fair. The cal step for transverse acceleration appeared to be + 155 cu ± 1-1/2% for all tapes (+.38 volts, 11% deviation). The step for vertical acceleration scattered ± 4%. An average value of + 97 cu was taken for this step (+0.24 volts, 7% deviation), it being felt that the scatter was due to variations of the estimate of sample mean. Though scatter in sample mean for this channel appeared no larger than that for other channels, it was a much larger percentage of the calibration swing.

The Tucker meter cal step was computed in the same way as for the accelerations. Interval to interval fluctuations were smaller (typically ± 1%), and were attributed to fluctuations in sample mean. The cal step was taken constant and equal to + 387 cu (+0.95 volts, 27% deviation) which is as expected from the original setup.

Zero Stability and Saturation

Enough data from the first pass analysis was available to check if the digitization had been started correctly during the electrical zero for each interval. The indications were that it had not been in a few intervals. These were discarded as far as subsequent analysis was concerned.

In principle, the average value for the digitized electrical zero for each interval is the reference level for that interval, irrespective of its deviation from zero volts input measured at the computer A/D interface. However, the magnitude of the offset of the tape electrical zero is an indicator of bias or zero stability of the entire system, including original signals and tape deck, and that of all the subsequent analog processing equipment. The general zero stability of the whole process is perhaps best judged by the zero stability for the roll and pitch channels. Electrical zero in these channels corresponds to a center tap on the potentiometric transducers rather than to the open circuited tape deck input utilized to create a zero on some other channels. In the case of roll and pitch the average offset throughout the data set was about 170 mv with what appeared to be random fluctuations of ± 50 mv. The typical mean electrical offset on other channels was in general not far different. A mean offset of 170 mv represents 8% of nominal full scale for the playback recorder. Absolute tape speed errors in the four recorders in the process could conceivably add up to this offset magnitude, to say nothing of small offsets in other analog components of the system. The fluctuations in offset of the pitch and roll channels amount to ± 3% of nominal full scale of the playback recorder. This, too could have been injected by the sum of absolute tape speed errors of original and final playback recorders. Overall, the apparent electrical offsets of the original electrical zero appear at least as small as could have been expected, though they are somewhat larger than those experienced in the second season data, Reference 5.

The final check on the validity of the digitized intervals was for saturation. As far as the digital part of the process is concerned all signals levels within ± 2-1/2 volts were resolved, signals outside this range appear digitized as the maximum possible number (± 1023 cu). The filters interposed between tape deck and computer have a ± 10 volt linear range. The tape machine used in playback has a nominal minimum linear reproduce electronics output range of ± 1.414 volts. In the present case the reproduce electronics are acceptably linear to ± 1.75 volts (50% signal deviation.) Their output deviates progressively more from linearity as output voltage increases beyond 1.75 volts to some figure above 2 volts where the FM demodulator goes mad and produces wild fluctuations of output signal.

Saturation is thus controlled by the analog tape playback machine. In the present case a digitized number corresponding to less than 1.75 volts was considered unsaturated. Results between 1.75 and 2.0 and 2.1 volts were considered questionable. Digitized results of 1023 cu or -1023 cu were almost certainly a result of over saturation of the tape.

The extremes of the digitized samples were viewed with these criteria. In one or two instances there appeared to be excessive tape saturation and these intervals were disregarded in subsequent analysis. After these discards and the others noted previously the data set had contracted from 80 to 73 intervals. Of these, there are only three intervals where some question exists. Two instances involve the radar signal on Tape 211, Voyage 60E. Intervals 26 and 30 contained extremes of 1.8 volts. In Voyage 61E, Tape 225, Interval 57 the longitudinal bending stress contained an extreme of 2.0 volts. In general, the mild conditions experienced in the third season, as well as some evident reductions in gain, resulted in a data set relatively free of saturation.

An additional check on the validity of the data was made by forming the ratio of the range of sample extremes (largest - smallest) to the computed rms. If the statistics of the maxima of the processes involved follow the Rayleigh distribution (as dictated by custom and conventional wisdom) this ratio should lie between 5 and 8 in 90% of all samples of 100 or 200 maxima. In the 73 intervals in the data set this ratio ranged from 5 to about 30, depending on channel. Table IV summarizes for each channel the percentage of intervals in which the ratio of range to rms lay outside the 5 to 8 acceptance range. The results look fairly consistent with the statistical assumptions, and not far different from the corresponding results from the second season data, Reference 5.

TABLE IV

SUMMARY OF INCIDENCE OF FAILURE OF RANGE/RMS TEST

| Channel | Percent of Intervals in which ratio of range to rms was outside range between 5 and 8 |
|---|---|
| Longitudinal Vertical Bending Stress | 11% |
| Radar | 18% |
| Roll | 4% |
| Pitch | 11% |
| Vertical Acceleration | 6% |
| Transverse Acceleration | 7% |
| Tucker Meter | 3% |

## SUMMARY OF DIGITIZED INTERVALS

### TMR Log-book Data

The last stage of the sampling and digitization phase of the project was to gather together the various parameters and scale up some pertinent results from the digitization. The product of this operation was four tables; these are intended to serve as a listing of which intervals of those digitized were to be considered in subsequent analyses, as well as a summary of the surrounding circumstances and of the raw digitized signal magnitudes. Each table pertains to one of the four voyage legs, and is divided into four parts (a through d).

Parts a and b of each table contain the log-book data extracted from Reference 3. With the exception of the first column of each page, the meaning of each entry is that established by TMR. The first column is the run number assigned to each interval during the digitization at D.L. This number is retained for identification in subsequent parts of the table. The draft column in part a of the tables is blank because draft was not recorded during the third season (Ref.3).

Comparison of TMR and Raw D.L. Results for Longitudinal Stress

Part c of each table is a comparison of results from the present digitization with that at TMR. Five columns are stress results obtained at TMR. Stresses are presented in thousands of pounds per square inch. The columns marked 6 through 8 are from the present digitization. The probable resolution of the analog tape recorder is ± 1% of full scale. This, according to the values of cal steps established previously, corresponds roughly to ±0.1 kpsi so that the two decimal places shown for stresses are optimistic.

Though it was not within the objectives of the present work to produce anything having to do with recorded midship bending stress, it was felt prudent to digitize this channel and make rudimentary comparisons with the results obtained by TMR. The main reason for this decision was to increase the credibility of the data processing methods described in this report. If the present results and those of TMR, Reference 3, were to diverge by unreasonably large margins, systematic errors in the present process would be suspected to exist in the data channels of primary interest as well as the midship bending stress channel.

Unfortunately the quantities compared in part c of the tables are in a strict sense, different things. This comes about because the two data reduction procedures are different and because the portions of the data interval actually analyzed was slightly different. Figure 1 illustrates some of the differences. The top sketch represents the combined vibratory and wave induced stress actually recorded. In the present analysis the largest and smallest combined stress were extracted. Subtraction of the two yields "range of recorded extremes" as noted in the figure, and recorded in column 6 of the tables. This number is comparable in principle to that produced by a mechanical scratch gage. The largest and smallest instantaneous stress are not necessarily associated except that they were observed in the same 20.5 minute sample. The second item obtained in the present analysis was the process rms, which is the square root of the mean squared deviation from the sample mean for the entire time history analyzed. The numbers produced by the TMR analysis were derived after two filtering operations separated "wave induced stress" and "vibratory stress." Sketches of the result of this operation upon the raw stresses are indicated in Figure 1. The TMR analysis produced only one number from the vibratory part of the stress, "the maximum first mode stress." As noted in Figure 1 this is just the largest double amplitude of vibration in the record. (It should be noted also that the TMR analysis recorded zero vibratory stress if the maximum

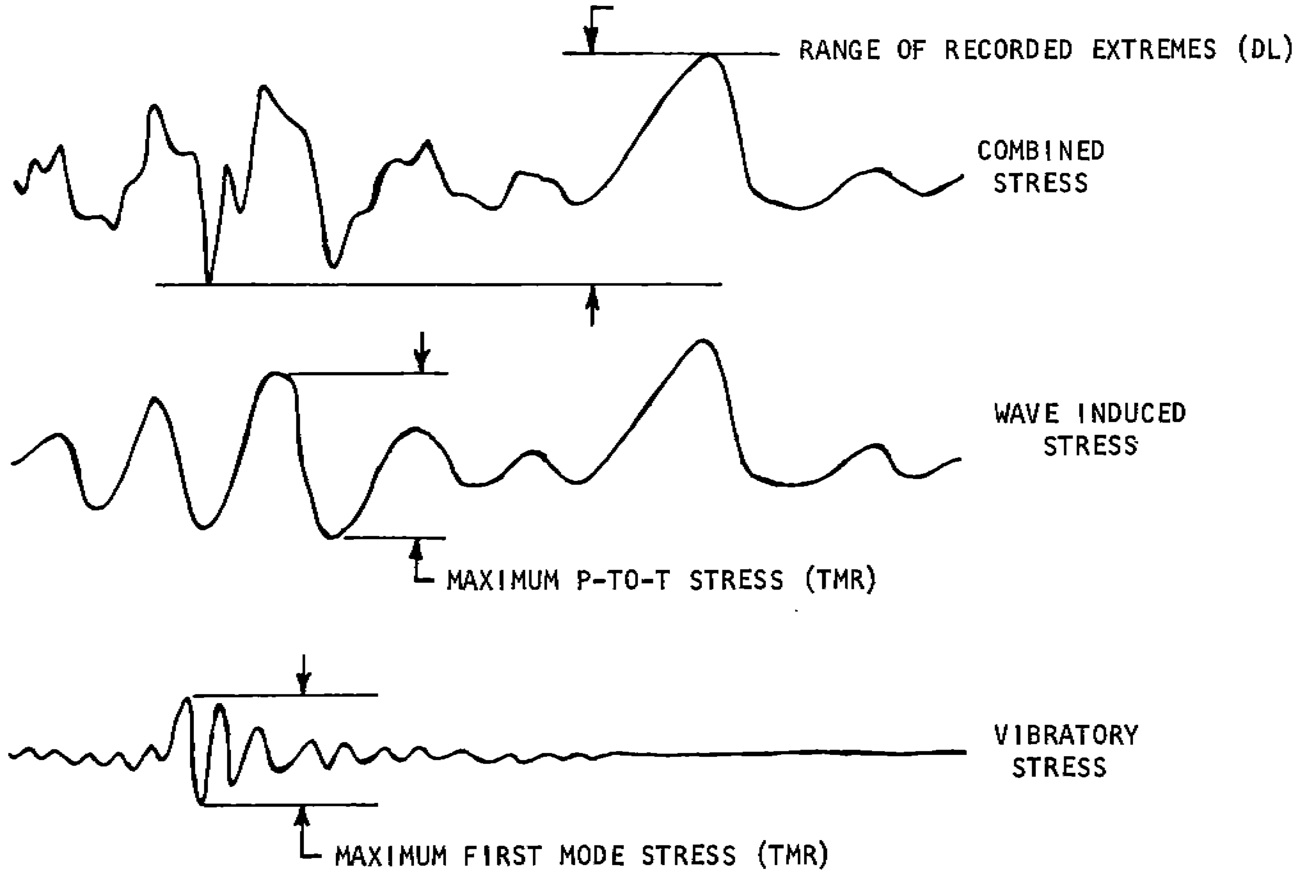


FIGURE 1 SKETCH ILLUSTRATING MAXIMUM STRESS PARAMETERS

vibration double amplitude was less than 0.4 to 0.6 kpsi.) With respect to the "wave induced stress" the basic TMR analysis is a "peak to trough" analysis; that is, a series of numbers representing the swing in stress (double amplitude) from each positive maximum to the succeeding negative minimum (the zero crossing convention is employed). A computation of the root mean square of this series of double amplitudes yields the number given in column 4 of the part c tables. Finally, the largest wave induced double amplitude is extracted and this number appears in column 3 of the table.

