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NOISE LEVELS AND CREW NOISE EXPOSURE ABOARD US MERCHANT VESSELS--ETC(U)

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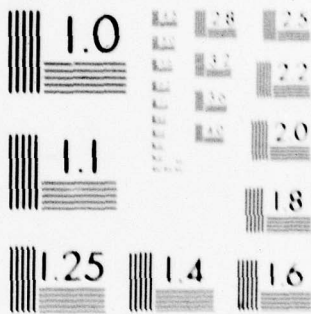
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Technical Report 405

NOISE LEVELS AND CREW NOISE EXPOSURE ABOARD US MERCHANT VESSELS

Data measured on seven ships during normal cruising

DR Schmidt

30 April 1979

Final Report for Period September to December 1978

Prepared for
US Coast Guard
Office of Research and Development
Washington DC 20590

Approved for public release; distribution unlimited

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ADMINISTRATIVE INFORMATION

This report describes a portion of work conducted by members of the Airborne Acoustics Branch (NOSC Code 5121) under project USCG MIPR Z-70099-8-846490-A (NOSC 512-MB09), for the US Coast Guard, Office of Research and Development. It covers work from September through December 1978 and was approved for publication 30 April 1979.

Thanks are extended to the following people, who helped take measurements aboard the merchant vessels: RS Gales, JA Hoke, RG Klumpp, and DR Lambert, of NOSC, and DT Jones and LT D Zedan of the US Coast Guard.

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number) To establish a data base for a US position on allowable noise on merchant vessels, NOSC was tasked by the US Coast Guard to obtain up-to-date data on noise levels on a small sample of US merchant vessels. This was done on seven vessels selected from representative types of the US merchant fleet available during the period September to December 1978. Data from the seven vessels measured are presented in this report.		

OBJECTIVE

Obtain up-to-date data on noise levels on a small sample of US merchant vessels, to establish a data base for a US position on allowable noise on such vessels.

RESULTS

The major source of noise on the seven selected ships was in the machinery spaces. The crew working in those spaces had estimated 24-hour equivalent levels (L_{eq24}) of 78-96 dB(A) if no hearing protection was worn. If hearing protection affording 20 dB(A) of effective attenuation were worn, the L_{eq24} range would be 62-76 dB(A).

Except on vessel TG1, all except two personnel would have an L_{eq24} of 70 dB(A) or less with 20 dB(A) hearing protection worn. The remaining two would have L_{eq24} of 71 dB(A). These levels would meet (or in the two cases, be very close to meeting) the stringent EPA criterion of $L_{eq24} = 70$ dB(A).

If hearing protection of 20 dB(A) were worn, all personnel on all vessels would meet the NOSC proposed criterion for current ships of $L_{eq24} = 80$ dB(A). All vessels except TG1 would meet the NOSC proposed criterion for future ships of 75 dB(A) for L_{eq24} . Of the six engine-room personnel surveyed on vessel TG1, only two would fail to meet the 75 dB(A) criterion. These two, with L_{eq24} of 76 dB(A), exceed it by only 1 dB.

If hearing protection affording 25 dB(A) of effective attenuation were worn, all personnel on all ships would meet the 75 dB(A) NOSC criterion; in cases with higher 24-hour equivalent levels, they would exceed by only 1 dB the stringent 70 dB(A) EPA criterion.

Without hearing protection, the L_{eq24} of non-engine-room personnel meets the NOSC 75 dB(A) criterion and in all but three cases meets the EPA criterion of 70 dB(A). Those three have an L_{eq24} of 71 dB(A), so exceed the EPA criterion by only 1 dB.

Measured levels in quarters, mess, and living areas were all marginally acceptable, in regard to rest and relaxation, at 70 dB(A) or less. Passageway levels are higher than 70 dB(A) in some cases, but little time would be spent in those areas.

RECOMMENDATIONS

1. Increase the size of the data base on US merchant ships by measuring noise on additional ships selected to sample a wider variety of ship types, propulsion, and construction.
2. Obtain a broad sample of data on noise exposure of the crew by providing wearable dosimeters, which will accurately measure the total exposure in both duty and nonduty areas.
3. Check the validity of the 24-hour equivalent level data by comparing two values:
a) levels measured directly with an integrating sound level meter and b) levels calculated from measured sound levels and estimated time in spaces obtained from crew questionnaires.

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INTRODUCTION

To establish a data base for a US position on allowable noise on merchant vessels, NOSC was tasked by the US Coast Guard to obtain up-to-date data on noise levels on a small sample of US merchant vessels. This was done on seven vessels selected from representative types of the US merchant fleet available during the period September to December 1978. Data from the seven vessels measured are presented in this report.

PROCEDURE

Through the courtesy of US merchant vessel owners, arrangements were made to ride their ships and take noise measurements on board. Primary emphasis was placed on measurements of the noise in work spaces, berthing spaces, messing spaces, and recreation spaces, and other areas such as passageways and storerooms were covered as time permitted.

Measurements were taken under conditions of normal cruising speed, in the Great Lakes for the ore ships and in the open ocean for all the others. Seas were low or calm during all measurement periods.

Measurements were made in accordance with ISO 2923, Acoustics – Measurement of Noise On Board Vessels.* ISO 2923 specifies two classes of tests: type tests and monitoring tests. Type tests are performed to prove that a newly manufactured vessel corresponds to noise specifications. These require compliance with specified conditions as closely as possible. Monitoring tests (the class reported herein) are performed to check changes in noise levels that may have occurred since type tests. Monitoring tests allow some deviation from the specified conditions. Deviations from specified conditions for this series of tests were as follows: (1) Loading condition could not be controlled by NOSC. Variations from the ISO 2923 requirement that ships be ballasted or fully loaded are noted with the data for each ship. (2) Measurements were taken primarily at cruising speed, not with the vessel at reduced speed or stopped. (3) The ventilation system was not operating in some areas of one ship. This is noted in the data for that ship.

A questionnaire was used to determine the time spent in various ship spaces by some of the crew. These times, with A-weighted sound levels taken in the spaces, were used to calculate crew duty levels, off-duty levels, and 24-hour equivalent levels. Equivalent level is that level which, if continuous over a stated time period, would have the same total energy as the fluctuating levels actually occurring over the same stated time period. This is sometimes called average sound level.

EQUIPMENT

The instruments used to measure the noise levels were precision sound-level meters capable of taking ANSI Slow A-weight, C-weight, and octave-band levels. Instruments conformed to IEC publication 179 for precision sound-level meters and to IEC publication 225 for octave-band filters. The instrument used on any given trip was one of the following types, all of which were battery powered so as to be portable and independent of ship's power:

1. Bruel and Kjaer type 2203 precision sound-level meter equipped with a Bruel and Kjaer type 1613 octave-band filter set and a Bruel and Kjaer type 4131 1-inch condenser microphone.

*Available from American National Standards Institute, 1430 Broadway, New York NY 10018.

2. General Radio model 1933 precision sound-level meter and octave-band analyzer, equipped with a General Radio model 1961 1-inch electret condenser microphone.

3. IVIE model IE30A precision sound-level meter and spectrum analyzer equipped with IVIE model IE-1M electret condenser microphone.

All instruments were calibrated before and after each test series with either a Bruel and Kjaer type 4220 pistonphone acoustic calibrator or a General Radio model 1562A sound-level calibrator. The B&K 4220 produces a calibrate signal of 124 dB at 250 Hz, while the General Radio 1562A produces a signal level of 114 dB at selectable frequencies of 125, 250, 500, 1000 and 2000 Hz. No significant changes in calibration level were noted between calibrations conducted before and after tests.

VESSELS MEASURED

The type of vessels on which noise measurements were made included tankers, cargo vessels, and ore carriers, with steam turbine, gas turbine or diesel power plants. All ships except one were built in 1955 or later; one ore carrier was built in the 1920s. To differentiate between vessels measured, a naming system consisting of two letters and a number was used for the purpose of this test. The first letter represents the vessel type — T = tanker, C = cargo, O = ore carrier. The second letter represents the type of power plant — S = steam turbine, G = gas turbine, D = diesel. The number indicates the order of measurement in ships of a given vessel power plant type. For example, TS2 represents the second steam turbine powered tanker that was measured.

The seven ships measured consisted of two steam turbine powered tankers, one gas turbine powered tanker, two steam turbine powered cargo vessels, and two diesel powered ore carriers.

Information specific to the vessel measured is included with the measured sound level data for that vessel.

RESULTS

Measurements taken on the seven vessels are shown in tables 1-7. (Tables follow the text, starting on p 16.) Figure 1 shows the deck layout for vessel TS2, showing sound levels in passageways and those compartments which were measured.

Tables 1-7 show the spaces measured and the A-weighted, C-weighted, and octave-band levels measured in those spaces. All levels are rounded to the nearest decibel. C-weighted and octave-band levels were not measured in some spaces. A summary of measured levels as listed in table 1-7 is presented as table 15 and is discussed later.

On vessels CS1 and TS2, A-weighted sound levels were measured over the route used by engine-room personnel while performing inspection tours of machinery spaces. These levels were energy-averaged to obtain an equivalent level for the inspection route, with the assumption that approximately equal time was spent at each inspection area. When averaging sound levels, energy averaging* should be used to achieve the highest

* Energy averages are obtained by taking the average of the sum of the antilogs to the base 10 of the measured levels expressed in bels, and taking 10 times the logarithm to the base 10 of the obtained average. Arithmetic averaging may be used at some loss of accuracy. For example, when averaging levels which are 5 dB apart, the error by arithmetic averaging would be 0.7 dB. As another example, if one were energy averaging the levels 60 dB, 80 dB, 70 dB, 80 dB, 60 dB, and 70 dB, the result would be 75.7 dB, much different from the arithmetic average of 70 dB.

