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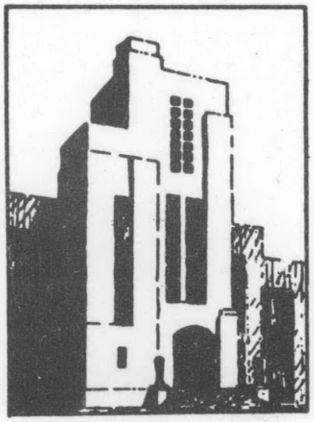
PRELIMINARY REPORT OF STRAINS AND MOTIONS OF THE SS ESSO ASHEVILLE FOR THE PERIOD 24 AUGUST 1952 THROUGH 31 JULY 1953

by

Norman H. Jasper



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PRELIMINARY REPORT OF STRAINS AND MOTIONS OF THE SS ESSO ASHEVILLE FOR THE PERIOD 24 AUGUST 1952 THROUGH 31 JULY 1953

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ABSTRACT

Stresses amidships as well as pitching and heaving accelerations were measured on the T-2 tanker ESSO ASHEVILLE during the vessel's normal commercial operations over the period August 1952 to July 1953. The data were obtained automatically, using a sampling procedure.

Analysis of the data indicates that the dynamic stress variations associated with the ship's motion in the waves will rarely exceed 10,000 psi peak to peak. Also, stress variations due to changes in temperature distribution, such as occur from night to day, are of the same order of magnitude as those due to changes in dead-load distribution. The maximum measured stress variation (free of stress concentration) due to change in temperature was about 10,900 psi.

SUMMARY

Stresses amidships as well as pitching and heaving accelerations were measured on the T-2 tanker ESSO ASHEVILLE during the vessel's normal commercial operations over the period 24 August 1952 to 31 July 1953. The data were obtained automatically, using a sampling procedure.

The data indicate that the dynamic stress variations in the hull girder, free of stress concentration, due to the motion of the ship in a seaway will rarely exceed 10,000 psi peak to peak. The greatest dynamic stress measured was 9,400 psi, and by far the largest number of variations were of a magnitude less than 4,000 psi. The periodicity of the stress variations is predominantly the same as that of the heaving and pitching motions. The stresses on the port and starboard side of the main deck amidships are not generally the same; there is frequently a considerable difference which may be due to the effects of torsion and transverse bending of the hull. It was

found that the pitch acceleration makes a major contribution to linear accelerations experienced at points removed from the center of the ship.

It is concluded that the stress variations due to changes in temperature distribution, such as occur from night to day, are quite large, as large or larger than those due to load changes, and occur regularly with a period of one day. The maximum measured variation in a day was about 10,000 psi. This stress variation is generally not the same on the port and starboard sides of the main deck.

It was not possible to separate stresses due to dead-load changes from those due to temperature changes. The largest stress change measured during any one loading operation took place on 17 April 1953 resulting in a stress variation of 10,900 psi (port) and -1000 psi (starboard) main deck, amidships.

INTRODUCTION

This interim report discusses the stresses and motions measured on a T-2 tanker, the ESSO ASHEVILLE, during the period from 24 August 1952 to 31 July 1953. During this period the vessel was engaged in coastal traffic along the Atlantic seaboard, Central America, and the Gulf ports. The vessel is a single-deck, longitudinally framed tanker with a length between perpendiculars of 503 ft, a molded beam of 68 ft, a molded depth of 39 ft 3 in., and a displacement of 21,880 tons.

It is the general purpose of these tests to determine the magnitudes and frequency distributions of the dynamic stresses (due to wave action) and the rigid-body motions of the ship under actual service conditions. It has been possible, in addition, to measure the deck stresses amidships during variations in static load distribution as well as those stresses incident to a non-uniform temperature distribution in the hull girder. The dynamic stresses and motions will be discussed first, and then the static load and temperature stresses will be discussed.

INSTRUMENTATION

The stresses in the fore-and-aft direction were measured at the port and starboard edges of the main deck at a point approximately 7 in. inboard from the deck coaming. The measurements were made by means of SR-4 strain gages connected so as to give an output proportional to stress in the fore-and-aft direction; see Figure 1. The measured stresses include the stress components due to static and dynamic load and those due to temperature gradients. The gages were temperature-compensated so as not to include strains unaccompanied by stress. An electro-mechanical strain gage was installed at Frame 57 over the starboard longitudinal bulkhead; a heave accelerometer was installed at this same location, which is close to the fore-and-aft position of the center of gravity. The rigid-body pitch acceleration of the ship was measured by means of two linear accelerometers spaced 12 ft 4 in. apart on the bridge deck which were connected so as to be electrically in opposition giving an output proportional to pitch acceleration. All accelerometers and the 10-in. strain gage were built by the Schaevitz Engineering Company and utilized differential transformers as the sensing elements.

The outputs of these gages were recorded, automatically, at hourly intervals for a 2-min duration. The recorder used was the "TMB Automatic Ship's Motion Recorder" which is described in TMB Report 777. The automatic timing motor on this recorder did, on occasion, fail to operate properly resulting in the loss of sampled data for some periods of time. The heave accelerometer and 10-in. strain gage did suffer occasional damage due to salt water corrosion; the SR-4 gages and pitch accelerometers operated satisfactorily throughout the tests.

