SSC-294

FURTHER SURVEY OF IN-SERVICE PERFORMANCE OF STRUCTURAL DETAILS

SHIP STRUCTURE COMMITTEE

1980

SHIP STRUCTURE COMMITTEE

The SHIP STRUCTURE COMMITTEE is constituted to prosecute a research program to improve the hull structures of ships and other marine structures by an extension of knowledge pertaining to design, materials and methods of construction.

RADM H. H. BELL (Chairman)
Chief, Office of Merchant Marine Safety
U.S. Coast Guard

Mr. M. PITKIN
Assistant Administrator for Commercial Development
Maritime Administration

Mr. P. M. PALERMO
Deputy Director, Hull Group
Naval Sea Systems Command

Mr. R. B. KRAHL
Chief, Branch of Marine Oil and Gas Operations
U.S. Geological Survey

Mr. W. N. HANNAN
Vice President
American Bureau of Shipping

Mr. [illegible] WHITESTONE
Chief Engineer
Military Sealift Command

LCDR T. H. ROBINSON, U.S. Coast Guard (Secretary)

SHIP STRUCTURE SUBCOMMITTEE

The SHIP STRUCTURE SUBCOMMITTEE acts for the Ship Structure Committee on technical matters by providing technical coordination for the determination of goals and objectives of the program, and by evaluating and interpreting the results in terms of structural design, construction and operation.

U.S. COAST GUARD

CAPT R. L. BROWN
CDR J. C. CARD
CDR J. A. SANIAL, JR.
CDR W. M. SIMPSON, JR.

MILITARY SEALIFT COMMAND

Mr. [illegible] ASHS
Mr. [illegible] CHAPMAN
Mr. [illegible] STAVOVY (Chairman)
Mr. [illegible] STEIN

NAVAL SEA SYSTEMS COMMAND

Mr. R. CHIU
Mr. R. JOHNSON
Mr. J. B. O'BRIEN

U.S. GEOLOGICAL SURVEY

Mr. [illegible] GIANGEPELLI
Mr. [illegible] GREGORY

AMERICAN BUREAU OF SHIPPING

DR. D. LIU
MR. I. L. STERN

MARITIME ADMINISTRATION

Mr. [illegible] HAMMER
DR. [illegible] MACLEAN
Mr. [illegible] SEIBOLD
Mr. M. TOUMA

NATIONAL ACADEMY OF SCIENCES
SHIP RESEARCH COMMITTEE

Mr. O. H. OAKLEY - Liaison
Mr. R. W. RUMKE - Liaison

INTERNATIONAL SHIP STRUCTURES CONGRESS

Dr. S. G. STIANSEN - Liaison

THE SOCIETY OF NAVAL ARCHITECTS & MARINE ENGINEERS

Mr. N. O. HAMMER - Liaison

AMERICAN IRON & STEEL INSTITUTE

Mr. [illegible] SCHOVE - Liaison

WELDING RESEARCH COUNCIL

Mr. K. H. KOOPMAN - Liaison

STATE UNIVERSITY OF NEW YORK MARITIME COLLEGE

Dr. W. R. PORTER - Liaison

U. S. MERCHANT MARINE ACADEMY

Dr. C. B. KIM - Liaison

U. S. COAST GUARD ACADEMY

CAPT W. C. NOLAN - Liaison

U. S. NAVAL ACADEMY

Dr. [illegible] BHATTACHARYYA - Liaison

SSC-294

Member Agencies:

United States Coast Guard
Naval Sea Systems Command
Military Sealift Command
Maritime Administration
United States Geological Survey
American Bureau of Shipping

Ship Structure Committee

An Interagency Advisory Committee
Dedicated to Improving the Structure of Ships

Address Correspondence to:

Secretary, Ship Structure Committee
U.S. Coast Guard Headquarters,(G-M/TP
Washington, D.C. 20593

APRIL 1980
SR-1258

In 1978, the Ship Structure Committee published a report entitled *In-Service Performance of Structural Details*(SSC-272). That report catalogued and defined the types and location of structural detail failures on a variety of merchant and naval vessels. This present report describes the results of a Ship Structure Committee project that continued the examination of failed or damaged details on an additional 36 ships undergoing repairs or periodic surveys. The purpose was to expand the previous 50-ship data base, with emphasis on the midship section, to determine the different type and frequency of use of structural details and to pin-point those areas where problems have occurred.