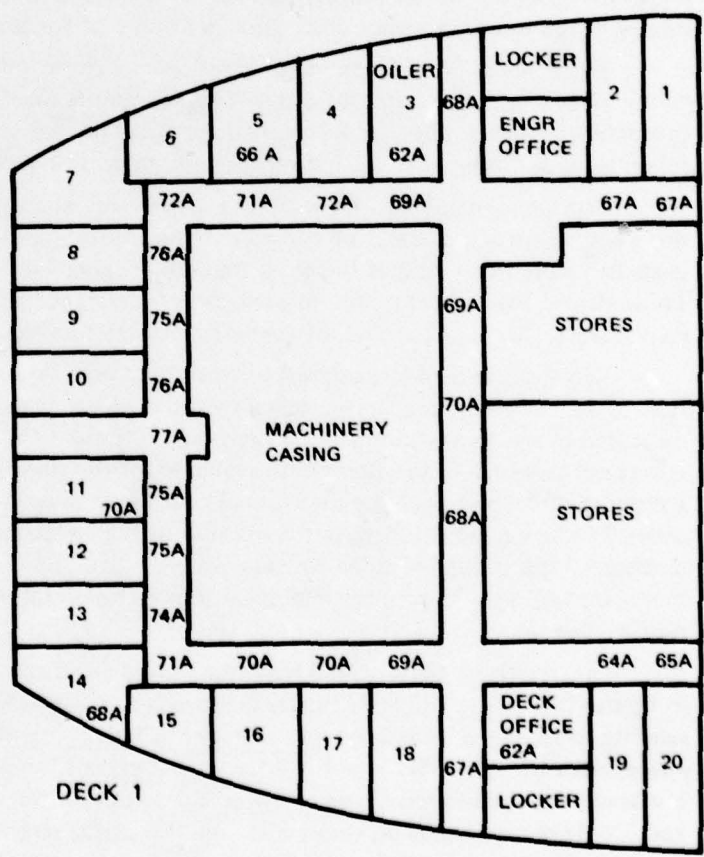
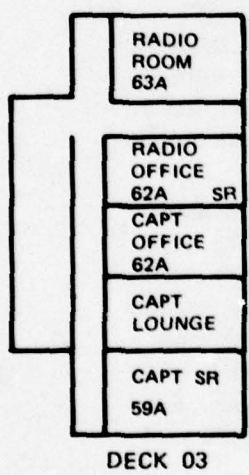
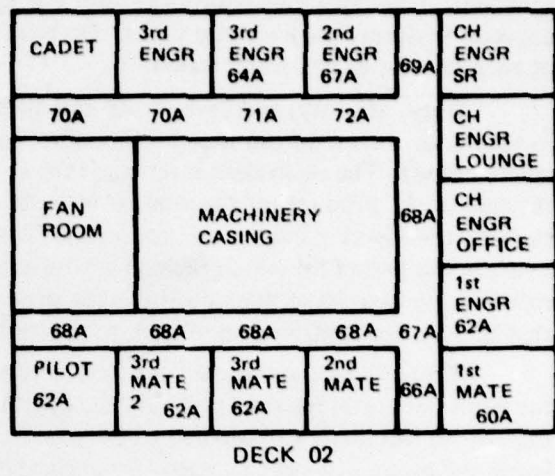
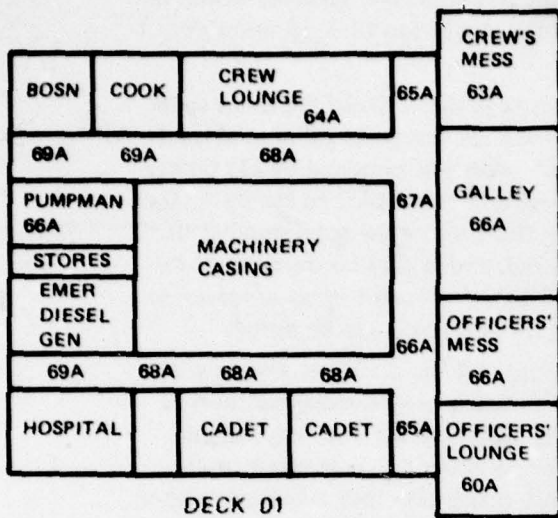


Figure 1. Vessel deck layout and measured A-levels for vessel TS2. Drawing not to scale.

accuracy. This calculated equivalent level was used as the level the crew member would be exposed to during the inspection tour. On both vessels the inspection took 15 minutes out of each hour of engine-room watch.

Duty, off-duty, and 24-hour equivalent levels were calculated from the times spent in spaces, as obtained from the questionnaire, and the measured levels (or calculated levels where noted). The equivalent level (L_{eq}) for a period of hours was obtained by (1) taking the sum of the products of the number of hours in a space and the antilog to the base 10 of the measured level in bels in that space, and (2) dividing this sum by the total number of hours in the period for which the equivalent level is desired, and taking 10 times the logarithm to the base 10 of this quotient. The duty and off-duty equivalent levels are given so that the relative contribution of each to the 24-hour equivalent level may be noted.

Tables 8-14 show these equivalent levels. They also list the crew member to whom the equivalent level relates, the hours in a location, and the measured A-weighted level in that space. All levels are rounded to the nearest dB. The duty and off-duty equivalent levels and hours will not calculate to exactly the 24-hour equivalent level in some cases, because of this rounding. In cases where machinery space inspection tour levels were taken, (CS1 - table 8, and TS2 - table 14), each appropriate hour and level column shows two numbers separated by a slash. The numbers in the upper left represent the hours and levels, respectively, of the watch station exposure, while the two numbers in the lower right represent the hours and calculated equivalent level of the inspection tour exposure.

In tables 8-14, only one equivalent level is given for some of the crew for each listing of 24-hour, duty, and off-duty. This represents the equivalent level where no ear protection is worn. These people have deck duty, such as that of the third mate, or other relatively quiet duty, such as that of the radio officer or stewards (table 8).

For crew members who work in noisy spaces, such as the second engineer (table 8), three equivalent levels are given for each 24-hour, duty, and off-duty column. The entries tagged by note (a) represent the exposures to be expected if no hearing protection is worn. Those tagged (b) and (c) represent exposures to be expected if hearing protectors affording, respectively, 20 dB (A) and 25 dB (A) effective attenuation are worn.

The accuracy of the calculated equivalent levels is based on the following assumptions: (1) The times in spaces as given by the crew are reasonably accurate. (2) The levels measured in spaces are relatively constant and represent the exposures of the crew members. It was not possible, in the short time available for the surveys, to follow crew members over a number of days so as to log their time in various spaces. With few exceptions, the times seemed to be a good estimate in the opinion of the NOSC observers on board. The levels in machinery spaces tended to be constant, varying little under ship cruising conditions. Readings were taken at the primary watch stations to represent the levels normally experienced by the crew.

The range of octave-band readings aboard all vessels except OD1 and OD2 is shown in figures 2-6. OD1 and OD2 ranges are not shown, since a limited number of octave-band readings were taken on those ships. Machinery spaces are plotted with dots, nonmachinery spaces with triangles. No major overlap is seen except for vessel TG1, on which relatively low levels were measured in the engineering control center. The overlap seen at 31.5-Hz and 63-Hz octave bands on vessel TS1 (fig 4) was due to the high levels measured in those bands in the quarters and mess, which were located in the after deckhouse. A narrow range for machinery spaces is seen in figure 6 for vessel TS2. This was due to a limited number of octave-band measurements taken in those spaces.

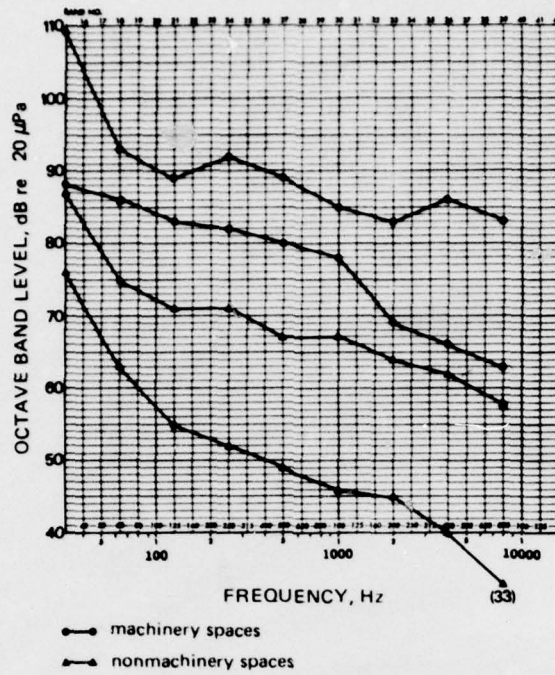


Figure 2. Range of octave band readings taken aboard vessel CS1.

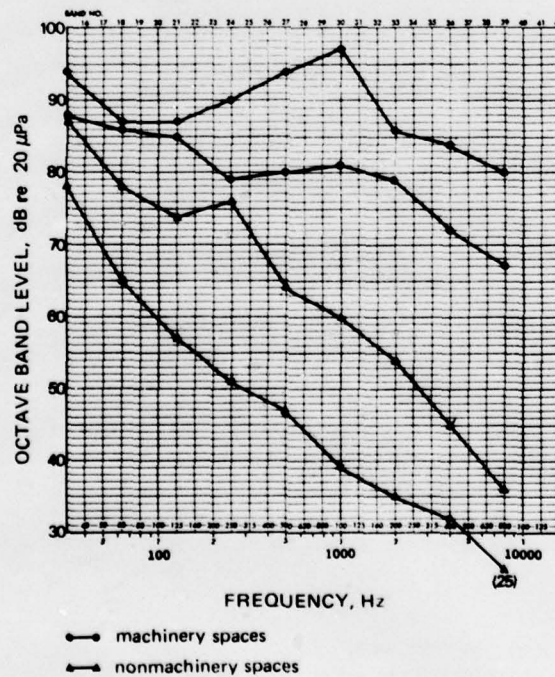


Figure 3. Range of octave band readings taken aboard vessel CS2.