On 11 April 1953 a Sperry roll and pitch angle recorder was installed on the ship; it was hooked up so as to record at the same time as the TMB recorder.

DYNAMIC STRESSES AND MOTIONS

It was intended to classify the data obtained for the loaded and ballast conditions separately; however, since the loading conditions of the ship, whether in ballast or loaded, are not known for all voyages the data are not separated. The analysis of the records is in a form which will readily permit such separation whenever the loading data are made available.

Figure 2 gives the stress and motion data measured during the past year classified according to the magnitude and the frequency of occurrence of the cyclic variations. Each cyclic variation is understood to mean a complete cycle; for example in the case of stress it would denote a stress variation from hog to sag and back to hog again such as would be encountered during the passage of a single wave.

The ratio of "Duration of Voyage" to the "Total Sampling Time" as stated in Figure 2 gives an indication of how representative of all conditions encountered during the particular voyage the sampled data probably is. If the ratio is 30, it means that a 2-min record was taken at hourly intervals and the data obtained may be expanded with a high degree of validity. If the ratio is much greater than 30, it indicates that, during portions of the voyage no automatically sampled data was obtained. The data given in Figure 2 include only those obtained during automatic sampling; data obtained during manual recording were used only in determining maximum stresses and motions as well as static stress variations. Sea conditions encountered varied from fairly severe to calm.

It is seen from an inspection of Figure 2 that by far the greatest number of stress variations associated with the passage of waves past the ship have a magnitude of less than 4000 psi peak to peak. No stress variations incident to the wave action, of magnitude greater than 10,000 psi, were observed at any time and therefore such occasions may be considered quite rare. The periods of the variations in stress, heave, and pitch are most often nearly the same and most of the cyclic variations occurred with periods of from 5 to 7 sec. Comparison of the pitch and heave accelerations shows that the pitch acceleration is responsible for by far the greater contribution to the resultant linear acceleration experienced near the ends of the ship.

It was observed throughout the tests that the stress variations on the port and starboard sides were generally of different magnitudes. For long periods at a time (many hours) the starboard gage would indicate greater stress variation than that on the port side; at other times the reverse would be true. On the whole the tendency was toward larger stresses on the starboard side. These differences in the stresses between port and starboard sides of the main deck may be due, in part, to the direction of the sea relative to the ship which may give rise to athwartships bending in combination with bending in the vertical plane.

Figure 3 presents in graphical form the maximum values of stresses and motions measured during the time covered here. The recorder was unfortunately inoperative during much of February and March, but no unusually heavy seas were reported during this time. No significant differences between ballast and load conditions were noted.

The most severe conditions encountered at any time were measured in Period 4 which covers the time from 14 December 1952 to 9 January 1953 during which the vessel operated between Norfolk, Virginia, and Baton Rouge, Louisiana, and Philadelphia, Pennsylvania. Typical severe conditions were as follows:

a. 23 Dec 0600 to 24 Dec 2400 (1952) - LOADED CONDITION

Pitching motion predominated. The following maxima were recorded at 1500 on 23 Dec: Heave acceleration 0.27 g's, pitch acceleration 0.10 radians/sec^2, stress, starboard gage 8000 psi, stress, port gage 7200 psi. All values given are peak-to-peak variations.

b. 30 Dec 1800 to 31 Dec 1200 (1952) - BALLAST CONDITION

Pitching motion is predominant, and the stress variations have the same periodicity as the pitching motions. The following maxima were recorded at 0800 on 31 December: Heave acceleration 0.13 g's, pitch acceleration 0.10 radians/sec^2, stress, starboard gage 9400 psi, stress, port gage 3500 psi. All values given are peak-to-peak variations.

c. 3 Jan 1700 to 4 Jan 2300 (1953) - LOADED CONDITION

Large stresses having a period of about 15 sec (roll period) were recorded. The maximum stresses and motions were recorded at about 0300 on 4 Jan and were as follows: Heave acceleration 0.06 g's, pitch acceleration - negligible, stress, starboard gage 5500 psi, stress, port gage 7400 psi. All values given are peak-to-peak variations and in this case the stresses given were not measured simultaneously.

The pitch acceleration has been given, in Figure 3, in terms of units of gravity per 100-ft difference in longitudinal position along the ship. This is done for the sake of convenience. For example if one wishes to know the contribution of the pitching acceleration to the linear acceleration at a point 300 ft from the center of pitching it is only necessary to multiply the figure given in Figure 3 by three.

The overall impressions gathered from the analysis of the dynamic stresses and motions are:

1. The stress variations in the hull girder (peak-to-peak) due to the action of the weather and seas will rarely exceed 10,000 psi.

2. The stress variations are predominantly of a periodicity which is the same as that of the pitching and heaving motions.

3. The stresses on the port and starboard side of the main deck amidships are generally not the same; there is, in fact, often a considerable difference.

4. The pitch acceleration makes a major contribution to the linear acceleration experienced at points far from the center of gravity of the ship.