Now considering a comparison of the present "range of recorded extremes" with the TMR results it should first be noted that the "range of recorded extremes" could be exactly equal to the maximum peak-trough wave induced moment or practically equal to the sum of maximum wave induced and maximum vibratory double amplitudes. Given the non-ideal characteristics of real data (the sketches in Figure 1 are fairly realistic) the above is most unlikely. Thus, as far as correlations with the TMR results are concerned, the present range of recorded extremes would be expected to be larger than the maximum peak to trough bending stress found by TMR; and quite possibly smaller than the sum of the TMR maximum peak to trough bending stress and the TMR maximum first mode stress. At the right of the table the ratios of the corresponding columns are formed.

Column 7 in the "c" part of the tables is $2\sqrt{2}$ times the scaled up stress process rms. This estimate should compare with the value given by TMR for "rms P to T stress," according to the Rayleigh assumption in common use. How well these latter two estimates compare is indicated by the ratio of column 7 to 4 shown at the right of the table.

Column 8 of part "c" of the tables is the scaled difference of the sample mean of the interval noted, from the sample mean of the first interval digitized in each voyage leg. This quantity should reflect the effects of ballast changes during the voyage. Direct correlation with results produced by TMR was not attempted.

Given the present state of knowledge about how the extremes of vibratory and wave induced stress ought to combine, and the extent to which the Rayleigh assumption is generally valid for wave induced stress, there seemed about as much chance of the expectations being wrong as the various analyses. In any event, the comparisons of the two different sets of results implied that no gross systematic problems were present in the present data reduction scheme.

Magnitude of Radar, Motion and Tucker Meter Signals

Part d of the tables involves scaled up indices of the magnitude of radar, roll, pitch, vertical and transverse acceleration, and Tucker meter signals. The first index in each case is 4.0 x the rms. This is a conventional approach to the significant double amplitude (or the average of the 1/3 highest double amplitudes).

The second and third indices are the positive and negative extremes for each channel. The extremes observed for roll and pitch were corrected for electrical zero on tape before scaling. The extremes for all other items were corrected to the sample mean before scaling. As a consequence, shifts in the mean of the radar are washed out, and the one "g" bias in vertical acceleration disappears. The extreme values shown are usually reasonably symmetrical, and, as was pointed out in a previous section, bear a believable relationship to the rms value.

The resolution of each channel on the basis of ± 1% of nominal full scale of the tape recorder is approximately as follows:

| | |
|---|---|
| Radar | ± 0.7 ft |
| Roll | ± 0.3 degree |
| Pitch | ± 0.15 degree |
| Vertical Accelerations | ± 0.03 g |
| Lateral Accelerations | ± 0.02 g |
| Tucker Meter | ± 0.2 ft |

The resolution of the accelerometers is significantly different from that estimated for the second season (Ref.5). Part d of the tables indicates that the rms signal magnitudes on the acceleration channels are quite often not much above the expected tape noise level. Resolution of the other channels is not very much different than that of the second season data, Reference 5.

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## TABLE Va

### SUMMARY OF TMR LOG-BOOK DATA CORRESPONDING TO INTERVALS SELECTED FOR WAVE METER DATA REDUCTION (PAGE 1 OF 2)

SEA LAND MC LEAN : 1974-1975 WINTER SEASON : VOYAGE 60 EAST

| D.L. RUN NO. | TMR TAPE NO. | TMR INDX NO. | TMR INTV NO. | DATE | TIME (GMT) | LATITUDE | LONGITUDE | COURSE | SPEED KT. | PROP RPM | DRAFT FT. | SEA/AIR TEMP |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2126 | 211 | 7 | 26 | 02-08-75 | 0400 | 36-46 N | 73-44 W | 094 | 29.5 | 120.7 | | 66/56 |
| 2130 | 211 | 8 | 30 | 02-08-75 | 0800 | 36-46 N | 73-44 W | 094 | 29.4 | 120.5 | | 70/58 |
| 2133 | 211 | 9 | 33 | 02-08-75 | 1200 | 36-46 N | 73-44 W | 094 | 29.5 | 120.7 | | 64/59 |
| 2138 | 211 | 10 | 38 | 02-09-75 | 1600 | 36-02 N | 60-14 W | 094 | 29.5 | 121.0 | | 63/60 |
| 2205 | 213 | 17 | 5 | 02-09-75 | 2000 | 35-12 N | 46-42 W | 072 | 19.5 | 79.8 | | 62/62 |
| 2209 | 213 | 18 | 9 | 02-09-75 | 2400 | 35-12 N | 46-42 W | 072 | 19.6 | 80.7 | | 60/59 |
| 2213 | 213 | 19 | 13 | 02-10-75 | 0400 | 35-12 N | 46-42 W | 072 | 19.7 | 80.9 | | 61/59 |
| 2217 | 213 | 20 | 17 | 02-10-75 | 0800 | 35-12 N | 46-42 W | 072 | 19.6 | 80.6 | | 61/59 |
| 2221 | 213 | 21 | 21 | 02-10-75 | 1200 | 37-20 N | 37-40 W | 073 | 19.8 | 81.3 | | 60/60 |
| 2225 | 213 | 22 | 25 | 02-10-75 | 1600 | 37-20 N | 37-40 W | 073 | 20.7 | 84.9 | | 59/65 |
| 2229 | 213 | 23 | 29 | 02-10-75 | 2000 | 37-20 N | 37-40 W | 073 | 20.7 | 84.8 | | 54/58 |
| 2233 | 213 | 24 | 33 | 02-10-75 | 2400 | 37-20 N | 37-40 W | 073 | 20.8 | 85.3 | | 57/57 |
| 2237 | 213 | 25 | 37 | 02-11-75 | 0400 | 37-20 N | 37-40 W | 073 | 20.8 | 85.2 | | 59/58 |
| 2241 | 213 | 26 | 41 | 02-11-75 | 0800 | 37-20 N | 37-40 W | 073 | 20.8 | 85.4 | | 58/58 |
| 2245 | 213 | 27 | 45 | 02-11-75 | 1200 | 39-40 N | 27-50 W | 073 | 20.8 | 85.3 | | 56/60 |
| 2249 | 213 | 28 | 49 | 02-11-75 | 1600 | 39-40 N | 27-50 W | 073 | 20.9 | 85.8 | | 57/60 |

## TABLE Vb

### SUMMARY OF TMR LOG-BOOK DATA CORRESPONDING TO INTERVALS SELECTED FOR WAVE METER DATA REDUCTION (PAGE 2 OF 2)

SEA LAND MC LEAN : 1974-1975 WINTER SEASON : VOYAGE 60 EAST

| D.L. RUN NO. | SEA STATE | <REL WIND> DIR/SPEED /(KT) | REL WAVE DIR | WAVE HT. FT. | REL SWELL DIR | <-SWELL-> HT FT. | LENGTH FT. | VISUAL WEATHER /TMR LOG-BOOK COMMENTS |
|---|---|---|---|---|---|---|---|---|
| 2126 | 6 | 161P/25 | 161P | 3 | 139P | 10 | 600 | OCAST / |
| 2130 | 7 | 139P/30 | 139P | 3 | 139P | 10 | 600 | OCAST / |
| 2133 | 6 | 139P/25 | 139P | 3 | 139P | 10 | 600 | OCAST / |
| 2138 | 7 | 161P/30 | 161P | 3 | 161P | 10 | 600 | OCAST / |
| 2205 | 4 | 139P/15 | 139P | 2 | 139P | 8 | 600 | OCAST / |
| 2209 | 3 | 117P/10 | 117P | 3 | 139P | 8 | 600 | PT CLDY / |
| 2213 | 2 | 117P/ 5 | 117P | 3 | 139P | 12 | 800 | PT CLDY / |
| 2217 | 4 | 117P/15 | 117P | 3 | 139P | 12 | 800 | PT CLDY / |
| 2221 | 4 | 118P/15 | 118P | 3 | 140P | 16 | 800 | PT CLDY / |
| 2225 | 2 | 163P/ 5 | 163P | 2 | 140P | 16 | 800 | PT CLDY / |
| 2229 | 3 | 163P/10 | 163P | 3 | 142P | 16 | 800 | PT CLDY / |
| 2233 | 3 | 152S/10 | 152S | 3 | 118P | 18 | 800 | PT CLDY / |
| 2237 | 3 | 174S/10 | 174S | 3 | 118P | 18 | 820 | PT CLDY /ROLLING IN 18 FT SWELLS |
| 2241 | 5 | 174S/20 | 174S | 4 | 118P | 16 | 800 | PT CLDY / |
| 2245 | 6 | 174S/25 | 174S | 4 | 118P | 16 | 800 | PT CLDY / |
| 2249 | 5 | 152S/20 | 152S | 4 | 118P | 14 | 700 | PT CLDY / |

## TABLE Vc

### COMPARISON OF TMR RESULTS FOR MIDSHIP VERTICAL BENDING STRESS WITH CORRESPONDING RAW DIGITIZATION RESULTS AT DAVIDSON LABORATORY