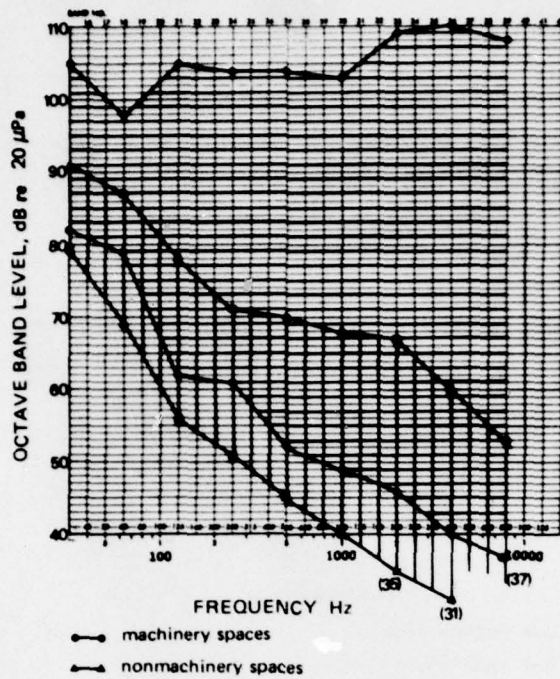


Figure 4. Range of octave band readings taken aboard vessel TG1.

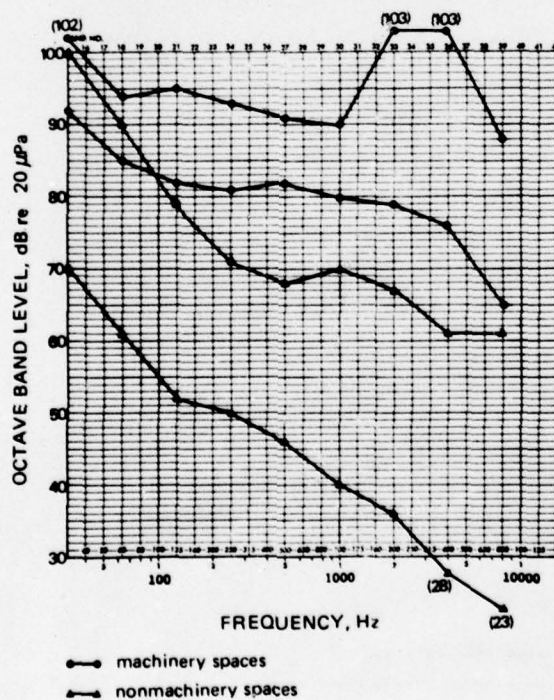


Figure 5. Range of octave band readings taken aboard vessel TS1.

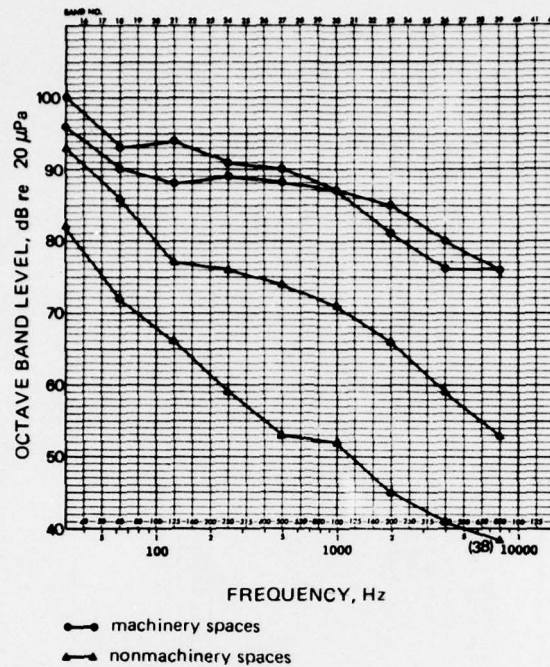


Figure 6. Range of octave band readings taken aboard vessel TS2.

Figures 7-13 are elevation views of each vessel. They show the deckhouse location(s) and list some of the compartments located on the decks.

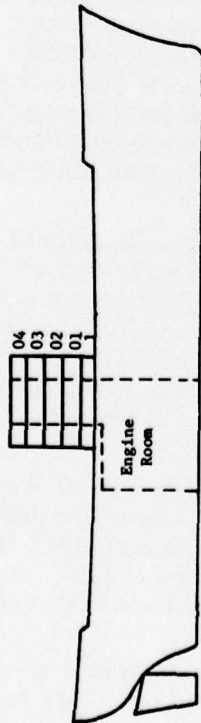
Table 15 is a summary of measured A-weighted sound levels in selected spaces — work areas, quarters, and living areas. Explanatory notes give the location and other pertinent information. Note 13 refers to vessel OD1, on which it was not possible to obtain measurements in crew quarters. To obtain an estimate of OD1 crew quarter levels, a difference was taken between the means of the officers' quarter levels and the passageways outside the officers' quarters that were measured. This difference was then subtracted from the mean of the passageway levels taken outside the crew quarters. This calculated level is shown in table 15 for OD1 crew quarters.

Table 16 lists the individual crew members' 24-hour equivalent levels, grouped by vessel and type of duty. The number of crew members for which data are given in each box of the table varies a result of the number of crew members available and is not indicative of their actual numbers on the ships. Equivalent levels listed within a box (type of duty aboard a given vessel) are taken from tables 8-14. The mean within a box is the energy mean of the equivalent levels within that box. The vessel mean in column 9 is an energy mean of the individual vessel means for a type of duty. All levels are rounded to the nearest dB.

Figure 14 shows the distribution of some of the 24-hour equivalent levels. Part A shows the distribution of the levels of crew members of the seven ships, assuming that no hearing protection was worn. The equivalent levels for the engine-room crew are clearly displaced higher in level than those of crew members not having engine-room duty. Engine-room crew equivalent levels ranged from 78 dB(A) to 96 dB(A), while those of non-engine-room crew members ranged from 57 dB(A) to 71 dB(A).

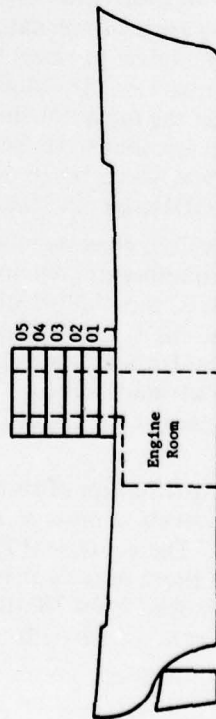
24-hour equivalent levels of engine-room crew members assumed to wear hearing protection affording 25 dB(A) of attenuation are shown along with the other crew members

NOTE: In each of the following elevation views, Fig 7-13, dotted lines show approximate machinery casing and engine room area.



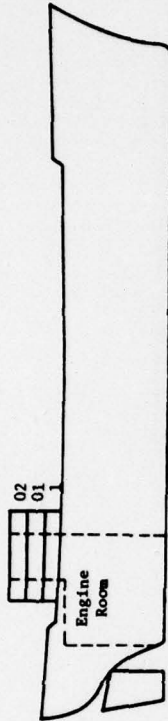
- Deck 04 Bridge, wheelhouse
- Deck 03 Captains quarters, Captains office
- Deck 02 Officers mess and lounge, radio room, Ch. Engr. quarters, First Mate quarters
- Deck 01 Officer quarters
- Deck 1 Crew quarters, crews mess and lounge, galley

Figure 7. Vessel CS1.



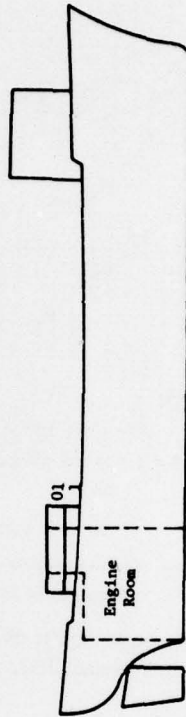
- Deck 05 Bridge, wheelhouse
- Deck 04 Captains quarters and office, radio room
- Deck 03 Officers quarters
- Deck 02 Officers quarters, officers mess and lounge
- Deck 01 Crews quarters, crews lounge
- Deck 1 Crews mess, galley

Figure 8. Vessel CS2.



- Deck 02 Bridge, wheelhouse
- Deck 01 Crews quarters
- Deck 1 Captains quarters, officers quarters, officers mess, crews mess, galley
- Deck 2 (One deck below main deck) Offices, shops
- Deck 3 (Two decks below main deck) Engineering control room

Figure 9. Vessel ODI.



- Aft
- Engineering officers quarters, crews quarters, officers mess, crews mess, galley
- Forward
- Bridge, Captains quarters, deck officers quarters, deck crew quarters

Figure 10. Vessel OD2.

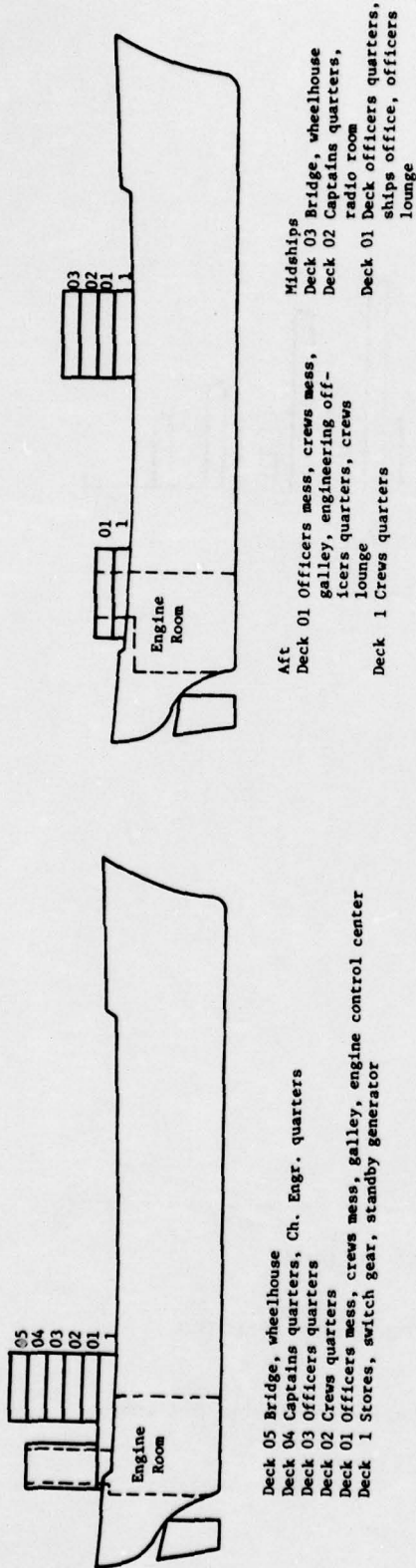


Figure 11. Vessel TG1.