This and similar projects provide feedback to design and construction offices for increased confidence in existing design methods as well as for future improvements. When a substantial data base is formed, meaningful statistical analyses can be conducted to provide useful information to shipowners, designers and builders for proper detail selection, proper repair and maintenance, and proper fabrication.

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

Technical Report Documentation Page

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
SSC-294		

4. Title and Subtitle	5. Report Date
Ship Structure Committee Project SR-1258 STRUCTURAL DETAILS FAILURE SURVEY "Further Survey of In-service Performance of Structural Details"	May, 1979
	6. Performing Organization Code
7. Author(s) C. R. Jordan, L. T. Knight	8. Performing Organization Report No. 1018-M
9. Performing Organization Name and Address Newport News Shipbuilding 4101 Washington Avenue Newport News, Virginia 23607	10. Work Unit No. (TRAIS)
	11. Contract or Grant No. DOT-CG-75172-A
12. Sponsoring Agency Name and Address U.S. Coast Guard 2100 Second Street, S.W. Washington, D.C. 20593 Ship Structure Committee U.S. Coast Guard Hdqtrs. Washington, D.C. 20593	13. Type of Report and Period Covered FINAL REPORT December 1977 to May 1979
	14. Sponsoring Agency Code G-M

15. Supplementary Notes

This report is a continuation of Ship Structure Committee Report SSC-272, "In-Service Performance of Structural Details," dated 1978.

16. Abstract

This project is an adjunct to the Ship Structure Committee report SSC-272. Using the same survey techniques and data analysis procedures described in that report, the midship/cargo areas of an additional twelve bulk carriers, twelve containerships, and twelve general cargo ships were surveyed under Project SR-1258. The goal of both projects is to provide design and repair personnel with structural service data and recommendations that can be used to significantly decrease the number of detail failures that occur on ships of all types. The data from both surveys are combined and summarized for ready use by design and repair offices.

Structural detail failure data were collected for twelve detail families (beam brackets, tripping brackets, non-tight collars, tight collars, gunwale connections, knife edge crossings, miscellaneous cutouts, clearance cuts, deck cutouts, stanchion ends, stiffener ends, and panel stiffeners) to provide guidance in the selection of structural detail configurations. Plots of percent failures versus ship type allow an engineer/designer to establish failure trends for a specific ship type.

A total of 607,584 details were observed with a total of 6,856 failures. Failures were attributed to either one or a combination of five categories - design, fabrication, welding, maintenance, and operation.

17. Key Words	18. Distribution Statement
structural detail failure survey detail families detail failures cracks buckles design fabrication welding maintenance operation	Document is available to the U.S. public through the National Technical Information Service, Springfield, Virginia 22161

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
UNCLASSIFIED	UNCLASSIFIED	187	

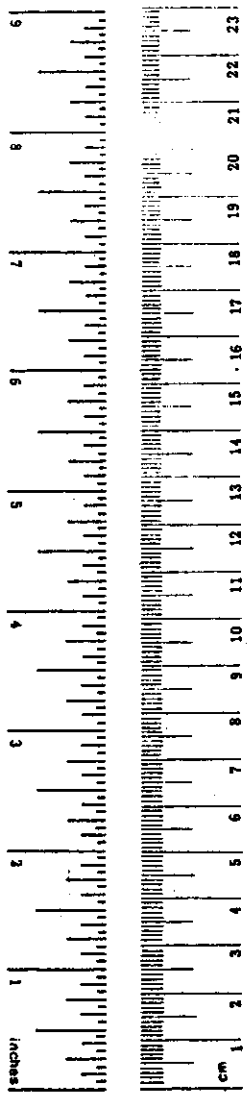
Form DOT F 1700.7 (8-72) Reproduction of completed page authorized