SEA LAND MC LEAN : 1974-1975 WINTER SEASON : VOYAGE 60 EAST

| | TMR RESULTS | | | | | D.L. DIGITIZATION | | | COLUMN RATIOS | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| D.L. RUN NO. | NO. WAVE INDUCED CYCLES (1) | NO. 1ST MODE BURSTS (2) | MAX P-TO-T STRESS KPSI (3) | RMS P-TO-T STRESS KPSI (4) | MAX 1ST MODE STRESS KPSI (5) | RANGE OF RECORDED EXTREMES KPSI (6) | 2.83X (SAMPLE RMS) KPSI (7) | REL MEAN STRESS KPSI (8) | (7) / (4) | (6) / (3+5) | (6) / (3) |
| 2126 | 65 | 0 | 5.45 | 2.49 | 0.00 | 8.51 | 3.17 | 0.74 | 1.27 | 1.56 | 1.56 |
| 2130 | 63 | 0 | 8.02 | 2.94 | 0.00 | 8.74 | 3.45 | 1.01 | 1.17 | 1.09 | 1.09 |
| 2133 | 72 | 0 | 5.72 | 2.35 | 0.00 | 6.63 | 3.02 | 0.95 | 1.29 | 1.16 | 1.16 |
| 2138 | 70 | 0 | 4.29 | 2.06 | 0.00 | 6.65 | 2.64 | 1.54 | 1.28 | 1.55 | 1.55 |
| 2205 | 71 | 0 | 5.25 | 2.78 | 0.00 | 5.93 | 2.68 | 1.87 | 0.96 | 1.13 | 1.13 |
| 2209 | 73 | 0 | 5.45 | 2.91 | 0.00 | 6.24 | 2.76 | 1.67 | 0.95 | 1.14 | 1.14 |
| 2213 | 79 | 0 | 6.59 | 2.81 | 0.02 | 7.24 | 3.07 | 1.55 | 1.10 | 1.10 | 1.10 |
| 2217 | 78 | 0 | 6.80 | 3.09 | 0.00 | 7.71 | 3.20 | 1.46 | 1.04 | 1.13 | 1.13 |
| 2221 | 77 | 0 | 5.77 | 3.18 | 0.00 | 7.71 | 3.17 | 1.68 | 1.00 | 1.33 | 1.33 |
| 2225 | 66 | 0 | 8.57 | 3.83 | 0.00 | 8.94 | 3.55 | 2.02 | 0.93 | 1.04 | 1.04 |
| 2229 | 65 | 0 | 9.10 | 4.27 | 0.00 | 9.15 | 3.98 | 1.38 | 0.93 | 1.01 | 1.01 |
| 2233 | 65 | 0 | 6.97 | 3.49 | 0.00 | 8.35 | 3.53 | 1.22 | 1.01 | 1.20 | 1.20 |
| 2237 | 76 | 0 | 6.82 | 3.13 | 0.00 | 7.28 | 3.16 | 1.04 | 1.01 | 1.07 | 1.07 |
| 2241 | 61 | 0 | 6.98 | 3.23 | 0.00 | 7.65 | 3.30 | 0.98 | 1.02 | 1.10 | 1.10 |
| 2245 | 70 | 0 | 7.17 | 3.53 | 0.00 | 7.92 | 3.40 | 1.87 | 0.96 | 1.11 | 1.11 |
| 2249 | 67 | 0 | 5.74 | 3.21 | 0.00 | 6.61 | 3.22 | 1.78 | 1.00 | 1.15 | 1.15 |

## TABLE Vd

### SUMMARY OF RAW DIGITIZATION RESULTS FOR RADAR RANGE ROLL, PITCH, DECK HOUSE ACCELERATIONS, AND TUCKER METER

SEA LAND MC LEAN : 1974-1975 WINTER SEASON : VOYAGE 60 EAST

| | RADAR | | | ROLL | | | PITCH | | | VERT ACCEL | | | LAT ACCEL | | | TUCKER | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| D.L. RUN NO. | 4.0 (RMS) FT | RECORDED EXTREMES FT | FT | 4.0 (RMS) DEG | RECORDED EXTREMES DEG | DEG | 4.0 (RMS) DEG | RECORDED EXTREMES DEG | DEG | 4.0 (RMS) (G) | RECORDED EXTREMES (G) | (G) | 4.0 (RMS) (G) | RECORDED EXTREMES (G) | (G) | 4.0 (RMS) FT | RECORDED EXTREMES FT | FT |
| 2126 | 29. | 30. | -63. | 10.7 | 6. | -13. | 0.8 | 0.3 | -2.8 | 0.28 | 1.7 | -0.4 | 0.21 | 0.2 | -0.4 | 3. | 2. | -3. |
| 2130 | 29. | 29. | -23. | 12.0 | 12. | -13. | 0.7 | 0.2 | -1.0 | 0.16 | 0.1 | -0.1 | 0.23 | 0.2 | -0.3 | 2. | 2. | -2. |
| 2133 | 25. | 22. | -20. | 10.1 | 7. | -8. | 0.7 | 0.1 | -1.2 | 0.17 | 0.2 | -0.1 | 0.19 | 0.1 | -0.2 | 2. | 2. | -2. |
| 2138 | 19. | 16. | -16. | 8.9 | 8. | -8. | 0.7 | 0.2 | -1.0 | 0.18 | 0.2 | -0.1 | 0.18 | 0.2 | -0.2 | 2. | 2. | -2. |
| 2205 | 16. | 13. | -14. | 10.5 | 7. | -8. | 0.7 | 0.1 | -1.2 | 0.21 | 0.2 | -0.2 | 0.21 | 0.2 | -0.2 | 3. | 2. | -3. |
| 2209 | 16. | 15. | -13. | 10.4 | 9. | -7. | 0.7 | 0.3 | -1.2 | 0.23 | 0.2 | -0.2 | 0.21 | 0.1 | -0.2 | 4. | 3. | -4. |
| 2213 | 17. | 14. | -13. | 12.0 | 10. | -10. | 0.8 | 0.2 | -2.5 | 0.54 | 1.8 | -0.3 | 0.25 | 0.2 | -0.3 | 5. | 4. | -5. |
| 2217 | 19. | 16. | -16. | 12.7 | 10. | -9. | 0.8 | 0.3 | -1.2 | 0.26 | 0.2 | -0.3 | 0.25 | 0.2 | -0.2 | 6. | 5. | -5. |
| 2221 | 20. | 16. | -19. | 12.7 | 12. | -11. | 0.9 | 0.3 | -1.3 | 0.27 | 0.3 | -0.3 | 0.25 | 0.2 | -0.2 | 8. | 7. | -6. |
| 2225 | 23. | 18. | -20. | 17.4 | 14. | -13. | 0.8 | 0.2 | -1.2 | 0.23 | 0.2 | -0.2 | 0.33 | 0.3 | -0.3 | 9. | 10. | -6. |
| 2229 | 23. | 23. | -21. | 18.6 | 17. | -14. | 0.8 | 0.3 | -1.1 | 0.22 | 0.2 | -0.2 | 0.35 | 0.3 | -0.3 | 8. | 10. | -7. |
| 2233 | 20. | 16. | -15. | 15.7 | 12. | -12. | 0.8 | 0.2 | -1.2 | 0.21 | 0.2 | -0.2 | 0.30 | 0.2 | -0.2 | 6. | 4. | -5. |
| 2237 | 21. | 20. | -19. | 15.3 | 11. | -13. | 0.8 | 0.3 | -1.1 | 0.22 | 0.2 | -0.2 | 0.30 | 0.3 | -0.2 | 8. | 6. | -6. |
| 2241 | 21. | 19. | -18. | 16.1 | 12. | -14. | 0.8 | 0.3 | -1.1 | 0.19 | 0.2 | -0.2 | 0.30 | 0.3 | -0.2 | 8. | 6. | -8. |
| 2245 | 25. | 21. | -19. | 20.5 | 15. | -15. | 0.9 | 0.3 | -1.0 | 0.22 | 0.2 | -0.2 | 0.38 | 0.3 | -0.3 | 9. | 6. | -7. |
| 2249 | 20. | 15. | -15. | 16.8 | 13. | -14. | 0.7 | 0.2 | -1.0 | 0.17 | 0.1 | -0.2 | 0.31 | 0.3 | -0.3 | 6. | 5. | -5. |

## TABLE VIa

### SUMMARY OF TMR LOG-BOOK DATA CORRESPONDING TO INTERVALS SELECTED FOR WAVE METER DATA REDUCTION (PAGE 1 OF 2)

SEA LAND MC LEAN : 1974-1975 WINTER SEASON : VOYAGE 60 WEST

| D.L. RUN NO. | TMR TAPE NO. | TMR INDX NO. | TMR INTV NO. | DATE | TIME (GMT) | LATITUDE | LONGITUDE | COURSE | SPEED KT. | PROP RPM | DRAFT FT. | SEA/AIR TEMP |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2301 | 217 | 1 | 1 | 02-18-75 | 1600 | | | 295 | 27.8 | 113.6 | | 48/53 |
| 2318 | 217 | 5 | 18 | 02-19-75 | 0820 | | | 229 | 32.6 | 133.8 | | 53/55 |
| 2329 | 217 | 8 | 29 | 02-19-75 | 2000 | 43-08 N | 14-40 W | 255 | 31.6 | 129.6 | | 56/55 |
| 2333 | 217 | 9 | 33 | 02-19-75 | 2400 | 43-08 N | 14-40 W | 255 | 31.5 | 129.0 | | 57/53 |
| 2337 | 217 | 10 | 37 | 02-20-75 | 0400 | 43-08 N | 14-40 W | 255 | 31.4 | 128.9 | | 56/53 |
| 2341 | 217 | 11 | 41 | 02-20-75 | 0800 | 43-08 N | 14-40 W | 270 | 31.5 | 129.3 | | 57/53 |
| 2348 | 217 | 12 | 48 | 02-20-75 | 1200 | 39-52 N | 31-00 W | 288 | 31.6 | 129.5 | | 55/56 |
| 2350 | 217 | 13 | 50 | 02-20-75 | 1600 | 39-52 N | 31-00 W | 270 | 31.4 | 128.5 | | 57/61 |
| 2401 | 219 | 16 | 1 | 02-21-75 | 0400 | 39-52 N | 31-00 W | 270 | 27.7 | 113.4 | | 58/55 |
| 2409 | 219 | 18 | 9 | 02-21-75 | 1200 | 39-53 N | 45-20 W | 270 | 21.3 | 87.4 | | 62/49 |
| 2413 | 219 | 19 | 13 | 02-21-75 | 1600 | 39-53 N | 45-20 W | 270 | 21.8 | 89.5 | | 62/50 |
| 2420 | 219 | 20 | 20 | 02-21-75 | 2000 | 39-53 N | 45-20 W | 270 | 22.6 | 92.8 | | 66/54 |
| 2424 | 219 | 21 | 24 | 02-21-75 | 2400 | 39-53 N | 45-20 W | 270 | 21.8 | 89.3 | | 67/57 |
| 2426 | 219 | 22 | 26 | 02-22-75 | 0400 | 39-53 N | 45-20 W | 270 | 22.3 | 91.6 | | 66/55 |
| 2430 | 219 | 23 | 30 | 02-22-75 | 0800 | 39-53 N | 45-20 W | 270 | 22.3 | 91.6 | | 66/55 |
| 2433 | 219 | 24 | 33 | 02-22-75 | 1200 | 39-53 N | 45-20 W | 270 | 22.4 | 91.7 | | 60/48 |
| 2437 | 219 | 25 | 37 | 02-22-75 | 1600 | 39-44 N | 57-05 W | 270 | 21.8 | 89.6 | | 59/49 |
| 2442 | 219 | 26 | 42 | 02-22-75 | 2000 | 39-44 N | 57-05 W | 272 | 21.6 | 88.6 | | 70/50 |
| 2448 | 219 | 27 | 48 | 02-22-75 | 2400 | 39-44 N | 57-05 W | 272 | 22.2 | 90.9 | | 60/50 |