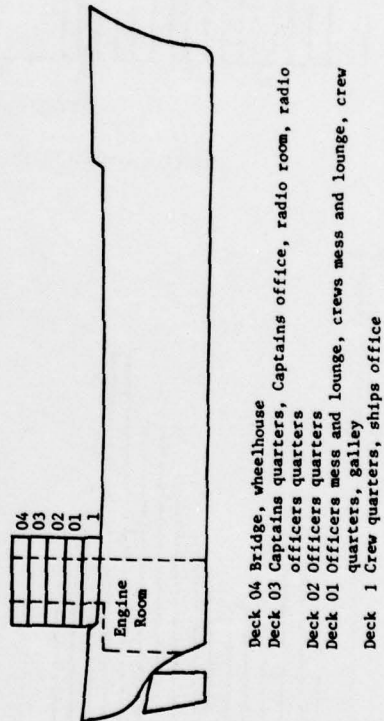
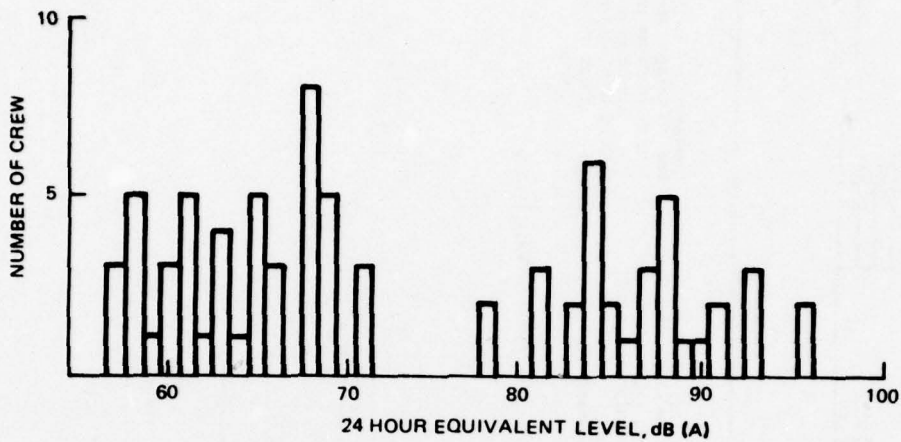
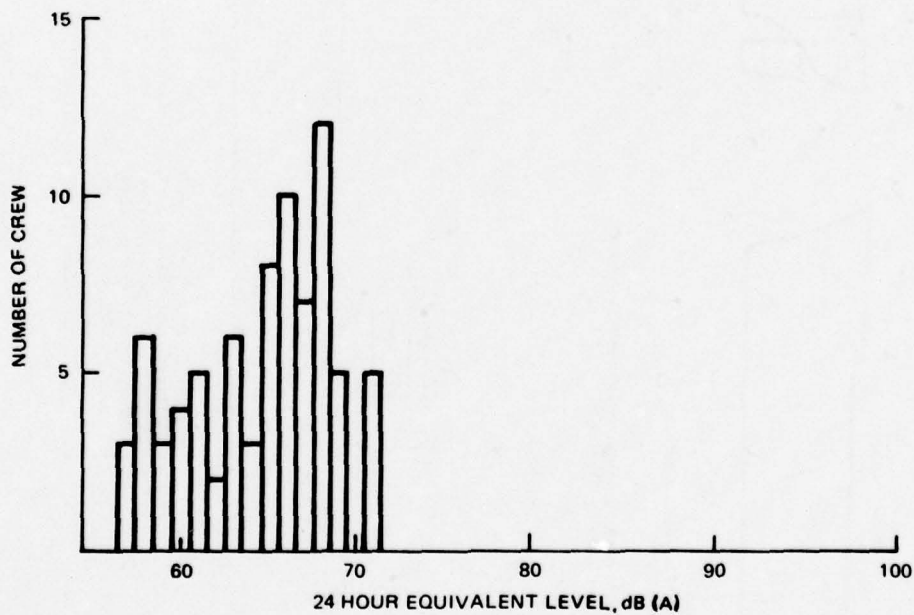


Figure 12. Vessel TS1.



PART A - NO HEARING PROTECTION WORN



PART B - HEARING PROTECTION AFFORDING 25 dB(A) OF EFFECTIVE ATTENUATION WORN

Figure 14. Combined number of 24-hour equivalent levels occurring aboard all vessels. Comparison shows effect of hearing protection worn.

in part B. The engine-room crew now group with the non-engine-room crew members. The equivalent levels for the engine-room crew range from 58 dB(A) to 71 dB(A), a range almost identical with that of non-engine-room crew members. All equivalent levels in part B are 71 dB(A) or lower.

CONCLUSIONS

The major source of noise on seven US merchant ships was found to be in the machinery spaces. The crew working in those spaces have estimated 24-hour equivalent levels (L_{eq24}) of 78-96 dB(A) if no hearing protection is worn. If hearing protection affording 20 dB(A) of effective attenuation is worn, the L_{eq24} range is 62-76 dB(A).

Except on vessel TG1, all but two personnel have an L_{eq24} of 70 dB(A) or less with 20 dB(A) hearing protection worn. The remaining two have L_{eq24} of 71 dB(A). These levels meet (or in the two cases, are very close to meeting) the stringent EPA criterion of $L_{eq24} = 70$ dB(A).

If hearing protection of 20 dB(A) is worn, all personnel on all vessels meet the NOSC proposed criterion for current ships of $L_{eq24} = 80$ dB(A). The proposed criteria for allowable noise levels and noise exposure aboard US merchant ships are contained in an NOSC Code 5121 letter report to the US Coast Guard entitled Recommended Noise Limits for Merchant Ships, by RS Gales. All vessels except TG1 meet the NOSC proposed criterion for future ships of 75 dB(A) for L_{eq24} . Of the six engine-room personnel surveyed on vessel TG1, only two fail to meet the 75 dB(A) criterion. These two, with L_{eq24} of 76 dB(A), exceed it by only 1 dB.

If hearing protection affording 25 dB(A) of effective attenuation is worn, all personnel on all ships meet the 75 dB(A) NOSC criterion; and in cases with higher 24-hour equivalent levels, they exceed by only 1 dB the stringent 70 dB(A) EPA criterion.

Without hearing protection, the L_{eq24} of non-engine-room personnel meets the NOSC 75 dB(A) criterion, and in all but three cases it meets the EPA criterion of 70 dB(A). Those three have an L_{eq24} of 71 dB(A), exceeding the EPA criterion by only 1 dB.

Measured levels in quarters, mess, and living areas are all marginally acceptable for rest and relaxation, at 70 dB(A) or lower. Passageway levels are higher than 70 dB(A) in some cases, but little time is spent in those areas.

RECOMMENDATIONS

1. Increase the size of the data base on US merchant ships by measuring noise on additional ships selected to sample a wider variety of ship types, propulsion, and construction.
2. Obtain a broad sample of data on noise exposure of the crew by providing wearable dosimeters, which will accurately measure the total exposure in both duty and non-duty areas.
3. Check the validity of the 24-hour equivalent level data by comparing values measured directly by an integrating sound level meter against levels calculated from measured sound levels in conjunction with crew questionnaire estimates of time in spaces.

Table 1. Measured sound levels from vessel CS1

Location	Level re 20 μ Pa octave band centered at (Hz)										
	A	C	31	63	125	250	500	1K	2K	4K	8K
Engine control	92	96	91	89	86	88	89	85	82	82	82
Turbine area	91	98	96	86	89	92	89	85	80	80	82
E.R. inspection tour, mean	91	-	-	-	-	-	-	-	-	-	-
Fire room com- bustion control	89	98	98	90	85	87	86	82	79	77	74
Pump area	91	107	109	93	85	90	87	85	83	86	83
Shaft alley	81	95	88	86	83	82	80	78	69	66	63
F.R. inspection tour, mean	92	-	-	-	-	-	-	-	-	-	-
Bridge	60	78	77	69	65	62	57	53	50	45	40
Galley	70	80	82	71	71	69	67	65	64	61	58
Galley, sink area	79	86	86	79	79	73	74	73	70	72	70
Electrical shop & stores	65	86	86	75	65	66	61	57	57	55	52
Radio Room	61	71	72	63	65	57	56	55	55	55	51
Bow watch station	73	92	91	92	76	76	69	67	65	62	59
Officers quarters, upper deck	54	79	78	68	55	52	54	46	46	43	41
Crews quarters, main deck	52	76	76	63	56	53	49	46	45	40	33
Radio Officers quarters	68	83	86	69	61	67	65	65	60	50	46
Officers mess and lounge	59	81	79	70	63	61	59	56	52	46	43
Crews mess and lounge	69	81	86	74	69	71	67	67	64	62	58
Passageway, main deck	65	77	78	68	64	64	62	58	58	55	48
Passageway, upper deck	63	80	81	68	63	64	63	58	54	51	44
Passageway, boat deck	65	83	87	71	62	66	64	58	55	50	44

Vessel data:

Type: Bulk cargo
 Power plant: steam turbine
 Gross tonnage group: 10000-15000
 Length group: 500-550 feet
 Period of manufacture: 1960-1965
 Load: Approximately 66% of capacity
 Measurement conditions: open ocean, deep water,
 calm seas, 20 knot speed.