STRESSES DUE TO CARGO LOADING AND TEMPERATURE GRADIENTS

Before discussing the stresses it may be well to look into the validity of the strain-gage measurements. The strains cause the electrical resistance of a gage to vary; therefore anything that causes the resistance to vary will be reflected in an apparent strain. Temperature-compensating gages (dummy gages) (see Figure 1) can be effective only if they are at substantially the same temperature as the active strain gages. Before the replacement of the SR-4 gages at Jacksonville in August 1953 tests were made in which the steel deck around the gages was heated by means of blowtorches; during the heating and cooling of the deck, temperatures of the steel at the location of active and dummy gages were measured by means of a thermocouple. The temperature of the gage locations reached about 160° F rising 22° F in 20 min; the temperature lag between the active and dummy gages was small, at all times less than 5° F. Temperature compensation is therefore considered satisfactory. The change in leakage resistance between the strain gage and the steel hull is another possible source of error. The gages continue to dry out over a period of weeks with consequent increase in the electrical resistance between gage and ship. For this reason not much reliance can be placed on very slow variations in stress measured up to about 24 September 1952. After this time the leakage resistance had sufficiently stabilized so that the errors due to variations in leakage resistance should be less than about 600 psi. Analysis of stress variations due to loading and due to temperature variations will therefore be restricted to the time subsequent to 25 September 1952. The directions of stress variation given in this report are believed to be correct, although it is remotely possible that all signs should be reversed. However, the assumed directions of stress (tension or compression) do consistently agree with the direction of stress variations that would be expected due to the temperature variations encountered.

TEMPERATURE STRESSES

Inspection of the stress records has indicated a definite pattern of stress variation with a periodicity of about one day. A stress variation in the direction of increasing compression occurs when going from night to day; the maximum compressive (sag) stress is reached about 1500. The stress then changes into the tensile (hog) direction reaching a maximum value somewhere near 0200. This phenomenon is best observed with the ship underway, or at other times when load changes are nil. This stress variation is not generally the same on the port and the starboard side of the deck. These slowly varying stresses are quite appreciable; the maximum measured variation was about 10,900 psi.

The following explanation is advanced for the foregoing phenomenon. The stress variations are believed to be caused by non-uniform temperature conditions in the ship girder. At night the temperature of the deck is relatively cool, probably approximately the same as that of the air. A• the sun rises above the horizon, the portion of the ship above the waterline is heated and that portion of the ship below the waterline remains substantially at the temperature of the water. The upper portion of the hull tries to expand, but the submerged portion resists the expansion thus causing compressive stresses in the deck. The reverse conditions occur as the deck cools during the night. Inasmuch as the sun does not shine on all portions of the exposed portions of the ship with equal intensity, combined horizontal and vertical bending and torsion may be expected. Figure 4 gives a method for computing the stresses in a uniform thin beam due to temperature gradients, and should be of some help in estimating temperature stresses in ships. Greater temperature gradients and consequently greater temperature stresses would be expected in a ship with little freeboard as compared to the same ship with greater freeboard under identical environmental conditions.

Following are tabulated values of stresses due to temperature gradients measured while the ship was enroute between ports. A positive sign denotes increasing tension, a negative sign decreasing tension.

		Stress Variation	
Date	Enroute To	Starboard	Port
2 Oct 52, 0130	Canal Zone		
		-1,000	-9,600
2 Oct 52. 1330	Canal Zone		
		0	+9,600
3 Oct 52, 0330	Canal Zone		
		0	-7,400
3 Oct 52, 1430	Canal Zone		
		+10,500	+14,400
27 Sep 52, 1530	Aruba from Norfolk	(includes effect of change in ballast between 1800 and 2300, 27 Sep)	
27 Sep 52, 2330	Aruba from Norfolk		
17 Dec 52, 0100	Harkness Point to Baytown		
		+ 1,100	- 4,800
17 Dec 52, 1700	Harkness Point to Baytown		
		+ 1,300	+ 4,200
18 Dec 52, 1000	Harkness Point to Baytown		
		-900	- 7,400
18 Dec 52, 1700	Harkness Point to Baytown		
28 Dec 52, 0200			
		-3,500	-3,000
28 Dec 52, 1000			
		+3,200	+1,700
29 Dec 52, 0200			
17 Apr 53, 0330			
		-1,000	-10,900
17 Apr 53, 1530			
		+1,000	+ 8,600
18 Apr 53, 0430			

STRESSES DUE TO LOADING

It has been impossible to obtain accurate measurements of stresses due to load variations alone because it was not possible to separate the stress contributions due to variations in temperature from the measured stresses. It is possible, on occasion, to minimize the effect of temperature variations by comparing the stress measurements taken during successive nights. To separate out temperature effects it would be necessary to know the temperatures.

Following is a tabulation of stresses measured under various loading conditions. All stresses are taken with respect to an arbitrary reference which is different for each of the three time periods tabulated.