## TABLE VIb

### SUMMARY OF TMR LOG-BOOK DATA CORRESPONDING TO INTERVALS SELECTED FOR WAVE METER DATA REDUCTION (PAGE 2 OF 2)

SEA LAND MC LEAN : 1974-1975 WINTER SEASON : VOYAGE 60 WEST

| D.L. RUN NO. | SEA STATE | <REL WIND> DIR/SPEED /(KT) | REL WAVE DIR | WAVE HT. FT. | REL SWELL DIR | <-SWELL-> HT FT. | <-SWELL-> LENGTH FT. | VISUAL WEATHER /TMR LOG-BOOK COMMENTS |
|---|---|---|---|---|---|---|---|---|
| 2301 | 2 | 70P/ 5 | 70P | 1 | 72P | 4 | 300 | OCAST FOG / |
| 2318 | 2 | 4P/ 5 | 4P | 2 | 4P | 3 | 300 | OCAST / |
| 2329 | 6 | 60S/25 | 60S | 5 | 30P | 4 | 400 | PT CLDY /SEAS OFF STARBOARD BOW |
| 2333 | 6 | 71S/25 | 71S | 6 | 62S | 7 | 600 | PT CLDY / |
| 2337 | 2 | 37S/ 5 | 37S | 4 | 60S | 8 | 600 | PT CLDY / |
| 2341 | | / | 22S | 1 | 22S | 8 | 600 | PT CLDY / |
| 2348 | 4 | 63P/15 | 63P | 3 | 4S | 6 | 600 | PT CLDY / |
| 2350 | 5 | 68P/20 | 68P | 3 | 22S | 3 | 500 | PT CLDY / |
| 2401 | 6 | 68P/25 | 68P | 5 | 22S | 12 | 600 | RAIN / |
| 2409 | 7 | 22S/30 | 22S | 5 | 22S | 14 | 800 | RAIN / |
| 2413 | 1 | 67S/ 2 | 67S | 2 | 67P | 8 | 800 | OCAST / |
| 2420 | 1 | 90P/ 2 | 90P | 1 | 22S | 8 | 800 | OCAST / |
| 2424 | 3 | 0 /10 | 0 | 2 | 67S | 5 | 500 | OCAST / |
| 2426 | 2 | 67S/ 5 | 67S | 2 | 45S | 8 | 600 | OCAST / |
| 2430 | 2 | 67S/ 5 | 67S | 2 | 45S | 10 | 600 | OCAST / |
| 2433 | 7 | 45S/30 | 45S | 5 | 45S | 10 | 600 | OCAST / |
| 2437 | 8 | 67S/35 | 67S | 7 | 45S | 10 | 600 | OCAST / |
| 2442 | 8 | 43S/35 | 43S | 7 | 43S | 6 | 600 | OCAST / |
| 2448 | 4 | 43S/15 | 43S | 4 | 43S | 6 | 600 | OCAST / |

## TABLE VIc

## COMPARISON OF TMR RESULTS FOR MIDSHIP VERTICAL BENDING STRESS WITH CORRESPONDING RAW DIGITIZATION RESULTS AT DAVIDSON LABORATORY

SEA LAND MC LEAN : 1974-1975 WINTER SEASON : VOYAGE 60 WEST

| D.L. RUN NO. | TMR RESULTS: NO. WAVE INDUCED CYCLES (1) | NO. 1ST MODE BURSTS (2) | MAX P-TO-T STRESS KPSI (3) | RMS P-TO-T STRESS KPSI (4) | MAX 1ST MODE STRESS KPSI (5) | D.L. DIGITIZATION: RANGE OF RECORDED EXTREMES KPSI (6) | 2.83X (SAMPLE RMS) KPSI (7) | REL MEAN STRESS KPSI (8) | COLUMN RATIOS: (7) / (4) | (6) / (3+5) | (6) / (3) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 2301 | 172 | 4 | 6.54 | 2.62 | 0.98 | 7.29 | 2.67 | 0.00 | 1.02 | 0.97 | 1.11 |
| 2318 | 154 | 0 | 3.66 | 1.61 | 0.02 | 4.38 | 1.69 | 0.61 | 1.05 | 1.20 | 1.20 |
| 2329 | 177 | 38 | 8.40 | 3.17 | 2.42 | 10.42 | 3.25 | 1.13 | 1.03 | 0.96 | 1.24 |
| 2333 | 179 | 26 | 7.99 | 3.39 | 2.24 | 10.76 | 3.53 | 1.01 | 1.03 | 1.05 | 1.35 |
| 2337 | 171 | 12 | 7.97 | 2.86 | 2.47 | 8.66 | 2.91 | 0.97 | 1.02 | 0.83 | 1.09 |
| 2341 | 180 | 35 | 7.23 | 3.18 | 2.29 | 9.49 | 3.09 | 1.02 | 0.97 | 1.00 | 1.31 |
| 2348 | 199 | 15 | 3.91 | 1.61 | 0.91 | 5.03 | 1.91 | 1.17 | 1.19 | 1.04 | 1.29 |
| 2350 | 176 | 7 | 2.99 | 1.12 | 0.87 | 4.46 | 1.46 | 1.61 | 1.30 | 1.16 | 1.49 |
| 2401 | 199 | 44 | 4.29 | 1.75 | 1.66 | 18.93 | 2.61 | 1.28 | 1.49 | 3.18 | 4.41 |
| 2409 | 184 | 37 | 8.49 | 3.47 | 2.62 | 10.03 | 3.44 | 1.94 | 0.99 | 0.90 | 1.18 |
| 2413 | 180 | 0 | 4.77 | 2.16 | 0.00 | 5.55 | 2.21 | 1.73 | 1.03 | 1.16 | 1.16 |
| 2420 | 186 | 3 | 4.85 | 2.48 | 1.13 | 6.12 | 2.61 | 1.67 | 1.05 | 1.02 | 1.26 |
| 2424 | 194 | 2 | 4.05 | 1.70 | 0.82 | 4.95 | 1.77 | 0.49 | 1.04 | 1.02 | 1.22 |
| 2426 | 182 | 0 | 2.79 | 1.32 | 0.00 | 3.95 | 1.50 | 0.33 | 1.14 | 1.42 | 1.42 |
| 2430 | 185 | 7 | 2.16 | 0.98 | 0.91 | 3.34 | 1.21 | 0.54 | 1.24 | 1.09 | 1.55 |
| 2433 | 185 | 6 | 2.46 | 1.24 | 0.93 | 4.24 | 1.58 | 0.52 | 1.27 | 1.25 | 1.73 |
| 2437 | 194 | 50 | 7.50 | 3.37 | 2.94 | 8.82 | 3.48 | 0.44 | 1.03 | 0.84 | 1.18 |
| 2442 | 206 | 8 | 3.72 | 1.64 | 0.98 | 5.65 | 2.03 | 0.53 | 1.24 | 1.20 | 1.52 |
| 2448 | 139 | 0 | 1.25 | 0.61 | 0.00 | 1.99 | 0.83 | 0.16 | 1.36 | 1.60 | 1.60 |