Table 2. Measured sound levels from vessel CS2

Location	Level re 20 μ Pa octave band centered at (Hz)										
	A	C	31	63	125	250	500	1K	2K	4K	8K
Engineering control	86	93	91	86	86	82	80	81	79	77	70
Turbine area	99	100	90	87	87	90	94	97	85	80	80
Engineering shop	90	93	88	86	85	79	83	84	86	84	79
Shaft alley entrance	95	99	94	86	85	88	89	92	80	72	67
After steering	88	100	-	-	-	-	-	-	-	-	-
Bridge, door open	66	84	84	72	61	67	64	60	54	45	36
Bridge, door closed	58	-	-	-	-	-	-	-	-	-	-
Bridge, door open, whistle	101	-	-	-	-	-	-	-	-	-	-
Bridge, door closed, whistle	90	-	-	-	-	-	-	-	-	-	-
Bridge deck, conning position	73	-	-	-	-	-	-	-	-	-	-
Bridge deck, con posit., whistle	119	-	-	-	-	-	-	-	-	-	-
Bridge deck, port side	78	87	82	83	79	77	76	73	64	51	40
Bridge deck, port, whistle	108	-	-	-	-	-	-	-	-	-	-
Bridge deck, by stack	90	96	84	82	89	91	89	85	77	68	57
Captains office	55	82	84	67	57	56	55	50	45	41	34
Captains office, whistle	74	-	-	-	-	-	-	-	-	-	-
Work cabin, port side	51	81	79	78	60	51	47	42	37	32	25
Galley	75	81	-	-	-	-	-	-	-	-	-
Chief Engineer office	62	80	80	74	74	76	55	49	45	40	35
Captains SR	53	85	78	72	58	52	50	48	40	35	25
Stateroom, cabin deck	50	78	78	65	58	53	47	39	35	34	29
Crew quarters	53	82	82	70	60	55	50	49	47	40	30
Main lounge	55	85	86	73	63	57	50	45	39	36	30
Officers mess	58	87	87	75	67	60	51	50	48	43	32
Officers rec room	55	87	86	72	57	54	49	47	47	41	34
Crew mess	62	76	-	-	-	-	-	-	-	-	-
Crew rec room	60	-	-	-	-	-	-	-	-	-	-
Passageway, casing door open	90	-	-	-	-	-	-	-	-	-	-
Passageway, casing door closed	64	-	-	-	-	-	-	-	-	-	-

Table 2. Measured sound levels from vessel CS2 (Continued)

Vessel data:

Type: Containerized cargo
Power plant: Steam turbine
Gross tonnage group: 15000-20000
Length group: 650-700 feet
Period of manufacture: 1965-1970
Load: Approximately 75% of capacity
Measurement conditions: open ocean, deep water,
calm seas, 20 knot speed.

Table 3. Measured sound levels from vessel 001

Location	Level re 20 μ Pa										
	octave band centered at (Hz)										
	A	C	31	63	125	250	500	1K	2K	4K	8K
Engine room control room	86	99	99	93	93	84	84	78	72	75	69
Platform above engines	108	111	-	-	-	-	-	-	-	-	-
Machine shop	95	101	-	-	-	-	-	-	-	-	-
Ch. Engr. office, in engine room	90	95	86	87	87	87	87	78	75	72	67
Conveyor control, maindeck (1)	89	94	-	-	-	-	-	-	-	-	-
Gate man position at conveyor (1)	94	98	-	-	-	-	-	-	-	-	-
Conveyor room (1)	101	104	-	-	-	-	-	-	-	-	-
Pilot house	63	92	-	-	-	-	-	-	-	-	-
Galley	73	91	89	80	74	71	68	62	62	56	47
Captains SR (1)	74	-	-	-	-	-	-	-	-	-	-
Ch. Engineer SR	64	82	80	83	74	65	56	50	48	44	-
First Engineer SR	61	84	-	-	-	-	-	-	-	-	-
Second Engineer SR	65	84	86	83	74	65	62	56	53	47	44
Third Engineer SR	62	85	83	80	74	62	59	56	50	-	-
Officers mess	68	88	86	86	77	65	62	59	56	47	47
Crew mess	69	89	84	84	75	66	69	69	69	66	63
Passage outside Ch. Engr. SR	75	92	-	-	-	-	-	-	-	-	-
Passage outside First Engr. SR	73	90	-	-	-	-	-	-	-	-	-
Passage outside Second Engr. SR	75	91	-	-	-	-	-	-	-	-	-
Passage outside Third Engr. SR	77	94	-	-	-	-	-	-	-	-	-
Passageway, crew quarters, mean	78	92	-	-	-	-	-	-	-	-	-

Note: (1) Measures taken during unloading of cargo.

Vessel data:

Type: ore carrier
 Power plant: Two diesel engines
 Dead weight tonnage group: 15000-20000
 Length group: 600-650 feet
 Period of manufacture: 1970-1975
 Load: Approximately 90% of capacity
 Measurement conditions: Great Lakes, shallow water, 2 ft. seas, 15 knot speed.

Table 4. Measured sound levels from vessel OD2

Location	Level re 20 μ Pa										
	octave band centered at (Hz)										
	A	C	31	63	125	250	500	1K	2K	4K	8K
Engine operating platform	89	95	84	87	90	87	87	71	68	65	66
Port side of engine, by generators	101	104	-	-	-	-	-	-	-	-	-
Port side of engine, by gen. in use	102	106	-	-	-	-	-	-	-	-	-
Port side of engine, by compressor	98	102	-	-	-	-	-	-	-	-	-
Port side of engine, forward	97	100	-	-	-	-	-	-	-	-	-
Starboard side of engine, by pump	90	97	-	-	-	-	-	-	-	-	-
Shaft area	93	98	-	-	-	-	-	-	-	-	-
Chief Engineer office/qtrs.	65	81	80	74	68	63	63	60	57	47	-
Galley	63	77	-	-	-	-	-	-	-	-	-
Third Engineer SR	56	79	80	72	68	65	62	50	59	53	-
Crew quarters 1	64	79	77	77	65	62	56	56	50	44	-
Crew quarters 2	60	83	80	69	65	65	56	52	53	47	-
Officers mess	64	80	83	68	72	59	53	47	47	-	-
Crew mess	70	84	83	77	74	65	59	56	50	47	47
Passage outside crew qtr. 1 (1)	82	92	-	-	-	-	-	-	-	-	-
Passage outside crew qtr. 2 (1)	79	91	-	-	-	-	-	-	-	-	-

Note: (1) Door from engine room to passageway blocked open.

Vessel data:

Type: ore carrier
 Powerplant: single diesel engine
 Gross tonnage group: 5000-10000
 Length group: 600-650 feet
 Period of manufacture: 1920-1925
 Load: empty
 Measurements conditions: Great Lakes, shallow water, 2 ft. seas, 13 knot speed.

Table 5. Measured sound levels from vessel TG1

Location	Level re 20 μ Pa										
	octave band centered at (Hz)										
	A	C	31	63	125	250	500	1K	1K	4K	8K
Turbine room	102	107	99	96	105	94	91	91	93	91	92
AC & machinery room	88	96	86	89	84	93	82	80	76	71	64
Propulsion motor room	105	109	100	98	92	96	102	103	93	85	74
Fan room	88	101	-	-	-	-	-	-	-	-	-
Aux. Turbine room	115	115	102	98	103	95	100	107	109	110	108
Aux. generator room	105	109	91	91	101	104	104	100	98	94	84
Engineering control center	56	82	82	79	62	61	52	49	46	40	37
Switch gear room	71	87	88	82	70	67	70	66	58	52	44
Bridge	56	84	80	74	61	57	54	49	47	39	35
Radio room	58	86	84	76	59	62	51	49	43	40	39
Captains day room	57	87	86	75	56	61	50	47	43	38	34
Captains SR	51	86	84	70	59	54	45	41	38	32	27
Ch. Engr. SR	55	90	91	74	60	54	47	44	41	36	26
Officers SR	57	78	79	69	56	64	47	43	36	33	28
Crews quarters	56	84	85	73	57	59	50	41	35	33	26
Officers mess and lounge	57	85	86	78	60	51	45	40	36	31	25
Passage, Third deck (1)	76	-	-	-	-	-	-	-	-	-	-
Passage, Third deck	57	84	-	-	-	-	-	-	-	-	-
Passage, Second deck (1)	75	89	-	-	-	-	-	-	-	-	-
Passage, Second deck	63	92	-	-	-	-	-	-	-	-	-
Treatment room	58	89	90	76	62	62	52	50	44	38	32
After stores, port	63	83	83	79	65	62	60	58	53	48	37
After stores, stbd.	73	93	91	87	78	71	70	68	67	60	53
Bow thruster area	96	105	105	95	92	93	90	90	94	80	-

Note: (1) measure taken 1 meter from vent.

Vessel data:

Type: tanker
 Power plant: gas turbine/electric
 Gross tonnage group: 15000-20000
 Length group: 600-650 feet
 Period of manufacture: 1975 to present
 Load: Approximately fully loaded
 Measurement conditions: Open ocean, deep water, calm seas, 16 knot speed.

Table 6. Measured sound levels from vessel TS1

Location	Level re 20 μ Pa octave band centered at (Hz)										
	A	C	31	63	125	250	500	1K	2K	4K	8K
Engine room, stbd. gen	106	108	100	92	91	92	91	89	103	103	88
Engine control board	94	100	96	90	89	93	91	90	89	87	80
Shaft alley, main red. gear	98	105	104	95	93	94	93	91	92	93	75
Engine room coffee mess	94	101	100	88	89	93	89	88	86	88	73
Fire room, port boiler	87	95	93	87	82	82	83	83	81	76	71
Fire room, stbd. boiler	86	97	94	85	82	81	82	80	79	77	71
Engineering shop	92	100	102	92	88	88	89	82	85	85	74
Radio room	64	73	69	63	65	61	65	60	52	47	39
Captains office	49	76	73	61	60	50	46	40	37	31	23
Ships office	50	71	73	61	52	55	51	44	37	29	25
Bridge	61	77	75	72	62	56	56	58	54	48	44
Galley-scuttlery	68	100	91	82	74	68	64	61	59	52	42
Captains SR	49	65	-	-	-	-	-	-	-	-	-
Engineer SR	64	91	92	84	74	67	57	54	53	55	48
Q Med #2 SR (crew)	59	87	87	80	67	59	56	52	49	46	39
Pursers SR	49	65	61	51	54	52	49	42	36	27	-
Officers mess	70	99	100	90	79	71	66	60	57	54	52
Officers lounge	49	74	70	62	58	52	46	44	36	28	23
Crews mess	70	96	97	79	73	69	68	63	62	59	47
Crews rec room	68	97	98	79	72	69	64	59	59	58	44
Crews lounge	64	84	86	76	66	65	62	58	57	52	45
Gyro room	73	82	76	71	70	67	68	70	67	61	61
Steering gear	88	95	92	91	83	84	90	82	83	81	65
Scupper pump	100	100	-	-	-	-	-	-	-	-	-
Gyro room	73	82	76	71	70	67	68	70	67	61	61
Forward passage, mean	50	-	-	-	-	-	-	-	-	-	-
Aft passage, mean	74	96	-	-	-	-	-	-	-	-	-

Vessel data:

Type: tanker
 Power plant: steam turbine
 Gross tonnage group: 15000-20000
 Length group: 550-600 feet
 Period of manufacture: 1955-1960
 Load: Approximately fully loaded
 Measurement conditions: open ocean, deep water, calm seas, 16 knot speed. Ventilation system was not operating in all areas.