Date and Time	Condition of Loading	Stress*	
		Starboard	Port
(Period from 25 Sep 1952 to 13 Dec 1952)			
28 Sep, 2330	In ballast, Norfolk to Aruba	+1,000	+2,400
30 Sep, 0130	At Aruba, before loading	-8,600	-10,000
30 Sep, 1700	Maximum during loading	-16,900	-17,800
1 Oct, 0830	Aruba-after completing loading	-5,200	-5,200
7 Oct, 1200	Aground in Buenaventura cargo almost discharged	-19,200	-15,400
12 Dec, 1430	Paulsboro, N.J., before discharging cargo	-2,000	+1,000
(Period from 13 Dec 1952 to 9 Jan 1953)			
13 Dec, 0145	Norfolk	0	0
14 Dec, 0900	Norfolk	-6,700	-2,500
15 Dec, 0100	Ballast,	-2,000	+1,900
17 Dec, 0100	Ballast,	-4,900	-4,600
20 Dec, 0200	Underway	- 500	- 500
22 Dec, 0200	Underway	- 500	-3,000
28 Dec, 0200	Underway	-2,500	+2,500
29 Dec, 0200	Underway	-2,700	-2,500
1 Jan, 0100	Baton Rouge, no ballast, before cargo	-8,900	-5,300
3 Jan, 1700	Underway from Baton Rouge after cargo	+2,200	-1,900
7 Jan, 1400 - 2100	Paulsboro loaded	-2,200	0
9 Jan, 1410	Harkness Point, rainy day after discharging cargo	-6,700	-2,100

Note that the stresses on 14 Dec and 9 Jan are the same.

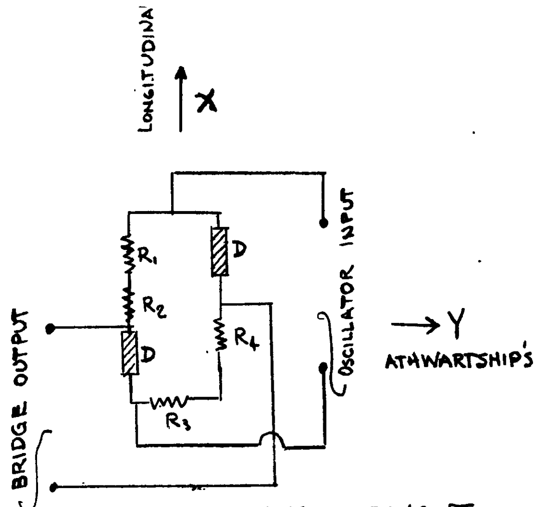
(Period from 11 Apr 1952 to 31 May 1953)			
14 Apr, 0730	Ballast, underway from Bayonne	-13,700	-2,100
17 Apr, 0330	Ballast, underway from Bayonne	-9,500	-4,200
17 Apr, 1530	Ballast, underway from Bayonne	-10,500	-14,800
18 Apr, 0430	Ballast, underway from Bayonne	-9,500	-6,300
19 Apr, 0730	In port, start loading	-9,500	-3,600
19 Apr, 1430	During loading	-19,000	-17,000
20 Apr, 0230	During loading	-20,000	-12,600
20 Apr, 1030	Leaving port, finished loading	-8,500	-5,200
21 Apr, 0230	Loaded - underway	-8,900	-3,100
23 Apr, 0530	In port, before unloading	-8,900	-3,100
24 Apr, 1230	Unloading, extreme stress (P)	-18,900	-20,000
24 Apr, 1930	Unloading, extreme stress (S)	-21,000	-16,300
10 May, 0430	In port, changing load	-13,700	-10,600
10 May, 1030	In port, extreme stress	-18,600	(-21,000)over
11 May, 0430	In port, final extreme stress condition before leaving port	-8,400	-6,300

*Positive sign refers to tension.

The largest stress variation measured during any one loading operation took place 23-24 April 1953 when stress changes of 16,900 psi on the port gage and 12,100 psi on the starboard gage were indicated. This includes stress variations due to temperature changes which tended to increase the magnitude of the variation.

It may be inferred from the data given here that the stress variations due to temperature variations are of the same order of magnitude as those due to the cargo load changes.

The principal conclusions are summarized at the beginning of the report.