METRIC CONVERSION FACTORS

Approximate Conversions to Metric Measures

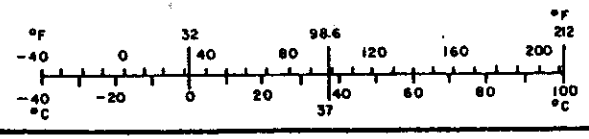
Symbol	When You Know	Multiply by	To Find	Symbol
	LENGTH			
in	inches	*2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
	AREA			
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	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	Symbol
	LENGTH			
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
	AREA			
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
	MASS (weight)			
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
	VOLUME			
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
	TEMPERATURE (exact)			
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



CONTENTS

LIST OF ILLUSTRATIONS

LIST OF ILLUSTRATIONS (Cont'd)

TABLES

NOTES

INTRODUCTION

Newport News Shipbuilding received a contract on December 6, 1977, from the United States Coast Guard to perform the Ship Structure Committee Project SR-1258. This project titled, "Structural Details Failure Survey, Part II," is a continuation of the Ship Structure Committee Project SR-1232, "Structural Details Failure Survey,"[1] completed in June, 1977, by Newport News Shipbuilding. In Part II, structural detail failure data and percentages of failures for twelve families of details were collected from surveys of the midship/cargo sections of thirty-six ships. The thirty-six ships included three ship types, bulk carriers, containerships, and general cargo ships. This project, under the advisorship of the National Academy of Sciences, Ship Research Committee, is intended to extend and confirm the conclusions of the report titled, "In-Service Performance of Structural Details."[1]

In project SR-1232, Newport News Shipbuilding surveyed fifty ships of various types while undergoing maintenance or repairs at various shipyard/repair facilities from which the structural details obtained were grouped into twelve typical families. Using the same survey techniques and data analysis procedures developed in that project, an additional twelve bulk carriers, twelve containerships, and twelve general cargo ships were surveyed in the midship/cargo area under project SR-1258. Sketches of configurations, discussions on noteworthy observations, and summary tables for the structural details observed in this second survey is contained in the text of this report. In addition, the data collected in the continued survey has been combined with the data from project SR-1232 to expand the data base in the midship sections of the three ship types and serves to confirm or refute any conclusions that were arrived at in the first survey. This combined data from both surveys is tabulated in Appendix A.

This report serves two purposes: It is an adjunct to SSC-272[1] by increasing surveyed data in the midship/cargo sections of three of the ship types; and, it summarizes the data of the two surveys for ready use by design and repair offices. It must be remembered that the often overlooked structural detail is the key link in providing structural continuity for the primary structural components throughout the entire ship and if that link fails, it could mean a costly lay-up in a repair yard or even the loss of the ship.

SHIPS SURVEYED

Table 1 is a summary of general information for the ships in the survey. The ships ranged from 428 to 847 feet (length between perpendiculars) in length, from 18,000 to 90,000 tons in displacement, and from five to twenty-six years in age. Five of the ships, ranging from twenty-four to thirty-five years of age had been converted, lengthened, and/or deepened seven to seventeen years ago and were still in use. Twenty-four of the surveyed ships were built or converted in sixteen domestic shipyards and twelve were built or converted in ten different foreign shipyards. When combined with the first survey, this brings the totals of the three ship types to sixteen bulk carriers, twenty-four containerships, and seventeen (17) general cargo ships.

LOCATIONS OF SHIPS SURVEYED

The majority of the ships surveyed were in repair yards on all three coasts of the United States. It quickly became apparent that bulk carriers were not as

---

1. Jordan, C. R.; Cochran, C. S., "In-Service Performance of Structural Details," Ship Structure Committee Report SSC-272, dated 1978.