Table 7. Measured sound levels from vessel TS2

Location	Level re 20 μ Pa										
	Octave band centered at (Hz)										
	A	C	31	63	125	250	500	1K	2K	4K	8K
Engine control board	91	101	100	90	88	89	88	87	82	76	76
Between FD blower inlets (1)	92	101	98	93	94	89	90	87	85	80	76
Shaft alley	95	108	-	-	-	-	-	-	-	-	-
Main thrust bearing, red. gears	104	-	-	-	-	-	-	-	-	-	-
ER inspection tour, mean	95	-	-	-	-	-	-	-	-	-	-
Bridge	64	95	93	78	68	65	60	59	52	46	38
Port bridge wing, ER vents "Low"	68	89	90	78	72	68	67	63	60	52	42
Port bridge wing, ER vents "High"	75	89	89	77	73	76	74	71	66	59	49
Captains office	62	88	87	72	68	64	60	56	52	45	45
Radio room	63	93	88	77	70	64	61	57	51	47	50
Ships office (deck office)	62	84	83	76	70	68	59	56	52	47	48
Galley	66	87	85	75	69	66	65	62	57	53	45
Captains SR	59	91	91	77	66	59	56	53	52	49	45
Radio officers SR	62	87	84	74	69	63	60	56	50	47	45
First mates SR	60	86	86	75	67	62	58	52	48	46	44
Third mate #1 SR	62	91	93	79	70	63	60	55	50	47	49
Third mate #2 SR	62	88	89	79	68	63	61	57	52	48	48
Pilot SR	62	90	92	81	68	62	61	55	49	46	48
First Engr. SR	62	86	87	74	68	65	61	56	50	44	41
Second Engr. SR	67	87	89	76	75	69	65	60	55	49	46
Third Engr. #1 SR	64	88	88	77	72	65	63	58	53	48	45
Pumpman SR	66	90	89	81	70	66	64	57	57	52	48
Crew SR #3 (oiler)	62	88	90	79	69	63	59	53	53	47	45
Crew SR #5	66	85	83	83	72	68	61	58	58	56	53
Crew SR #11 (O/S)	70	88	88	86	77	72	65	60	63	53	49
Crew SR #14 (A/B)	68	92	88	85	75	70	60	55	53	48	47
Officers lounge	60	85	82	76	73	59	53	50	45	41	43
Officers mess	66	84	83	78	71	69	66	60	52	49	48
Crew lounge	64	88	89	80	72	65	62	57	52	48	45
Crews mess	63	87	84	78	68	64	60	58	52	47	45
After steering	88	107	-	-	-	-	-	-	-	-	-
On deck	69	-	-	-	-	-	-	-	-	-	-

Table 7. Measured sound levels from vessel TS2 (Continued)

Note: (1) Silencers installed on forced draft blower inlets.

Vessel data:

Type: tanker

Power plant: steam turbine

Gross tonnage group: 35000-40000

Length group: 750-800 feet

Period of manufacture: 1970-1975

Load: 40% of DWT

Measurement conditions: open ocean, deepwater,
4 ft. seas, 16 knot speed

Table 8. Estimated Equivalent Continuous Sound Levels (L_{eq}) for Crewmen of Vessel CS1

All levels A weighted, in dB re 20 μ Pa

Crewman	Hours	Location	Level	Equivalent level (L_{eq})		
				24 hours	Duty(hours)	Offduty(hours)
Third Mate	14	Quarters	54			
	2	Mess	59	57	60(8)	55(16)
	8	Bridge	60			
Radio Officer	8	Quarters	68			
	2	Mess	59	65	63(14)	67(10)
	10	Radio room	61			
	4	On deck	65(d)			
Second Engineer	9	Quarters	54			
	3	Mess	59	(a)86	91(8)	59(16)
	3/1	Engine room	92/91	(b)67	71(8)	59(16)
	3/1	Fire room	89/92	(c)63	66(8)	59(16)
	2	Rec. room	59			
	2	On deck	65(d)			
A/B Seaman	8	Quarters	52			
	2	Mess	69			
	4	Bridge	60	66	68(10)	65(14)
	4	On deck	65(d)			
	2	Fwd. lookout	73			
	4	Rec. room	69			
Oiler	12	Quarters	52	(a)85	90(8)	63(16)
	2	Mess	69	(b)67	70(8)	63(16)
	6/2	Fire room	89/92	(c)64	65(8)	63(16)
	2	Rec. room	69			
Off. Mess Steward (2 men)	8	Quarters	52	58	59(16)	52(8)
	16	Mess	59			
Crew Mess Steward (3 men)	8	Quarters	52			
	14	Mess	69	71	72(16)	52(8)
	2	Sink area	79			
Cook (4 men)	8	Quarters	52			
	14	Galley	70	68	70(16)	52(8)
	2	Mess	69			

Table 8. Estimated Equivalent Continuous Sound Levels (L_{eq}) for
Crewmen of Vessel CS1 (Continued)

- Notes: (a) L_{eq} assuming no hearing protection worn in machinery spaces.
(b) L_{eq} assuming hearing protectors affording 20 dB(A) of protection worn.
(c) L_{eq} assuming hearing protectors affording 25 dB(A) of protection worn.
(d) Estimated values.

Table 9. Estimated Equivalent Continuous Sound Levels (L_{eq}) for Crewmen of Vessel CS2.

All Levels A weighted, in dB re 20 μ Pa

Crewman	Hours	Location	Level	Equivalent level (L_{eq})		
				24 hours	Duty(hours)	Offduty(hours)
Ch. Engineer	8	Quarters	53			
	1.5	Mess	58			
	4	Engine room	86	(a)78	-	-
	0.5	Rec. room	55	(b)63	-	-
	1	On deck	65(d)	(c)62	-	-
	3	Office	62			
6	About ship	65(d)				
First Engineer	11	Quarters	53			
	1.5	Mess	58	(a)83	86(11)	54(13)
	11	Engine room	86	(b)63	66(11)	54(13)
	0.5	Rec. room	55	(c)59	61(11)	54(13)
Third Engineer	12	Quarters	53			
	1	Mess	58			
	8	Engine room	86	(a)81	86(8)	58(16)
	1	Rec. room	55	(b)63	66(8)	58(16)
	2	On deck	65(d)	(c)59	61(8)	58(16)
Third Engineer	8	Quarters	53			
	3	Mess	58			
	8	Engine room	86	(a)81	86(8)	60(16)
	2	Rec. room	55	(b)63	66(8)	60(16)
	1	On deck	65(d)	(c)60	61(8)	60(16)
	2	Coming & going	65(d)			
Jr. Engineer	14	Quarters	53			
	1	Mess	58	(a)81	86(8)	54(16)
	8	Engine room	86	(b)62	66(8)	54(16)
	1	Rec. room	55	(c)58	61(8)	54(16)
Jr. Engineer	9.5	Quarters	53			
	2	Mess	58			
	7	Engine room	86	(a)81	86(8)	60(16)
	2	Rec. room	55	(b)63	66(8)	60(16)
	3	On deck	65(d)	(c)60	61(8)	60(16)
	0.5	Steering gear	88			

Table 9. Estimated Equivalent Continuous Sound Levels (L_{eq}) for Crewmen of Vessel CS2 (Continued)

All Levels A weighted, in dB re 20 μ Pa

Crewman	Hours	Location	Level	Equivalent level (L_{eq})		
				24 hours	Duty(hours)	Offduty(hours)
A/B Seaman	10	Quarters	53			
	4	Mess	62			
	3	Bridge	66	62	65(8)	58(16)
	2	Rec. room	60			
	5	On deck	65(d)			
A/B Seaman	16	Quarters	53			
	2	Mess	62			
	3	Bridge	66	60	-	-
	1	Rec. room	60			
	2	On deck	65(d)			
Maintenance Man	15	Quarters	53			
	1	Mess	62	61	65(7)	55(17)
	1	Rec. room	60			
	7	On deck	65(d)			

- Notes: (a) L_{eq} assuming no hearing protection worn in machinery spaces.
 (b) L_{eq} assuming hearing protectors affording 20 dB(A) of protection worn.
 (c) L_{eq} assuming hearing protectors affording 25 dB(A) of protection worn.
 (d) Estimated values.