CIRCUIT FOR MEASURING σ_x

R_1, R_2, R_3, R_4, ARE 60Ω SR4 STRAIN GAGES

D ARE TEMPERATURE COMPENSATING GAGES

LET σ_x, σ_y NORMAL STRESSES IN THE X OR Y DIRECTION

$\varepsilon_x, \varepsilon_y$ STRAINS IN THE X, Y DIRECTION

E MODULUS OF ELASTICITY

ν POISSON'S RATION ≈ 1/3

α TEMPERATUR COEFFICIENT OF EXPANSION

T TEMPERATURE AT POINT X,Y

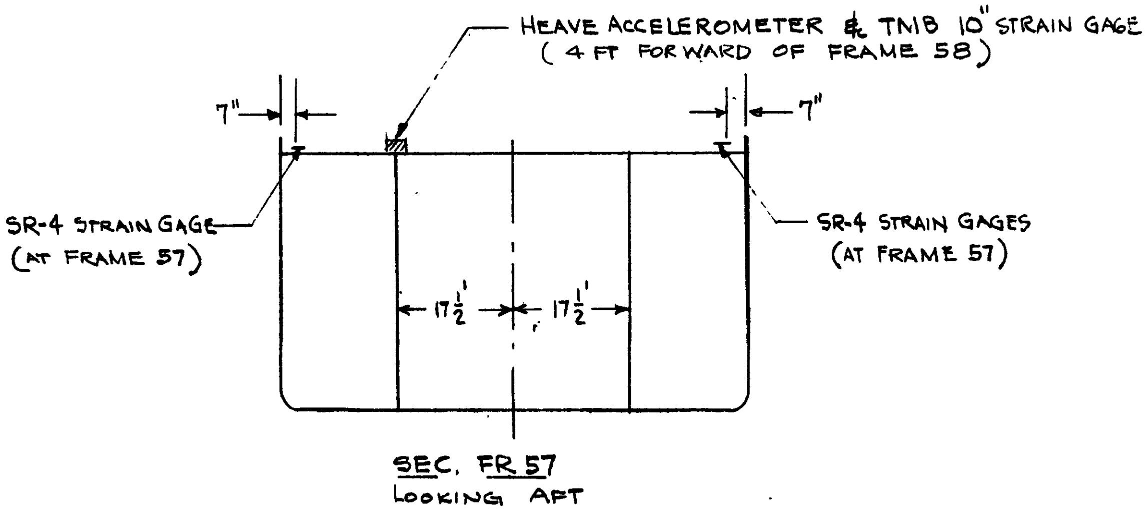
Then:

$$\sigma_x = \frac{E}{1-\nu^2}\left[\varepsilon_x + \nu\varepsilon_y - \alpha T - \nu\alpha T\right]$$

$$\sigma_y = \frac{E}{1-\nu^2}\left[\varepsilon_y + \nu\varepsilon_x - \alpha T - \nu\alpha T\right]$$

FIG. 1a

CIRCUIT FOR MEASURING LONGITUDINAL STRESS



NOTE: THE PITCH ACCELEROMETERS WERE LOCATED ON THE BRIDGE DECK

FIGURE 1 b

S.S. ESSO ASHEVILLE - LOCATION OF INSTRUMENTS

FIG. I

RECORD NUMBER		1	2	3	4	5	6	7	8	SUM OF MEASURED NUMBER OF CYCLES **	PROJECTED TOTAL NUMBER OF CYCLES (omitting records 5,6,8) ***
DATA OBTAINED	FROM	8-24	9-1	9-25	12-14	1-9	3-29	4-11	5-31		
	TO	8-31 (1952)	9-24	12-12	1-9 (1953)	3-29	4-10	5-31	7-31		
DURATION OF VOYAGE-HOURS		177	578	1873	589	1889	298	1200			
ACTUAL SAMPLING TIME - HOURS		$5\frac{54}{60}$	$4\frac{36}{60}$	$9\frac{58}{60}$	$18\frac{48}{60}$	$1\frac{24}{60}$ *	$1\frac{48}{60}$	$14\frac{43}{60}$	MILD SEAS - RECORDER INOPERATIVE FROM 8 JUNE		
RATIO = $\frac{\text{DURATION OF VOYAGE}}{\Sigma \text{SAMPLING TIME}}$		30	126	188	31	1349 *	166	41			
NUMBER OF STRESS CYCLES MEASURED BY STBD GAGE (AT SEA)	2-4 KIPS/IN²	212	14	219	336	225	-	254		1260	70 126
	4-6 "	5	0	5	97	47	-	23		177	5 040
	6-8 "	0	0	0	14	7	-	4		25	598
	8-10 "	0	0	0	2	1	-	0		3	62
	10-12 "	0	0	0	0	0	-	0		0	0
NUMBER OF STRESS CYCLES MEASURED BY PORT GAGE (AT SEA)	2-4 KIPS/IN²	13	1	56	339	231	-	420		1060	38773
	4-6 "	0	0	3	54	49	-	49		155	4247
	6-8 "	0	0	0	5	3	-	7		15	442
	8-10 "	0	0	0	0	1	-	2		3	82
	10-12 "	0	0	0	0	0	-	0		0	0
NUMBER OF STRESS CYCLES WITH GIVEN PERIODS	3-5 SECS	21	3	11	2	0	-	60		97	5598
	5-7 "	101	1	143	127	284	-	185		841	41 562
	7-9 "	16	11	0	143	0	-	22		192	7201
	9-13 "	2	0	16	30	0	-	9		57	4367
	13-19 "	56	0	31	92	0	-	2		181	10442
	19-30 "	0	0	0	1	0	-	4		5	195
NUMBER OF CYCLES OF HEAVE ACCELERATION	0.1-0.2 Gs	38	0	46	223	91	41	117		515	21 498
	0.2-0.4 "	0	0	0	11	5	21	1		17	382
	0.4-0.6 "	0	0	0	0	0	0	0		0	0
	0.6-0.8 "	0	0	0	0	0	0	0		0	0
NUMBER OF CYCLES OF PITCH ACCELERATION	0.1-0.2 G's/100 FT	270	20	86	703	237	85	447		1763	66908
	0.2-0.4 "	2	0	7	518	248	17	322		1097	30 636
	0.4-0.6 "	0	0	0	15	22	0	6		43	711
	0.6-0.8 "	0	0	0	0	0	0	0		0	0