## TABLE VId

## SUMMARY OF RAW DIGITIZATION RESULTS FOR RADAR RANGE ROLL, PITCH, DECK HOUSE ACCELERATIONS, AND TUCKER METER

SEA LAND MC LEAN : 1974-1975 WINTER SEASON : VOYAGE 60 WEST

| D.L. RUN NO. | RADAR 4.0 (RMS) FT | RADAR RECORDED EXTREMES FT | RADAR RECORDED EXTREMES FT | ROLL 4.0 (RMS) DEG | ROLL RECORDED EXTREMES DEG | ROLL RECORDED EXTREMES DEG | PITCH 4.0 (RMS) DEG | PITCH RECORDED EXTREMES DEG | PITCH RECORDED EXTREMES DEG | VERT ACCEL 4.0 (RMS) (G) | VERT ACCEL RECORDED EXTREMES (G) | VERT ACCEL RECORDED EXTREMES (G) | LAT ACCEL 4.0 (RMS) (G) | LAT ACCEL RECORDED EXTREMES (G) | LAT ACCEL RECORDED EXTREMES (G) | TUCKER 4.0 (RMS) FT | TUCKER RECORDED EXTREMES FT | TUCKER RECORDED EXTREMES FT |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2301 | 9. | 30. | -13. | 1.5 | 2. | -1. | 1.6 | 1.1 | -1.7 | 0.38 | 0.3 | -0.3 | 0.07 | 0.0 | -0.1 | 2. | 2. | -3. |
| 2318 | 20. | 16. | -17. | 5.9 | 5. | -6. | 1.2 | 0.7 | -1.5 | 0.31 | 0.3 | -0.2 | 0.14 | 0.1 | -0.1 | 4. | 4. | -4. |
| 2329 | 35. | 49. | -55. | 3.7 | 1. | -5. | 2.0 | 1.2 | -2.1 | 0.48 | 0.4 | -0.5 | 0.10 | 0.1 | -0.1 | 4. | 3. | -3. |
| 2333 | 29. | 40. | -29. | 3.8 | 1. | -5. | 1.9 | 1.2 | -2.1 | 0.45 | 0.4 | -0.4 | 0.10 | 0.1 | -0.1 | 3. | 2. | -4. |
| 2337 | 37. | 56. | -56. | 3.8 | 2. | -4. | 1.9 | 1.2 | -2.0 | 0.46 | 0.4 | -0.4 | 0.10 | 0.1 | -0.1 | 4. | 3. | -3. |
| 2341 | 36. | 34. | -31. | 3.6 | 2. | -4. | 2.0 | 1.3 | -1.9 | 0.49 | 0.4 | -0.4 | 0.10 | 0.1 | -0.1 | 4. | 3. | -4. |
| 2348 | 25. | 65. | -38. | 3.1 | 4. | -2. | 1.2 | 0.6 | -1.6 | 0.30 | 0.3 | -0.3 | 0.10 | 0.1 | -0.1 | 3. | 2. | -2. |
| 2350 | 14. | 14. | -12. | 3.8 | 4. | -3. | 0.8 | 0.5 | -1.2 | 0.21 | 0.2 | -0.2 | 0.10 | 0.1 | -0.1 | 3. | 3. | -2. |
| 2401 | 38. | 68. | -46. | 4.4 | 6. | -2. | 1.1 | 0.9 | -1.6 | 0.30 | 0.3 | -0.3 | 0.12 | 0.1 | -0.1 | 3. | 2. | -3. |
| 2409 | 42. | 62. | -60. | 4.7 | 2. | -5. | 1.6 | 0.8 | -1.7 | 0.43 | 0.3 | -0.3 | 0.12 | 0.1 | -0.1 | 3. | 2. | -3. |
| 2413 | 42. | 38. | -40. | 3.3 | 2. | -3. | 1.1 | 0.7 | -1.4 | 0.30 | 0.3 | -0.3 | 0.09 | 0.1 | -0.1 | 2. | 2. | -2. |
| 2420 | 24. | 23. | -19. | 3.4 | 3. | -3. | 1.3 | 0.7 | -1.5 | 0.34 | 0.3 | -0.3 | 0.10 | 0.1 | -0.1 | 2. | 2. | -3. |
| 2424 | 16. | 14. | -13. | 2.5 | 2. | -2. | 1.0 | 0.5 | -1.3 | 0.25 | 0.2 | -0.2 | 0.09 | 0.1 | -0.1 | 2. | 1. | -2. |
| 2426 | 14. | 13. | -12. | 3.4 | 2. | -4. | 0.8 | 0.4 | -1.1 | 0.20 | 0.2 | -0.2 | 0.09 | 0.1 | -0.1 | 2. | 1. | -2. |
| 2430 | 12. | 13. | -12. | 2.8 | 0. | -5. | 0.7 | 0.1 | -1.0 | 0.17 | 0.2 | -0.1 | 0.09 | 0.1 | -0.1 | 1. | 1. | -1. |
| 2433 | 25. | 24. | -21. | 4.3 | 0. | -8. | 0.8 | 0.2 | -1.3 | 0.22 | 0.2 | -0.2 | 0.11 | 0.1 | -0.1 | 2. | 2. | -2. |
| 2437 | 32. | 45. | -54. | 5.6 | 2. | -8. | 1.6 | 1.1 | -1.8 | 0.45 | 0.4 | -0.4 | 0.14 | 0.1 | -0.1 | 4. | 3. | -4. |
| 2442 | 16. | 19. | -14. | 3.1 | 1. | -4. | 0.8 | 0.3 | -1.2 | 0.20 | 0.2 | -0.2 | 0.09 | 0.1 | -0.1 | 2. | 2. | -2. |
| 2448 | 10. | 14. | -10. | 2.6 | 2. | -2. | 0.6 | 0.1 | -0.9 | 0.12 | 0.1 | -0.1 | 0.08 | 0.1 | -0.1 | 1. | 1. | -1. |

## TABLE VIIa

## SUMMARY OF TMR LOG-BOOK DATA CORRESPONDING TO INTERVALS SELECTED FOR WAVE METER DATA REDUCTION (PAGE 1 OF 2)

SEA LAND MC LEAN : 1974-1975 WINTER SEASON : VOYAGE 61 EAST

| D.L. RUN NO. | TMR TAPE NO. | TMR INDX NO. | TMR INTV NO. | DATE | TIME (GMT) | LATITUDE | LONGITUDE | COURSE | SPEED KT. | PROP RPM | DRAFT FT. | SEA/AIR TEMP |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2518 | 223 | 5 | 18 | 03-01-75 | 1200 | 38-26 N | 64-10 W | 081 | 29.5 | 121.0 | | 73/60 |
| 2524 | 223 | 6 | 24 | 03-01-75 | 1600 | 38-26 N | 64-10 W | 081 | 29.0 | 119.1 | | 70/61 |
| 2528 | 223 | 7 | 28 | 03-01-75 | 2000 | 38-26 N | 64-10 W | 081 | 29.0 | 119.2 | | 66/60 |
| 2530 | 223 | 8 | 30 | 03-01-75 | 2400 | 38-26 N | 64-10 W | 081 | 28.8 | 118.4 | | 65/65 |
| 2536 | 223 | 9 | 36 | 03-02-75 | 0400 | 38-26 N | 64-10 W | 081 | 29.0 | 119.0 | | 66/65 |
| 2539 | 223 | 10 | 39 | 03-02-75 | 0800 | 38-26 N | 64-10 W | 081 | 29.0 | 119.0 | | 57/54 |
| 2541 | 223 | 11 | 41 | 03-02-75 | 1200 | 40-26 N | 49-37 W | 081 | 29.0 | 119.0 | | 59/64 |
| 2547 | 223 | 12 | 47 | 03-02-75 | 1600 | 40-26 N | 49-37 W | 076 | 29.1 | 119.4 | | 58/62 |
| 2551 | 223 | 13 | 51 | 03-02-75 | 2000 | 40-26 N | 49-37 W | 076 | 28.7 | 118.0 | | 57/60 |
| 2553 | 223 | 14 | 53 | 03-02-75 | 2400 | 40-26 N | 49-37 W | 076 | 29.1 | 119.5 | | 58/60 |
| 2557 | 223 | 15 | 57 | 03-03-75 | 0400 | 40-26 N | 49-37 W | 090 | 29.1 | 119.4 | | 56/61 |
| 2601 | 225 | 16 | 1 | 03-03-75 | 0800 | 40-26 N | 49-37 W | 090 | 20.0 | 82.0 | | 57/61 |
| 2609 | 225 | 18 | 9 | 03-03-75 | 1600 | 41-48 N | 36-08 W | 090 | 19.7 | 80.9 | | 55/69 |
| 2617 | 225 | 20 | 17 | 03-03-75 | 2400 | 41-48 N | 36-08 W | 071 | 19.9 | 81.5 | | 56/57 |
| 2625 | 225 | 22 | 25 | 03-04-75 | 0800 | 41-48 N | 36-08 W | 071 | 19.6 | 80.5 | | 53/58 |
| 2633 | 225 | 24 | 33 | 03-04-75 | 1600 | 43-45 N | 26-00 W | 071 | 19.5 | 80.1 | | 54/59 |
| 2641 | 225 | 26 | 41 | 03-04-75 | 2400 | 43-45 N | 26-00 W | 071 | 19.5 | 79.4 | | 53/58 |
| 2649 | 225 | 28 | 49 | 03-05-75 | 0800 | 43-45 N | 26-00 W | 071 | 19.5 | 80.1 | | 53/56 |
| 2657 | 225 | 30 | 57 | 03-05-75 | 1600 | 46-12 N | 15-42 W | 071 | 19.4 | 79.5 | | 52/53 |

## TABLE VIIb

## SUMMARY OF TMR LOG-BOOK DATA CORRESPONDING TO INTERVALS SELECTED FOR WAVE METER DATA REDUCTION (PAGE 2 OF 2)

SEA LAND MC LEAN : 1974-1975 WINTER SEASON : VOYAGE 61 EAST

| D.L. RUN NO. | SEA STATE | <REL WIND> DIR/SPEED /(KT) | REL WAVE DIR | WAVE HT. FT. | REL SWELL DIR | <-SWELL-> HT FT. | <-SWELL-> LENGTH FT. | VISUAL WEATHER /TMR LOG-BOOK COMMENTS |
|---|---|---|---|---|---|---|---|---|
| 2518 | 4 | 144S/15 | 144S | 3 | 144S | 3 | 600 | OCAST / |
| 2524 | 7 | 121S/30 | 121S | 4 | 144S | 6 | 600 | RAIN FOG / ROLLING 10 DEG PORT 5 STB |
| 2528 | 8 | 88S/35 | 88S | 6 | 99S | 8 | 600 | RAIN / |
| 2530 | 8 | 88S/40 | 88S | 6 | 99S | 8 | 600 | RAIN LIGHTNING / |
| 2534 | 8 | 99S/40 | 99S | 6 | 99S | 8 | 600 | RAIN LIGHTNING / HEAVY ROLL |
| 2539 | 6 | 54S/25 | 54S | 4 | 99S | 6 | 600 | OCAST / |
| 2541 | 6 | 99S/25 | 99S | 4 | 99S | 6 | 600 | OCAST / SLOW HEAVY ROLL |
| 2547 | 6 | 126S/25 | 126S | 4 | 149S | 6 | 800 | OCAST / |
| 2551 | 3 | 149S/10 | 149S | 4 | 149S | 6 | 800 | OCAST / |
| 2553 | 4 | 177P/15 | 177P | 4 | 149S | 6 | 800 | OCAST / |
| 2557 | 4 | 169S/15 | 169S | 3 | 149S | 6 | 600 | PT CLDY / |
| 2601 | 6 | 157S/25 | 157S | 2 | 157S | 5 | 600 | PT CLDY / |
| 2609 | 3 | 180 /10 | 180 | 1 | 146S | 4 | 600 | CLEAR / |
| 2617 | 4 | 159P/15 | 159P | 1 | 159P | 4 | 600 | CLEAR / |
| 2625 | 4 | 159P/15 | 159P | 1 | 159P | 3 | 600 | OCAST / |
| 2633 | 3 | 159P/10 | 159P | 1 | 159P | 3 | 600 | FOG OCAST / |
| 2641 | 3 | 159P/10 | 159P | 1 | 159P | 3 | 800 | FOG RAIN / |
| 2649 | 2 | 159P/ 5 | 159P | 1 | 159P | 2 | 800 | FOG RAIN / |
| 2657 | 4 | 131S/15 | 131S | 2 | 131S | 2 | 800 | FOG RAIN / |

TABLE VIIc

## COMPARISON OF TMR RESULTS FOR MIDSHIP VERTICAL BENDING STRESS WITH CORRESPONDING RAW DIGITIZATION RESULTS AT DAVIDSON LABORATORY