Table 10. Estimated Equivalent Continuous Sound Levels (L_{eq}) for Crewmen of Vessel OD1

All levels A weighted, in dB re 20 μ Pa

Crewman	Hours	Location	Level	Equivalent level (L_{eq})		
				24 hours	Duty(hours)	Offduty(hours)
Captain	15	Quarters	62(1)			
	2	Mess	68	63	-	-
	7	Bridge	63			
First Engineer (2)	15	Quarters	61			
	1	Mess	68	(a)87	93(8)	62(16)
	4	Engine room	95	(b)68	73(8)	62(16)
	4	Control room	86	(c)65	68(8)	62(16)
Third Engineer (2)	12	Quarters	62	(a)87	93(8)	64(16)
	4	Mess	68	(b)69	73(8)	64(16)
	4	Engine room	95	(c)66	68(8)	64(16)
	4	Control room	86			
Oiler (2)(3)	12	Quarters	66	(a)88	93(8)	67(16)
	4	Mess	69	(b)70	73(8)	67(16)
	4	Engine room	95	(c)67	68(8)	67(16)
	4	Control room	86			
Oiler (2)(3)	12	Quarters	66	(a)88	93(8)	67(16)
	4	Mess	69	(b)70	73(8)	67(16)
	4	Engine room	95	(c)67	68(8)	67(16)
	4	Control room	86			
Steward	10	Quarters	66			
	1.5	Mess	69	68	69(9)	67(15)
	3.5	Rec. room	69			
	9	Mess (work)	69			

- Notes: (1) The quarters level is estimated. The measure in table 3 for Captains' quarters was taken during unloading conditions and is not typical of levels during cruising conditions.
- (2) Time in machinery spaces was stated as 8 hours. This is estimated to consist of 4 hours in engine control room and 4 hours in engine room.

Table 10. Estimated Equivalent Continuous Sound Levels (L_{eq}) for Crewmen of Vessel OD1 (Continued)

- (3) Level for quarters is calculated from passageway levels and loss through doors and bulkheads from officers quarters on deck above. Crew quarters were not available for measurement.
 - (a) L_{eq} assuming no hearing protection worn in machinery spaces.
 - (b) L_{eq} assuming hearing protectors affording 20 dB(A) of protection worn.
 - (c) L_{eq} assuming hearing protectors affording 25 dB(A) of protection worn.

Table 11. Estimated Equivalent Continuous Sound Levels (L_{eq}) for Crewmen of Vessel 002

All levels A weighted, in dB re 20 μ PA

Crewman	Hours	Location	Level	Equivalent level (L_{eq})		
				24 hours	Duty(hours)	Offduty(hours)
Chief Engineer	8	Quarters	65			
	2	Mess	64	(a)83	-	-
	6	Engine room	89	(b)66	-	-
	2	On deck	65(d)	(c)64	-	-
	6	Office	65			
Third Engineer	8	Quarters	56	(a)84	89(8)	62(16)
	2	Mess	64	(b)66	69(8)	62(16)
	8	Engine room	89	(c)63	64(8)	62(16)
	2	On deck	65(d)			
	4	Rec. room	64(d)			
Wiper	8	Quarters	64	(a)84	89(8)	67(16)
	4	Mess	70	(b)68	69(8)	67(16)
	8	Engine room	89	(c)66	64(8)	67(16)
	1	Rec. room	70(d)			
	3	On deck	65(d)			
Wiper	9	Quarters	64	(a)84	89(8)	67(16)
	2	Mess	70	(b)68	69(8)	67(16)
	1	Bridge	63(d)	(c)66	64(8)	67(16)
	8	Engine room	89			
	1	On deck	65(d)			
3	Rec. room	70(d)				
Oiler	10	Quarters	64	(a)84	89(8)	67(16)
	3	Mess	70	(b)67	69(8)	67(16)
	8	Engine room	89	(c)66	64(8)	67(16)
	1	On deck	65(d)			
	2	Rec. room	70(d)			
Steward/ Cook	10	Quarters	64			
	13	Mess	70	68	70(13)	64(11)
	1	On deck	65(d)			
Galley Porter	9	Quarters	64	69	-	-
	12	Mess	70			
	3	Rec. room	70(d)			

Table 11. Estimated Equivalent Continuous Sound Levels (L_{eq}) for
Crewmen of Vessel OD2 (Continued)

- Notes: (a) L_{eq} assuming no hearing protection worn in machinery spaces.
(b) L_{eq} assuming hearing protectors affording 20 dB(A) of protection worn.
(c) L_{eq} assuming hearing protectors affording 25 dB(A) of protection worn.
(d) Estimated values.

Table 12. Estimated Equivalent Continuous Sound Levels (L_{eq}) for Crewmen of Vessel TG1

All levels A weighted, in dB re 20 μ PA

Crewman	Hours	Location	Level	Equivalent level (L_{eq})		
				24 hours	Duty(hours)	Offduty(hours)
Captain	15	Quarters/ Office	57			
	2	Mess	57			
	3	Bridge	56	58	-	-
	3	Rec. room	57			
	1	On deck	65(e)			
Chief Mate	11	Quarters	57			
	2	Mess	57			
	7.5	Bridge	56	57	-	-
	0.5	Rec. room	57			
	3	Office	57			
First Mate	10	Quarters	57			
	2	Mess	57			
	4	Bridge	56	61	63(10)	57(14)
	2	Rec. room	57			
	6	On deck	65(e)			
Second Mate	11	Quarters	57			
	2	Mess	57			
	8	Bridge	56	58	56(8)	58(16)
	2	Rec. room	57			
	1	On deck	65(e)			
Third Mate	10	Quarters	57			
	2	Mess	57			
	8	Bridge	56	58	56(9)	58(15)
	1	Control room	56			
	1	Rec. room	57			
	1	On deck	65(e)			
	1	Passage- ways	61			
Radio Officer	10	Quarters	57			
	1.5	Mess	57			
	4	Rec. room	57	59	61(8)	58(16)
	2.5	On deck	65(e)			
	6	Radio room	58			

Table 12. Estimated Equivalent Continuous Sound Levels (L_{eq}) for Crewmen of Vessel TG1 (Continued)

All levels A weighted, in dB re 20 μ PA

Crewman	Hours	Location	Level	Equivalent level (L_{eq})		
				24 hours	Duty(hours)	Offduty(hours)
Chief Engineer	10	Quarters	57			
	4	Mess	57	(a)91	95(10)	57(14)
	2	Engine room	102	(b)71	75(10)	57(14)
	8	Control room	56	(c)67	70(10)	57(14)
First Engineer	7	Quarters	57			
	1	Mess	57	(a)93	96(11)	57(13)
	3	Engine room	102	(b)73	76(11)	57(13)
	5	Rec. room	57	(c)68	71(11)	57(13)
	8	Control room	56			
Third Engineer	7	Quarters	57			
	1	Mess	57	(a)96	98(14)	57(10)
	6	Engine room	102	(b)76	78(14)	57(10)
	2	Rec. room	57	(c)71	73(14)	57(10)
	6	Control room	56			
	2	On deck	65(e)			
A/B Seaman	9	Quarters	56			
	2	Mess	57(e)			
	4	Bridge	56	61	64(12)	57(12)
	8	On deck	65(e)			
	1	Rec. room	57			
A/B Seaman (d)	7.5	Quarters	56			
	2	Mess	57(e)	(a)93	97(9)	58(15)
	4	Bridge	56	(b)73	77(9)	58(15)
	3	Engine room	102	(c)68	72(9)	58(15)
	4	Rec. room	57			
	2	On deck	65(e)			
	1.5	Non-engine room	62			

Table 12. Estimated Equivalent Continuous Sound Levels (L_{eq}) for Crewmen of Vessel TG1 (Continued)

All levels A weighted, in dB re 20 μ PA

Crewman	Hours	Location	Level	Equivalent level (L_{eq})		
				24 hours	Duty(hours)	Offduty(hours)
A/B Seaman (d)	7	Quarters	56			
	2	Mess	57(e)	(a)96	98(14)	57(10)
	4	Bridge	56	(b)76	78(14)	57(10)
	6	Engine room	102	(c)71	74(14)	57(10)
	1	Rec. room	57			
	4	On deck	65(e)			
A/B Seaman	8	Quarters	56			
	4	Mess	57(e)	(a)93	97(10)	57(14)
	4	Bridge	56	(b)73	77(10)	57(14)
	3	Engine room	102	(c)68	71(10)	57(14)
	2	Rec. room	57			
	3	On deck	65(e)			
Mess Man	9	Quarters	56			
	14	Mess	57(e)	57	57(14)	57(10)
	1	Rec. room	57			

- Notes:
- (a) L_{eq} assuming no hearing protection worn in machinery spaces.
 - (b) L_{eq} assuming hearing protectors affording 20 dB(A) of protection worn.
 - (c) L_{eq} assuming hearing protectors affording 25 dB(A) of protection worn.
 - (d) Times stated by crewman added to greater than 24 hours. Times shown are estimated.
 - (e) Estimated values.

Table 13. Estimated Equivalent Continuous Sound Levels (L_{eq}) for Crewmen of Vessel TS1

All levels A weighted, in dB re 20 μ PA

Crewman	Hours	Location	Level	Equivalent level (L_{eq})		
				24 hours	Duty(hours)	Offduty(hours)
Captain	12	Quarters	49			
	2	Mess	70	60	-	-
	4	Bridge	61			
	2	Ships office	50			
	4	Rec. room	49			
Chief Mate	8	Quarters	50(d)			
	1	Mess	70			
	12	On deck	65(d)	64	-	-
	2	Around ship	65(d)			
	1	Rec. room	49			
Second Mate	12	Quarters	50(d)			
	2	Mess	70	61	61(8)	61(16)
	8	Bridge	61			
	2	Rec. room	49			
Third Mate	10	Quarters	50(d)			
	1	Mess	70	61	62(10)	61(14)
	8	Bridge	61			
	4	On deck	65(d)			
	1	Rec. room	49			
Third Mate	15	Quarters	50(d)			
	1	Mess	70	60	61(8)	59(16)
	8	Bridge	61			
Radio Officer	13	Quarters	49			
	2	Mess	70	63	64(8)	62(16)
	8	Radio room	64			
	1	On deck	65(d)			
Chief Engineer	12	Quarters	64			
	1.5	mess	70			
	2	Engine room	94			
	1	Fire room	87	(a)84	-	-
	1	On deck	65(d)	(b)67	-	-
	1	Rec. room	49	(c)65	-	-
	1.5	Office	64(d)			

Table 13. Estimated Equivalent Continuous Sound Levels (L_{eq}) for Crewmen of Vessel TS1 (Continued)