* FOR RECORD #3, SAMPLING TIME REFERS TO THE "AT SEA" OPERATION ONLY

** FOR THIS SUMMATION THE DATA FROM RECORDS #6 AND #8 ARE OMITTED DUE TO THEIR INCOMPLETENESS

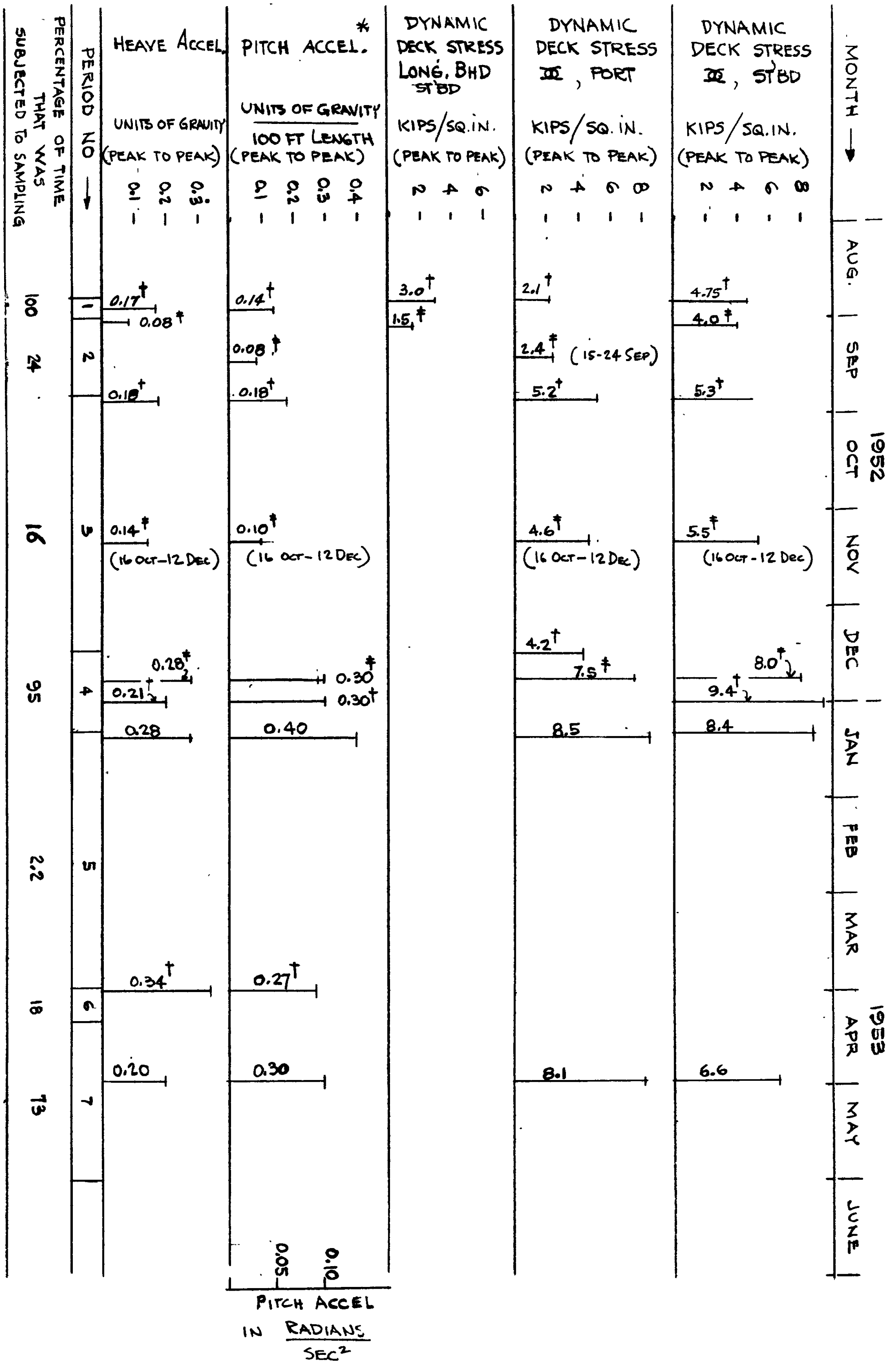
*** THIS PROJECTION WOULD BE VALID ONLY IF THE SAMPLES WERE REPRESENTATIVE OF ALL CONDITIONS ENCOUNTERED BY THE SHIP DURING THIS PERIOD.

NOTE: STRESS AND ACCELERATION ARE GIVEN IN TERMS OF PEAK TO PEAK VARIATION
ALL DATA GIVEN HERE WERE OBTAINED DURING AUTOMATIC OPERATION.