SEA LAND MC LEAN : 1974-1975 WINTER SEASON : VOYAGE 61 EAST

| D.L. RUN NO. | NO. WAVE INDUCED CYCLES (1) | NO. 1ST MODE BURSTS (2) | MAX P-TO-T STRESS KPSI (3) | RMS P-TO-T STRESS KPSI (4) | MAX 1ST MODE STRESS KPSI. (5) | RANGE OF RECORDED EXTREMES KPSI (6) | 2.83X (SAMPLE RMS) KPSI (7) | REL MEAN STRESS KPSI (8) | (7) / (4) | (6) / (3+5) | (6) / (3) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | *<---------TMR RESULTS | | | | ---------------->* | <----D.L. DIGITIZATION | | --->* | <--COLUMN RATIOS--> | | |
| 2518 | 106 | 11 | 4.82 | 1.99 | 1.30 | 5.12 | 2.09 | 0.57 | 1.05 | 0.84 | 1.06 |
| 2524 | 100 | 32 | 6.87 | 3.01 | 1.56 | 8.23 | 3.15 | 0.67 | 1.05 | 0.98 | 1.20 |
| 2528 | 92 | 35 | 6.69 | 3.37 | 1.64 | 8.33 | 3.47 | 0.89 | 1.03 | 1.00 | 1.25 |
| 2530 | 91 | 34 | 5.75 | 2.81 | 1.28 | 7.90 | 3.06 | 0.72 | 1.09 | 1.13 | 1.38 |
| 2536 | 165 | 41 | 4.23 | 2.11 | 1.70 | 7.67 | 2.86 | 0.67 | 1.35 | 1.29 | 1.81 |
| 2539 | 122 | 29 | 6.63 | 2.77 | 1.27 | 8.53 | 3.10 | 0.69 | 1.12 | 1.08 | 1.29 |
| 2541 | 112 | 17 | 5.49 | 2.63 | 1.37 | 7.45 | 3.01 | 0.25 | 1.14 | 1.09 | 1.36 |
| 2547 | 96 | 9 | 6.95 | 3.16 | 1.22 | 8.51 | 3.43 | 0.16 | 1.08 | 1.04 | 1.22 |
| 2551 | 70 | 14 | 11.41 | 3.97 | 1.11 | 10.50 | 4.25 | 0.38 | 1.07 | 0.84 | 0.92 |
| 2553 | 67 | 5 | 8.13 | 4.17 | 0.95 | 9.50 | 4.20 | -0.30 | 1.01 | 1.05 | 1.17 |
| 2557 | 76 | 7 | 7.36 | 3.65 | 1.05 | 8.90 | 3.84 | -0.37 | 1.05 | 1.06 | 1.21 |
| 2601 | 74 | 0 | 8.28 | 3.93 | 0.00 | 9.15 | 4.00 | 0.51 | 1.02 | 1.11 | 1.11 |
| 2609 | 76 | 0 | 7.54 | 3.46 | 0.00 | 8.37 | 3.27 | 1.22 | 0.94 | 1.11 | 1.11 |
| 2617 | 68 | 0 | 8.21 | 3.25 | 0.00 | 7.39 | 3.06 | 1.86 | 0.94 | 0.90 | 0.90 |
| 2625 | 86 | 0 | [illegible].10 | 2.09 | 0.00 | 5.34 | 2.40 | 1.68 | 1.15 | 1.05 | 1.05 |
| 2633 | 75 | 0 | 4.12 | 2.47 | 0.00 | 5.48 | 2.55 | 1.48 | 1.03 | 1.33 | 1.33 |
| 2641 | 73 | 0 | 5.66 | 2.45 | 0.00 | 6.45 | 2.30 | 2.03 | 0.94 | 1.14 | 1.14 |
| 2649 | 70 | 0 | 4.81 | 2.19 | 0.00 | 4.85 | 2.33 | 1.89 | 1.06 | 1.01 | 1.01 |
| 2657 | 73 | 0 | 4.99 | 2.10 | 0.00 | 21.02 ** | 2.19 | 1.81 | 1.04 | 4.22 | 4.22 |

** Probable tape saturation or unrelated transient.

TABLE VIId

## SUMMARY OF RAW DIGITIZATION RESULTS FOR RADAR RANGE ROLL, PITCH, DECK HOUSE ACCELERATIONS, AND TUCKER METER

SEA LAND MC LEAN : 1974-1975 WINTER SEASON : VOYAGE 61 EAST

| D.L. RUN NO. | RADAR 4.0 (RMS) FT | RADAR RECORDED EXTREMES FT | RADAR RECORDED EXTREMES FT | ROLL 4.0 (RMS) DEG | ROLL RECORDED EXTREMES DEG | ROLL RECORDED EXTREMES DEG | PITCH 4.0 (RMS) DEG | PITCH RECORDED EXTREMES DEG | PITCH RECORDED EXTREMES DEG | VERT ACCEL 4.0 (RMS) (G) | VERT ACCEL RECORDED EXTREMES (G) | VERT ACCEL RECORDED EXTREMES (G) | LAT ACCEL 4.0 (RMS) (G) | LAT ACCEL RECORDED EXTREMES (G) | LAT ACCEL RECORDED EXTREMES (G) | TUCKER 4.0 (RMS) FT | TUCKER RECORDED EXTREMES FT | TUCKER RECORDED EXTREMES FT |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2518 | 22. | 20. | -29. | 9.6 | 3. | -11. | 0.8 | 0.2 | -1.2 | 0.20 | 0.2 | -0.2 | 0.14 | 0.1 | -0.1 | 2. | 2. | -3. |
| 2524 | 31. | 30. | -43. | 16.3 | 10. | -18. | 1.0 | 1.0 | -1.6 | 0.26 | 0.3 | -0.3 | 0.31 | 0.3 | -0.3 | 3. | 3. | -3. |
| 2528 | 32. | 28. | -23. | 16.0 | 3. | -17. | 1.0 | 0.5 | -1.5 | 0.32 | 0.3 | -0.3 | 0.32 | 0.2 | -0.2 | 5. | 3. | -5. |
| 2530 | 32. | 31. | -24. | 16.1 | 5. | -18. | 1.0 | 0.4 | -1.3 | 0.28 | 0.3 | -0.2 | 0.30 | 0.2 | -0.2 | 4. | 3. | -4. |
| 2536 | 31. | 28. | -30. | 10.8 | 4. | -15. | 1.2 | 0.6 | -1.8 | 0.35 | 0.3 | -0.3 | 0.21 | 0.2 | -0.2 | 5. | 3. | -5. |
| 2539 | 31. | 27. | -22. | 14.0 | 6. | -16. | 1.2 | 0.7 | -1.6 | 0.35 | 0.3 | -0.3 | 0.27 | 0.2 | -0.2 | 5. | 4. | -4. |
| 2541 | 31. | 24. | -23. | 14.0 | 5. | -16. | 1.0 | 0.6 | -1.6 | 0.32 | 0.3 | -0.3 | 0.28 | 0.2 | -0.2 | 5. | 4. | -4. |
| 2547 | 41. | 39. | -45. | 23.4 | 11. | -24. | 0.9 | 0.3 | -1.7 | 0.29 | 0.3 | -0.2 | 0.44 | 0.4 | -0.3 | 5. | 3. | -4. |
| 2551 | 52. | 51. | -49. | 27.9 | 13. | -27. | 0.9 | 0.4 | -1.5 | 0.28 | 0.3 | -0.3 | 0.50 | 0.4 | -0.4 | 4. | 4. | -4. |
| 2553 | 44. | 35. | -36. | 24.7 | 11. | -27. | 0.9 | 0.2 | -1.7 | 0.28 | 0.3 | -0.2 | 0.44 | 0.4 | -0.3 | 5. | 3. | -4. |
| 2557 | 47. | 50. | -42. | 27.9 | 17. | -28. | 0.9 | 0.3 | -1.6 | 0.29 | 0.3 | -0.2 | 0.51 | 0.4 | -0.4 | 5. | 3. | -4. |
| 2601 | 35. | 29. | -36. | 16.2 | 8. | -17. | 0.7 | 0.1 | -1.5 | 0.22 | 0.2 | -0.2 | 0.31 | 0.3 | -0.3 | 5. | 3. | -4. |
| 2609 | 25. | 20. | -22. | 10.1 | 4. | -11. | 0.7 | 0.1 | -1.3 | 0.20 | 0.2 | -0.2 | 0.20 | 0.2 | -0.2 | 4. | 3. | -3. |
| 2617 | 18. | 14. | -14. | 8.2 | 6. | -8. | 0.8 | 0.1 | -1.1 | 0.20 | 0.2 | -0.1 | 0.17 | 0.2 | -0.1 | 3. | 3. | -2. |
| 2625 | 18. | 15. | -18. | 8.3 | 7. | -6. | 0.8 | 0.2 | -0.9 | 0.19 | 0.2 | -0.2 | 0.17 | 0.1 | -0.1 | 3. | 2. | -2. |
| 2633 | 18. | 16. | -14. | 7.6 | 5. | -7. | 0.7 | 0.2 | -1.0 | 0.18 | 0.2 | -0.2 | 0.16 | 0.1 | -0.1 | 3. | 2. | -2. |
| 2641 | 17. | 14. | -16. | 6.8 | 4. | -7. | 0.7 | 0.1 | -1.0 | 0.15 | 0.1 | -0.1 | 0.15 | 0.1 | -0.1 | 2. | 2. | -2. |
| 2649 | 13. | 11. | -12. | 6.6 | 4. | -8. | 0.7 | 0.0 | -1.0 | 0.15 | 0.1 | -0.1 | 0.14 | 0.1 | -0.1 | 2. | 1. | -2. |
| 2657 | 13. | 12. | -11. | 6.5 | 3. | -9. | 0.7 | -0.0 | -1.0 | 0.14 | 0.1 | -0.1 | 0.14 | 0.1 | -0.1 | 2. | 2. | -2. |