TABLE 1

SUMMARY OF SHIPS SURVEYED

No. of Ships	Classification	Average LBP (Feet)	Average Displacement (Long Tons)	Average Age Years	Number Built	
					USA	Foreign
12	Containerships	630	29,600	10	10	2
12	General Cargo	518	21,200	18	12	0
12	Bulk Carriers	639	44,900	13	2	10
36	Average/Total	596	31,900	14	24	12

easy to locate as the other types of ships since the majority of the bulk carriers fly foreign flag and, thus, have their repair work done in foreign yards. Therefore, four of the bulk carriers surveyed were located at loading facilities. Although this was not as convenient for the surveyors as having the ship in a repair yard (because of loading or unloading), the shipowners were very cooperative by opening holds, wing tanks, etc., that were normally closed.

Nineteen of the surveyed ships were at Newport News Shipbuilding. The remaining seventeen ships, eight general cargo ships and nine bulk carriers, were surveyed elsewhere.

The following is a list of survey locations:

Newport News Shipbuilding, Newport News, Virginia
Norfolk Shipbuilding and Drydock Corporation, Norfolk, Virginia
Bethlehem Steel Corporation, Sparrows Point, Maryland
Alabama Dry Dock and Shipbuilding Company, Mobile, Alabama
Tampa Ship Repair and Dry Dock Company, Tampa, Florida
Two loading facilities near San Francisco, California
One loading facility near Perth Amboy, New Jersey
Norfolk and Western Coal Piers, Norfolk, Virginia

SHIPBOARD SURVEYS

The same twelve typical structural detail families that were selected in the first survey (project SR-1232) were used in this survey. The family groups are beam brackets, tripping brackets, non-tight collars, tight collars, gunwale connections, knife edge crossings, miscellaneous cutouts, clearance cutouts, structural deck cuts, stanchion ends, stiffener ends and panel stiffeners. Figure 1 shows the typical configuration for each family group and a description of its principal function.

The following procedures were used in conducting this survey:

- Review data and interview sheets from project SR-1232
- Review the final report of project SR-1232 (This was to assure the same approach and/or techniques were used in both surveys.)

FIGURE 1

TYPICAL DETAILS SURVEYED

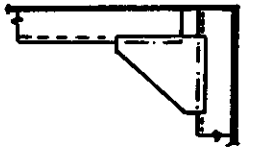
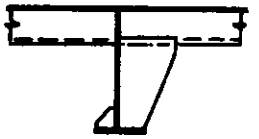
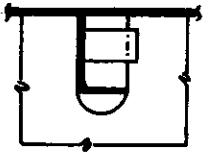
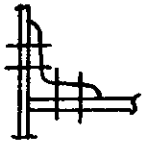
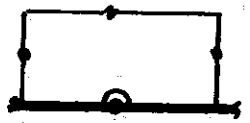
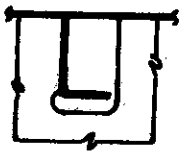
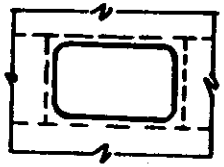
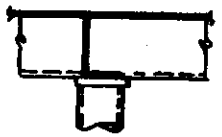
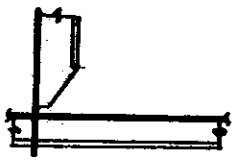
Detail Family No.	Family Name	Function	Typical Configuration
1	Beam Brackets	Provide designed end constraint for primary framing and stiffening members.	
2	Tripping Brackets	Provide lateral support for framing and stiffening members.	
3	Non-Tight Collars	Provide a shear connection for framing and stiffening that are continuous through support plating.	
4	Tight Collars	Same as 3 above with the additional function of ensuring a tight condition for the penetrated plate.	
5	Gunwale Connections	Join the strength deck stringer plate to the shear strake.	
6	Knife Edge Crossing	Has no useful function. It is a potential problem area that should be avoided.	

FIGURE 1, TYPICAL DETAILS SURVEYED (Cont'd)

No.	Name	Function	Typical Configuration
7	Miscellaneous Cutouts	Provide a wide variety of holes for access, drainage, ease of fabrication, cableways, pipes, air holes, etc.	
8	Clearance Cutouts	Provide passage of one member through another member.	
9	Structural Deck Cuts	Provide passage through decks for access, tank cleaning, piping, cables, etc.	
10	Stanchion Ends	Provide path of transferring forces between stanchions and deck supporting members.	
11	Stiffener Ends	Develop the designed end restraint of the stiffener.	
12	Panel Stiffeners	Provide stability to large panels of bulkhead plating and deep girder webs.	