S.S. ESSO ASHEVILLE

TABULATION OF CYCLIC VARIATIONS IN DYNAMIC DECK STRESSES AND RIGID-BODY ACCELERATIONS DURING THE PERIOD AUG. 52 TO JUNE 53

FIG. 2



NOTES:

ALL VALUES GIVEN ARE PEAK TO PEAK VARIATIONS

† SHIP IN BALLAST CONDITION

‡ SHIP IN LOADED CONDITION

* THE ANGULAR ACCELERATION IS GIVEN IN TERMS OF AN EQUIVALENT LINEAR ACCELERATION WHICH IS EQUAL TO ± (ANGULAR ACCELERATION) × (100 FEET) ÷ 32.2 FT/SEC²

SS ESSO ASHEVILLE
MAXIMUM MEASURED VALUES OF DYNAMIC DECK STRESSES
AND RIGID-BODY ACCELERATION DURING THE PERIOD
AUG '52 TO JUNE '53

FIG. 3

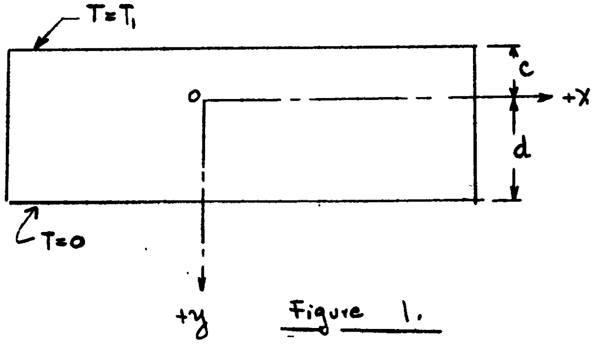


Figure 1.

Assume:

1. Ship is approximated by a simple uniform beam - Fig 1
2. The axis 0-X is assumed to lie in the waterplane
3. The temperature distribution is the same at every transverse section, does not vary with time.
4. The keel is taken at $y = -d$

REFERENCE

Timoshenko "Theory of Elasticity" 1st Edition, Article 65

The longitudinal stress $(\sigma_{x_0})_y$ at any point y in the section $x = x_0$ is:

$$(\sigma_{x_0})_y = \alpha E\left[-T + \frac{1}{c+d}\int_{-c}^{+d} T\,dy + \frac{3y}{c^3+d^3}\int_{-c}^{+d} Ty\,dy\right]$$

WHERE: α is the temperature coefficient of expansion of the material
E is the modulus of elasticity of the material
T is the temperature given as a function of y and taken with reference to the temperature at the keel. $(T_{-d} = 0)$

ASSUME $T = \frac{(y-d)^n}{(-c-d)^n} T_1$ where n is a constant

THEN $$(\sigma_{x_0})_y = \alpha E T_1\left[-\frac{(y-d)^n}{(-c-d)^n} + \frac{1}{(n+1)} - \frac{3y}{(c^3+d^3)}\left(\frac{(-c-d)^2}{n+2} + \frac{d(-c-d)}{n+1}\right)\right]$$

a positive sign denotes tension

Example (see Fig 4b) T-2 TANKER

ASSUME $n = 11$

Depth to main deck $= c + d = 39.25$ FT.
Draft $= d = 35.25$ FT, Freeboard $= c = 4$ FT
$\alpha = 6 \times 10^{-6}$, $E = 30 \times 10^{6}$ LBS/IN^2
Temperature difference, keel-main deck = 70°
$\therefore T_1 = 70°$

$\therefore \sigma_{x_0}$ (at main deck) $= 12600\left[-1 + 0.0833 + 0.0087\right] = -11,440$ p.s.i.