## TABLE VIIIa

### SUMMARY OF TMR LOG-BOOK DATA CORRESPONDING TO INTERVALS SELECTED FOR WAVE METER DATA REDUCTION (PAGE 1 OF 2)

SEA LAND MC LEAN : 1974-1975 WINTER SEASON : VOYAGE 61 WEST

| D.L. RUN NO. | TMR TAPE NO. | TMR INDX NO. | TMR INTV NO. | DATE | TIME (GMT) | LATITUDE | LONGITUDE | COURSE | SPEED KT. | PROP RPM | DRAFT FT. | SEA/AIR TEMP |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2713 | 229 | 4 | 13 | 03-11-75 | 2400 | 50-02 N | 00-47 W | 244 | 33.1 | 133.5 | | 51/48 |
| 2725 | 229 | 7 | 25 | 03-12-75 | 1200 | 44-15 N | 17-36 W | 244 | 32.2 | 132.0 | | 52/52 |
| 2737 | 229 | 10 | 37 | 03-12-75 | 2400 | 44-15 N | 17-36 W | 244 | 29.3 | 120.0 | | 53/55 |
| 2749 | 229 | 13 | 49 | 03-13-75 | 1200 | 38-53 N | 32-04 W | 246 | 29.4 | 120.5 | | 55/61 |
| 2761 | 229 | 16 | 61 | 03-13-75 | 2400 | 38-53 N | 32-04 W | 273 | 16.8 | 69.1 | | 55/58 |
| 2811 | 231 | 19 | 11 | 03-14-75 | 1200 | 39-16 N | 44-00 W | 273 | 16.8 | 69.1 | | 58/61 |
| 2833 | 231 | 25 | 33 | 03-15-75 | 1200 | 39-29 N | 52-40 W | 273 | 17.4 | 71.7 | | 58/54 |
| 2837 | 231 | 26 | 37 | 03-15-75 | 1600 | 39-29 N | 52-40 W | 273 | 17.5 | 72.3 | | 58/63 |
| 2841 | 231 | 27 | 41 | 03-15-75 | 2000 | 39-29 N | 52-40 W | 273 | 17.0 | 73.0 | | 58/60 |
| 2846 | 231 | 28 | 46 | 03-15-75 | 2400 | 39-29 N | 52-40 W | 273 | 16.6 | 68.0 | | 63/62 |
| 2849 | 231 | 29 | 49 | 03-16-75 | 0400 | 39-29 N | 52-40 W | 273 | 16.3 | 67.0 | | 65/52 |
| 2853 | 231 | 30 | 53 | 03-16-75 | 0800 | 39-29 N | 52-40 W | 270 | 17.1 | 70.5 | | 61/55 |
| 2905 | 233 | 32 | 5 | 03-16-75 | 1400 | 39-54 N | 60-37 W | 270 | 17.1 | 70.4 | | 60/53 |
| 2906 | 233 | 32 | 6 | 03-16-75 | 1400 | 39-54 N | 60-37 W | 270 | 17.1 | 70.4 | | 60/53 |
| 2911 | 233 | 33 | 11 | 03-16-75 | 1600 | 39-54 N | 60-37 W | 270 | 17.1 | 70.8 | | 64/52 |
| 2914 | 233 | 34 | 14 | 03-16-75 | 1800 | 39-54 N | 60-37 W | 270 | 17.1 | 73.6 | | 64/52 |
| 2918 | 233 | 35 | 18 | 03-16-75 | 2000 | 39-54 N | 60-37 W | 270 | 17.6 | 72.5 | | 66/45 |
| 2921 | 233 | 36 | 21 | 03-16-75 | 2400 | 39-54 N | 60-37 W | 270 | 18.0 | 74.1 | | 48/49 |
| 2925 | 233 | 37 | 25 | 03-17-75 | 0400 | 39-54 N | 60-37 W | 270 | 17.2 | 71.0 | | 60/53 |

## TABLE VIIIb

### SUMMARY OF TMR LOG-BOOK DATA CORRESPONDING TO INTERVALS SELECTED FOR WAVE METER DATA REDUCTION (PAGE 2 OF 2)

SEA LAND MC LEAN : 1974-1975 WINTER SEASON : VOYAGE 61 WEST

| D.L. RUN NO. | SEA STATE | <REL WIND> DIR/SPEED /(KT) | REL WAVE DIR | WAVE HT. FT. | REL SWELL DIR | <-SWELL-> HT FT. | LENGTH FT. | VISUAL WEATHER /TMR LOG-BOOK COMMENTS |
|---|---|---|---|---|---|---|---|---|
| 2713 | 3 | 177P/10 | 177P | 2 | 116S | 2 | 500 | PT CLDY / |
| 2725 | 4 | 71S/15 | 71S | 1 | 116S | 2 | 600 | CLEAR / |
| 2737 | 4 | 3S/15 | 3S | 1 | 19P | 2 | 600 | OCAST / |
| 2749 | 3 | 55P/10 | 55P | 1 | 21P | 2 | 400 | PT CLDY / |
| 2761 | 2 | 87S/ 5 | 87S | 1 | 87S | 2 | 400 | PT CLDY / |
| 2811 | 1 | 42S/ 2 | 42S | 1 | 87S | 2 | 600 | CLEAR / |
| 2833 | 5 | 138P/20 | 138P | 2 | 48P | 2 | 400 | OCAST / |
| 2837 | 6 | 117P/25 | 117P | 4 | 48P | 4 | 400 | OCAST / |
| 2841 | 7 | 48P/30 | 48P | 6 | 48P | 6 | 400 | OCAST / |
| 2846 | 7 | 48P/30 | 48P | 10 | 48P | 10 | 600 | OCAST / |
| 2849 | 7 | 3P/35 | 3P | 20 | 3P | 20 | 600 | OCAST / |
| 2853 | 9 | 22S/45 | 22S | 20 | 0 | 20 | 600 | OCAST / |
| 2905 | 7 | 67S/35 | 67S | 15 | 67S | 15 | 600 | OCAST / |
| 2906 | 7 | 67S/35 | 67S | 15 | 67S | 15 | 600 | OCAST / |
| 2911 | 6 | 67S/25 | 67S | 10 | 67S | 10 | 600 | PT CLDY / |
| 2914 | 6 | 67S/25 | 67S | 10 | 67S | 10 | 600 | PT CLDY / |
| 2918 | 5 | 67S/20 | 67S | 10 | 67S | 10 | 600 | PT CLDY / END MANUAL RECORD |
| 2921 | 4 | 67S/15 | 67S | 6 | 67S | 6 | 600 | PT CLDY / |
| 2925 | 3 | 67S/10 | 67S | 2 | 67S | 2 | 800 | PT CLDY / |

## TABLE VIIIc

## COMPARISON OF TMR RESULTS FOR MIDSHIP VERTICAL BENDING STRESS WITH CORRESPONDING RAW DIGITIZATION RESULTS AT DAVIDSON LABORATORY

SEA LAND MC LEAN : 1974-1975 WINTER SEASON : VOYAGE 61 WEST

| | TMR RESULTS | | | | | D.L. DIGITIZATION | | | COLUMN RATIOS | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| D.L. RUN NO. | NO. WAVE INDUCED CYCLES (1) | NO. 1ST MODE BURSTS (2) | MAX P-TO-T STRESS KPSI (3) | RMS P-TO-T STRESS KPSI (4) | MAX 1ST MODE STRESS KPSI (5) | RANGE OF RECORDED EXTREMES KPSI (6) | 2.83X (SAMPLE RMS) KPSI (7) | REL MEAN STRESS KPSI (8) | (7) / (4) | (6) / (3+5) | (6) / (3) |
| 2713 | 95 | 0 | 3.91 | 1.70 | 0.00 | 4.56 | 1.98 | 0.08 | 1.16 | 1.17 | 1.17 |
| 2725 | 81 | 0 | 4.01 | 1.70 | 0.00 | 4.24 | 1.91 | 1.46 | 1.13 | 1.06 | 1.06 |
| 2737 | 153 | 2 | 3.84 | 1.69 | 0.71 | 4.56 | 1.79 | -0.47 | 1.06 | 1.00 | 1.19 |
| 2749 | 161 | 0 | 2.53 | 1.39 | 0.00 | 3.54 | 1.53 | 0.22 | 1.10 | 1.40 | 1.40 |
| 2761 | 129 | 0 | 5.75 | 2.44 | 0.00 | 4.44 | 2.04 | 1.90 | 0.84 | 0.77 | 0.77 |
| 2811 | 149 | 0 | 2.72 | 1.22 | 0.00 | 3.01 | 1.30 | 0.65 | 1.06 | 1.11 | 1.11 |
| 2833 | 179 | 0 | 2.59 | 1.06 | 0.00 | 2.62 | 1.11 | 0.27 | 1.05 | 1.01 | 1.01 |
| 2837 | 165 | 0 | 2.05 | 0.99 | 0.00 | 2.46 | 1.04 | 0.06 | 1.05 | 1.20 | 1.20 |
| 2841 | 180 | 14 | 6.38 | 2.43 | 1.20 | 6.36 | 2.49 | 0.18 | 1.02 | 0.84 | 1.00 |
| 2846 | 166 | 37 | 9.41 | 4.10 | 2.18 | 10.01 | 3.94 | 0.35 | 0.96 | 0.86 | 1.06 |
| 2849 | 164 | 43 | 11.64 | 4.92 | 3.34 | 12.93 | 4.51 | 0.65 | 0.92 | 0.86 | 1.11 |
| 2853 | 144 | 69 | 15.33 | 5.94 | 2.78 | 14.20 | 5.25 | 0.71 | 0.88 | 0.78 | 0.93 |
| 2905 | 148 | 72 | 17.38 | 7.58 | 4.74 | 17.56 | 7.39 | 0.22 | 0.98 | 0.79 | 1.01 |
| 2906 | 152 | 82 | 13.96 | 6.40 | 3.85 | 17.03 | 5.93 | 0.22 | 0.93 | 0.96 | 1.22 |
| 2911 | 150 | 37 | 10.19 | 4.42 | 2.72 | 10.93 | 4.16 | 0.10 | 0.94 | 0.85 | 1.07 |
| 2914 | 156 | 22 | 8.71 | 3.59 | 1.56 | 9.52 | 3.45 | -0.03 | 0.96 | 0.93 | 1.09 |
| 2918 | 157 | 17 | 6.46 | 3.16 | 1.43 | 6.77 | 2.99 | 0.13 | 0.95 | 0.86 | 1.05 |
| 2921 | 149 | 3 | 4.04 | 1.86 | 0.67 | 4.65 | 1.95 | 0.19 | 1.05 | 0.99 | 1.15 |
| 2925 | 123 | 0 | 2.93 | 1.[illegible]1 | 0.00 | 3.03 | 1.20 | 0.13 | 1.08 | 1.04 | 1.04 |