All levels A weighted, in dB re 20 μ PA

Crewman	Hours	Location	Level	Equivalent level (L_{eq})		
				24 hours	Duty(hours)	Offduty(hours)
Second Engineer	12	Quarters	64			
	1	Mess	70			
	4	Engine room	94	(a)87	92(8)	64(16)
	4	Fire room	87	(b)68	72(8)	64(16)
	2	Rec. room	49	(c)65	67(8)	64(16)
	1	On deck	65(d)			
Third Engineer	10	Quarters	64			
	1	Mess	70			
	9	Engine room	94	(a)90	93(11)	65(13)
	2	Fire room	87	(b)71	73(11)	65(13)
	1	Rec. room	49	(c)67	68(11)	65(13)
	1	On deck	65(d)			
A/B Seaman	11	Quarters	64			
	3	Mess	70	66	64(9)	66(15)
	3	Bridge	61			
	6	On deck	65(d)			
	1	Rec. room	68			
A/B Seaman	10	Quarters	64			
	1.5	Mess	70			
	4	Bridge	61	65	64(12)	66(12)
	8	On deck	65(d)			
	0.5	Rec. room	68			
A/B Seaman	6	Quarters	64			
	2	Mess	70			
	2	Bridge	61	66	65(12)	67(12)
	12	On deck	65(d)			
	2	Rec. room	68			
A/B Seaman	6	Quarters	64			
	3	Mess	70	65	63(12)	67(12)
	8	Bridge	61			
	7	On deck	65(d)			

Table 13. Estimated Equivalent Continuous Sound Levels (L_{eq}) for Crewmen of Vessel TS1 (Continued)

All levels A weighted, in dB re 20 μ PA

Crewman	Hours	Location	Level	Equivalent level (L_{eq})		
				24 hours	Duty(hours)	Offduty(hours)
A/B Seaman	6	Quarters	64			
	2	Mess	70			
	2	Bridge	61	66	65(12)	67(12)
	12	On deck	65(d)			
	2	Rec. room	68			
A/B Seaman	8	Quarters	64			
	2	Mess	70			
	4	Bridge	61	65	64(12)	66(12)
	9	On deck	65(d)			
	1	Rec. room	68			
Wiper	9.5	Quarters	64			
	1.5	Mess	70	(a)91	94(12)	66(12)
	11.5	Engine room	94	(b)71	74(12)	66(12)
	0.5	Fire room	87	(c)68	69(12)	66(12)
	1	Rec. room	68			
Pumpman	4	Quarters	64	(a)85		
	1	Mess	70	(b)68	-	-
	3	Engine room	94	(c)66		
	16	On deck	65(d)			
Steward/ Cook	6	Quarters	64			
	16	Galley	68	67	68(16)	65(8)
	2	Rec. room	68			
Cook/ Baker	8	Quarters	64			
	2	Mess	70	67	68(12)	66(12)
	12	Galley	68			
	2	Rec. room	68			
Third Cook	8	Quarters	64			
	12	Galley	68			
	2	Rec. room	68	67	68(14)	65(10)
	2	Storerooms	65(d)			

Table 13. Estimated Equivalent Continuous Sound Levels (L_{eq}) for Crewmen of Vessel TS1 (Continued)

All levels A weighted, in dB re 20 μ PA

Crewman	Hours	Location	Level	Equivalent level (L_{eq})		
				24 hours	Duty(hours)	Offduty(hours)
Crew Messman (2 men)	8	Quarters	64			
	2	Mess	70			
	12	Mess (duty)	70	69	70(12)	66(12)
	2	Rec. room	68			
Utility Man	8	Quarters	64			
	1	Mess	70			
	4	Rec. room	68			
	5	Fwd. Qtrs.	50	65	64(11)	66(13)
	5	Aft Qtrs.	64			
	0.5	Fwd. passages	50			
	0.5	Aft passages	74			

- Notes: (a) L_{eq} assuming no hearing protection worn in machinery spaces.
 (b) L_{eq} assuming hearing protectors affording 20 dB(A) of protection worn.
 (c) L_{eq} assuming hearing protectors affording 25 dB(A) of protection worn.
 (d) Estimated level.

Table 14. Estimated Equivalent Continuous Sound Levels (Leq) for Crewmen of Vessel TS2

All levels A weighted, in dB re 20 μ PA

Crewman	Hours	Location	Level	Equivalent level (Leq)		
				24 hours	Duty(hours)	Offduty(hours)
Third Mate	10	Quarters	62			
	2	Mess	66			
	8	Bridge	64	63	64(8)	63(16)
	2	Rec. room	60			
	2	Ships office	62			
Radio Officer	9.5	Quarters	62			
	1.5	Mess	66			
	1	Bridge	64	63	63(10)	64(14)
	1	Rec. room	60			
	1	On deck	69			
	10	Radio room	63			
Second Engineer	8	Quarters	67			
	2	Mess	66	(a)88	92(10)	67(14)
	8/2	Engine room	91/95	(b)70	72(10)	67(14)
	2	Rec. room	60	(c)67	67(10)	67(14)
	2	On deck	69			
Second Engineer	12	Quarters	64			
	1.5	Mess	66	(a)88	92(8)	64(16)
	6/2	Engine room	91/95	(b)69	72(8)	64(16)
	2	Rec. room	60	(c)66	67(8)	64(16)
	0.5	On deck	69			
Third Engineer	5.5	Quarters	64			
	1.5	Mess	66	(a)89	92(12)	66(12)
	10/2	Engine room	91/95	(b)70	72(12)	66(12)
	1	Rec. room	60	(c)67	67(12)	66(12)
	4	On deck	69			
A/B Seaman	6	Quarters	68			
	3	Mess	63			
	4	Bridge	64	68	67(12)	68(12)
	1	Rec. room	64			
	10	On deck	69			

Table 14. Estimated Equivalent Continuous Sound Levels (L_{eq}) for Crewmen of Vessel TS2 (Continued)

All levels A weighted, in dB re 20 μ PA

Crewman	Hours	Location	Level	Equivalent level (L_{eq})		
				24 hours	Duty(hours)	Offduty(hours)
Seaman	9	Quarters	70			
	2	Mess	63	(a)78	81(11)	69(13)
	1	Engine room	91	(b)69	69(11)	69(13)
	2	Rec. room	64	(c)69	69(11)	69(13)
	10	On deck	69			
Oiler	11	Quarters	62			
	1	Mess	63	(a)88	92(10)	64(14)
	8/2	Engine room	91/95	(b)69	72(10)	64(14)
	2	On deck	69	(c)66	67(10)	64(14)
Pumpman	8	Quarters	66	(a)84	86(13)	67(11)
	1	Mess	63	(b)68	70(13)	67(11)
	4	Engine room	91	(c)67	68(13)	67(11)
	10	On deck	69			
	1	Pumproom	85(d)			

- Notes: (a) L_{eq} assuming no hearing protection worn in machinery spaces.
 (b) L_{eq} assuming hearing protectors affording 20 dB(A) of protection worn.
 (c) L_{eq} assuming hearing protectors affording 25 dB(A) of protection worn.
 (d) Estimated level.

Table 15. Comparison of Measured Levels in Selected Spaces

All levels are A weighted in dB re 20 μ Pa

Location	Vessel CS1	Vessel CS2	Vessel OD1	Vessel OD2	Vessel TG1	Vessel TS1	Vessel TS2
Engine room control panel	92	86	-	89	-	94	91
Max. level in machinery spaces	102(1)	99(2)	108(3)	102(4)	115(5)	106(6)	104(7)
Machinery space shop	91	90	95	-	-	92	-
Engine room control room	-(8)	-(8)	86	-(8)	56	-(8)	-(8)
Enclosed bridge	60	58	63	-	56	61	64
Open bridge	-	73	-	-	-	-	68/75(9)
Officers mess	59	58	68	64	57	70	66
Crews mess	69	62	69	70	57	70	63
Office	54	55	90(10)	65	57	50	62
Officer quarters	54	53	63(11)	63(11)	56(11)	50/64(12)	62(11)
Crew quarters	52	53	66(13)	62(11)	56	64	67(11)

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Note:

- (1) Main thrust bearing, reduction gear.
- (2) Turbine area.
- (3) Platform above engines.
- (4) Diesel generator.
- (5) Aux. turbine, max. level in engine room = 105.
- (6) Stbd. generator reduction gear.
- (7) Main thrust bearing, reduction gear.
- (8) Vessel does not have control room.
- (9) ER vent fans on "Low" and "High" speed.
- (10) Ch. Engr. office in engine room.
- (11) Mean of measured quarters.
- (12) Officers quarters amidships and aft.
- (13) Value calculated from passageway levels.

Table 16. 24-Hour Equivalent Continuous Sound Level (Leq) Related to Type of Duty

Type of crew duty	Vessel								Mean of Vessels
	CS1	CS2	001	002	TG1	TS1	TS2		
Engine room, no hearing protectors worn	86	78 81	87 88	83 84	91 93	84 91	88 78		
		83 81	87	84 84	93 96	87 85	88 38		
		81	88	84	96 93	90	89 84		
Mean	86	81	88	84	94	88	87	89	
Engine room with 20 dB(A) hearing protectors worn	67	63 63	68 70	66 67	71 73	67 71	70 69		
	67	63 62	69	66 67	73 76	68 68	69 69		
		63 63	70	68	76 73	71	70 68		
Mean	67	63	69	67	74	69	69	69	
Deck	57	62	-	-	57 58	64 60	66 63		
	66	60			61 61	61 66	65 68		
		61			58	61 65	65 65		
Mean	64	61	-	-	59	64	66	63	
Other (Captain, Radio officer, Stewards, cooks)	65 71 68	-	68	68	59	60 69	69 63		
	58 71 68		63	68	57	63 68	65		
	58 71 68				58	69 69			
Mean	68	-	66	68	58	67	63	66	

Note: Values shown are 24 hours Leq's taken from tables 8-14. They are broken into 4 classes by the type of crew duty, and within engine room group whether no hearing protectors are worn or protectors affording 20 dB(A) of protection are worn.

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