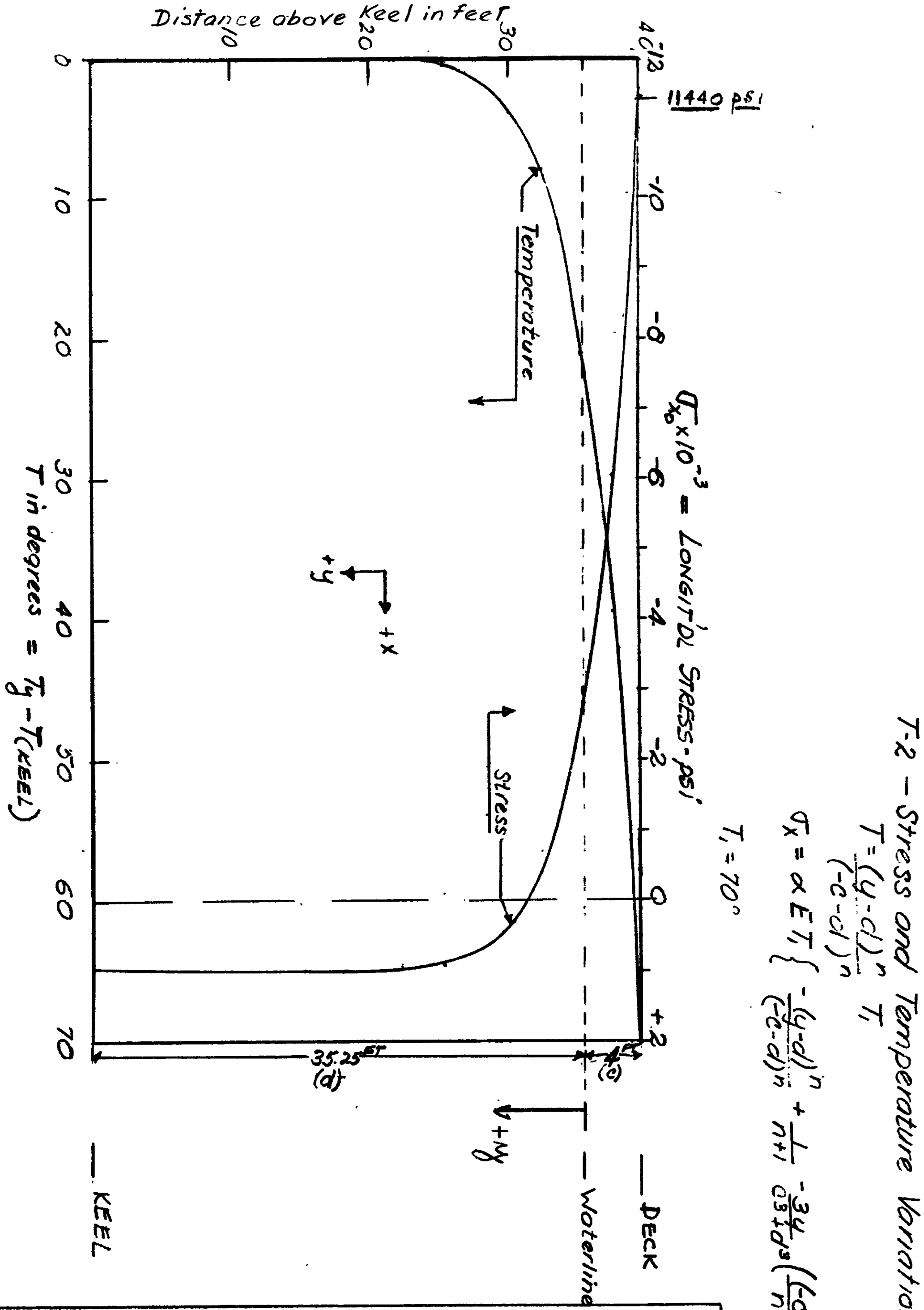
σ_{x_0} (at keel) $= +953$ p.s.i.

σ_{x_0} (at waterline) $= -2802$ p.s.i.

S.S. ESSO ASHEVILLE

STRESSES IN A UNIFORM BEAM
DUE TO TEMPERATURE GRADIENTS

Fig. 4a



S.S. ESSO ASHEVILLE

THEORETICAL STRESS DISTRIBUTION DUE TO AN ASSUMED TEMPERATURE GRADIENT

(SEE FIG 4a)

FIG. 4b

INITIAL DISTRIBUTION

Copies	
11	Chief, Bureau of Ships, Technical Library (Code 327), for distribution: 5 Technical Library 1 Technical Assistant to Chief of Bureau (Code 106) 1 Applied Science (Code 370) 1 Preliminary Design and Ship Protection (Code 420) 2 Hull Design (Code 440) 1 Hull Design, Scientific (Code 442)
2	Military Sea Transportation Service, Navy Department, Washington 25, D.C.
2	Commandant, U.S. Coast Guard, Headquarters, Washington 25, D.C.
2	Maritime Administration, Washington 25, D.C.
2	Secretary, Ship Structure Committee, U. S. Coast Guard Headquarters, Washington 25, D.C.
4	Secretary, American Society of Naval Architects and Marine Engineers, 29 West 39th Street, New York 18, New York
2	A. Gatewood, Chief Engineer, American Bureau of Shipping, 45 Broad Street, New York 4, New York
1	J. B. Letherbury, Assistant to Naval Architect, New York Shipbuilding Company, Camden, New Jersey
1	C. Ridgely Nevitt, Webb Institute of Naval Architecture, Glen Cove, New York
1	E. V. Lewis, Experimental Towing Tank, Stevens Institute of Technology, Hoboken, New Jersey
1	R. Krack, 4914 Dent Street, Washington 19, D.C.
1	J. H. McDonald, Naval Architect, Bethlehem Steel Company, Shipbuilding Division, Quincy 69, Mass.
1	E. L. Steward, Manager, Construction and Repair Division, Marine Department, Standard Oil Co., 30 Rockefeller Plaza, New York 20, New York
1	F. L. Pavlik, Hull Technical Assistant, Sun Shipbuilding and Drydock Co., Chester, Pennsylvania

David W. Taylor Model Basin. Rept. 875.
PRELIMINARY REPORT OF STRAINS AND MOTIONS OF THE SS ESSO ASHEVILLE FOR THE PERIOD 24 AUGUST 1952 THROUGH 31 JULY 1953, by Norman H. Jasper. October 1953. 11 p. [5] figs. UNCLASSIFIED

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Analysis of the data indicates that the dynamic stress variations associated with the ship's motion in the waves will rarely exceed 10,000 psi peak to peak. Also, stress variations due to changes in temperature distribution, such as occur from night to day, are of the same order of magnitude as those due to changes

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