## TABLE VIIId

## SUMMARY OF RAW DIGITIZATION RESULTS FOR RADAR RANGE ROLL, PITCH, DECK HOUSE ACCELERATIONS, AND TUCKER METER

SEA LAND MC LEAN : 1974-1975 WINTER SEASON : VOYAGE 61 WEST

| | RADAR | | | ROLL | | | PITCH | | | VERT ACCEL | | | LAT ACCEL | | | TUCKER | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| D.L. RUN NO. | 4.0 (RMS) FT | RECORDED EXTREMES FT | FT | 4.0 (RMS) DEG | RECORDED EXTREMES DEG | DEG | 4.0 (RMS) DEG | RECORDED EXTREMES DEG | DEG | 4.0 (RMS) (G) | RECORDED EXTREMES (G) | (G) | 4.0 (RMS) (G) | RECORDED EXTREMES (G) | (G) | 4.0 (RMS) FT | RECORDED EXTREMES FT | FT |
| 2713 | 19. | 16. | -16. | 7.6 | 5. | -8. | 0.8 | 0.2 | -1.3 | 0.24 | 0.2 | -0.2 | 0.16 | 0.1 | -0.1 | 3. | 3. | -3. |
| 2725 | 17. | 14. | -13. | 8.8 | 5. | -8. | 0.7 | 0.2 | -0.9 | 0.15 | 0.1 | -0.1 | 0.18 | 0.1 | -0.1 | 2. | 2. | -2. |
| 2737 | 16. | 17. | -13. | 4.4 | 3. | -4. | 1.0 | 0.5 | -1.3 | 0.24 | 0.2 | -0.2 | 0.10 | 0.1 | -0.1 | 2. | 2. | -2. |
| 2749 | 14. | 12. | -13. | 4.2 | 3. | -3. | 0.9 | 0.3 | -1.2 | 0.21 | 0.2 | -0.2 | 0.11 | 0.1 | -0.1 | 2. | 2. | -2. |
| 2761 | 19. | 17. | -16. | 3.2 | 2. | -5. | 1.0 | 0.4 | -1.4 | 0.24 | 0.2 | -0.2 | 0.13 | 0.1 | -0.1 | 3. | 2. | -3. |
| 2811 | 13. | 12. | -10. | 4.0 | 3. | -4. | 0.7 | 0.2 | -0.9 | 0.17 | 0.1 | -0.1 | 0.10 | 0.1 | -0.1 | 2. | 2. | -2. |
| 2833 | 10. | 9. | -8. | 2.9 | 1. | -4. | 0.7 | 0.2 | -0.9 | 0.16 | 0.1 | -0.1 | 0.09 | 0.1 | -0.1 | 2. | 1. | -1. |
| 2837 | 11. | 10. | -11. | 2.7 | 4. | -1. | 0.7 | 0.1 | -1.0 | 0.17 | 0.1 | -0.1 | 0.09 | 0.1 | -0.1 | 1. | 1. | -1. |
| 2841 | 23. | 16. | -29. | 3.9 | 5. | -2. | 1.3 | 0.7 | -1.6 | 0.39 | 0.3 | -0.3 | 0.11 | 0.1 | -0.1 | 3. | 2. | -3. |
| 2846 | 33. | 28. | -37. | 3.9 | 7. | -2. | 1.6 | 1.3 | -1.6 | 0.48 | 0.4 | -0.4 | 0.12 | 0.1 | -0.1 | 3. | 3. | -3. |
| 2849 | 36. | 27. | -39. | 3.7 | 3. | -3. | 1.6 | 1.0 | -1.7 | 0.43 | 0.4 | -0.4 | 0.11 | 0.1 | -0.1 | 4. | 3. | -4. |
| 2853 | 42. | 33. | -50. | 3.7 | 2. | -4. | 1.9 | 1.4 | -1.8 | 0.50 | 0.4 | -0.4 | 0.10 | 0.1 | -0.1 | 5. | 3. | -4. |
| 2905 | 62. | 41. | -61. | 5.4 | 1. | -7. | 2.4 | 1.8 | -2.0 | 0.62 | 0.5 | -0.5 | 0.14 | 0.1 | -0.1 | 5. | 4. | -4. |
| 2906 | 52. | 40. | -54. | 5.2 | 1. | -7. | 2.1 | 1.3 | -1.8 | 0.57 | 0.5 | -0.5 | 0.13 | 0.1 | -0.1 | 4. | 4. | -4. |
| 2911 | 44. | 31. | -44. | 4.8 | 2. | -7. | 1.9 | 1.2 | -1.8 | 0.50 | 0.4 | -0.4 | 0.12 | 0.1 | -0.1 | 5. | 4. | -4. |
| 2914 | 39. | 30. | -41. | 5.6 | 3. | -7. | 1.6 | 0.9 | -1.7 | 0.46 | 0.4 | -0.4 | 0.14 | 0.1 | -0.1 | 5. | 4. | -4. |
| 2918 | 31. | 26. | -31. | 6.7 | 3. | -9. | 1.4 | 0.8 | -1.6 | 0.40 | 0.3 | -0.4 | 0.15 | 0.1 | -0.1 | 5. | 3. | -4. |
| 2921 | 16. | 14. | -23. | 4.3 | 3. | -5. | 1.0 | 0.5 | -1.2 | 0.25 | 0.2 | -0.2 | 0.12 | 0.1 | -0.1 | 3. | 3. | -3. |
| 2925 | 9. | 9. | -8. | 2.6 | 1. | -3. | 0.7 | 0.2 | -1.0 | 0.15 | 0.1 | -0.1 | 0.09 | 0.1 | -0.1 | 2. | 2. | -2. |

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So that more precise correlations between full scale observations and analytical and model results could be carried out, one of the objectives of the instrumentation program for the SL-7 class container ships was the provision of instrumental measures of the wave environment. To this end, two wave meter systems were installed on the S.S. SEA-LAND McLEAN. Raw data was collected from both systems during the second (1973-1974) and third (1974-1975) winter data collecting seasons.


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It was the purpose of the present work to reduce this raw data, to develop and implement such corrections as were found necessary and feasible, and to correlate and evaluate the final results from the two wave meters. In carrying out this work it was necessary to at least partly reduce several other channels of recorded data, so that, as a by-product, reduced results were also obtained for midship bending stresses, roll, pitch, and two components of acceleration on the ship's bridge.

As the work progressed it became evident that the volume of documentation required would grow beyond the usual dimensions of a single technical report. For this reason the analyses, the methods, the detailed results, discussions, and conclusions are contained in a series of ten related reports.

The present report parallels the first report in the series in that it documents the sampling and calibration of data from the third (1974-1975) recording season, and presents a summary of initial results.

# METRIC CONVERSION FACTORS

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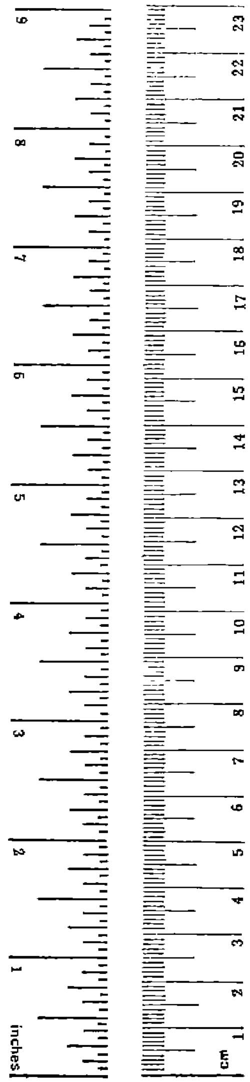
## Approximate Conversions to Metric Measures

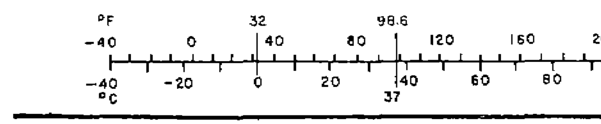
| Symbol | When You Know | Multiply by | To Find | Symbol |
|---|---|---|---|---|
| | | **LENGTH** | | |
| in | inches | *2.5 | centimeters | cm |
| ft | feet | 30 | centimeters | cm |
| yd | yards | 0.9 | meters | m |
| mi | miles | 1.6 | kilometers | km |
| | | **AREA** | | |
| $in^2$ | square inches | 6.5 | square centimeters | $cm^2$ |
| $ft^2$ | square feet | 0.09 | square meters | $m^2$ |
| $yd^2$ | square yards | 0.8 | square meters | $m^2$ |
| $mi^2$ | square miles | 2.6 | square kilometers | $km^2$ |
| | acres | 0.4 | hectares | ha |
| | | **MASS (weight)** | | |
| oz | ounces | 28 | grams | g |
| lb | pounds | 0.45 | kilograms | kg |
| | short tons (2000 lb) | 0.9 | tonnes | t |
| | | **VOLUME** | | |
| tsp | teaspoons | 5 | milliliters | ml |
| Tbsp | tablespoons | 15 | milliliters | ml |
| fl oz | fluid ounces | 30 | milliliters | ml |
| c | cups | 0.24 | liters | l |
| pt | pints | 0.47 | liters | l |
| qt | quarts | 0.95 | liters | l |
| gal | gallons | 3.8 | liters | l |
| $ft^3$ | cubic feet | 0.03 | cubic meters | $m^3$ |
| $yd^3$ | cubic yards | 0.76 | cubic meters | $m^3$ |
| | | **TEMPERATURE (exact)** | | |
| °F | Fahrenheit temperature | 5/9 (after subtracting 32) | Celsius temperature | °C |

*1 in = 2.54 (exactly). For other exact conversions and more detailed tables, see NBS Misc. Publ. 286, Units of Weights and Measures, Price $2.25, SD Catalog No. C13.10:286.




## Approximate Conversions from Metric Measures

| Symbol | When You Know | Multiply by | To Find |
|---|---|---|---|
| | | **LENGTH** | |
| mm | millimeters | 0.04 | inches |
| cm | centimeters | 0.4 | inches |
| m | meters | 3.3 | feet |
| m | meters | 1.1 | yards |
| km | kilometers | 0.6 | miles |
| | | **AREA** | |
| $cm^2$ | square centimeters | 0.16 | square inches |
| $m^2$ | square meters | 1.2 | square yards |
| $km^2$ | square kilometers | 0.4 | square miles |
| ha | hectares (10,000 $m^2$) | 2.5 | acres |
| | | **MASS (weight)** | |
| g | grams | 0.035 | ounces |
| kg | kilograms | 2.2 | pounds |
| t | tonnes (1000 kg) | 1.1 | short tons |
| | | **VOLUME** | |
| ml | milliliters | 0.03 | fluid ounces |
| l | liters | 2.1 | pints |
| l | liters | 1.06 | quarts |
| l | liters | 0.26 | gallons |
| $m^3$ | cubic meters | 35 | cubic feet |
| $m^3$ | cubic meters | 1.3 | cubic yards |
| | | **TEMPERATURE (exact)** | |
| °C | Celsius temperature | 9/5 (then add 32) | Fahrenheit temperature |



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SL-7-16, *Radar and Tucker Wavemeter Data from S. S. SEA-LAND McLEAN - Voyage 32* by J. F. Dalzell. 1978.

SL-7-17, *Radar and Tucker Wavemeter Data from S. S. SEA-LAND McLEAN - Voyage 33* by J. F. Dalzell. 1978.

SL-7-18, *Radar and Tucker Wavemeter Data from S. S. SEA-LAND McLEAN - Voyage 34* by J. F. Dalzell. 1978.

SL-7-19, *Radar and Tucker Wavemeter Data from S. S. SEA-LAND McLEAN - Voyages 35 and 36E* by J. F. Dalzell. 1978.

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