- Obtain and review a copy of the ship's repair specifications, when possible
- Receive approval from Port Engineer (or owner's representative) and Captain to survey the ship
- Interview Port Engineer, Captain, First Mate or Chief Engineer for present and historical structural problems, as well as any other in-performance incidents that would affect the project
- Inspect the detail families in all accessible compartments in the midship/ cargo section of the ship
- Record all data and take photographs of unusual conditions, where allowed.

Identical ready reference data sheets used by the surveyor for the first fifty ships were used and included such data as:

Ship

- Type
- Size (but not name)
- Age
- Whether domestic or foreign built
- Shaft horsepower

Each Configuration

- Detail family number
- Geometrical sketch
- Location on ship
- Number of details observed
- Estimated number of failed details
- Failure mode
- Corroded condition
- Weld condition
- Workmanship
- Conformity of parts to shape intended
- Manual or machine preparation
- Material type
- Alignment
- Probable cause of failure

Access to the ships was by the shipowner's permission only. The surveyors were, therefore, careful not to disrupt any repair work that was in progress or to jeopardize the lay-up schedule of the ship in anyway. Thus, only the structure that was visibly accessible in the open compartments was surveyed. It must be noted that accessibility to cargo spaces greatly increased from the first survey. This was made possible by leaving out potential survey candidates because their holds were loaded or partially loaded with cargo. Table 2 lists the type of compartments surveyed and the percentage of accessibility for each.

SYNTHESIS BY FAMILY GROUPS

As the survey data were collected and analyzed, it became apparent that each family contained many types of configurations with unique geometrical features that

TABLE 2

COMPARTMENT ACCESSIBILITY

Compartments	Number Open (%)
Cargo Spaces	85
Inner bottom	5
Box girders (fore and aft passageways)	95
Transverse box girders	80
Wing tanks	20
Ballast tanks	5
Fuel oil tanks	3
Potable water tanks	0
Voids	5

could significantly affect the stress patterns within and around the structural detail. However, some of these configurations were only observed a few times on one or several ship types. Therefore, emphasis was placed on the individual detail configuration and how it and its family group performed in service, without regard to which ship type the configuration came from. This method provides design and repair offices a ready reference to the maximum available information of each individual detail.

In project SR-1232, there were 490,210 details observed and placed into twelve detail families. Each family was then separated into groups which contained related configurations, but differed geometrically. Out of the fifty-six groups that were formed, there were 553 distinct configurations.

The details observed in this survey that were similar to those seen in the first survey have been assigned the same detail family/group/detail numbers shown in SSC-272. For those configurations that were different, new detail numbers are assigned. There were eighty-one new configurations identified in the second survey, bringing the total for both surveys to 634 distinct variations as shown in Table 3.

Each of the twelve family details is discussed. There are sketches of configurations, discussions on noteworthy observations, and summary tables. Figures of details include both new and previous details observed. The summary tables give observed data for the second survey, plus combined results from both surveys. Since estimated data are purely subjective with no factual value, only the actual observed data are used in the summary tables.

FAMILY NUMBER 1 - BEAM BRACKETS

There were twenty new beam bracket configurations identified, thus, increasing the total to 145 for both surveys. This makes this family the most diversified of all. Also, beam brackets maintain their lead in the detail failure category by contributing a total of 1,364 failures. This is an increase of 476 over the first survey. The leading causes for this high rate of failures, particularly in the midship/cargo section, continues to be heavy seas and collisions with tugs, large floating objects, and piers.

TABLE 3

DISTRIBUTION OF DETAIL CONFIGURATIONS

Detail Family Number	Detail Family	Number of Groups	Number of Configurations
1	Beam Brackets	14	145
2	Tripping Brackets	3	82
3	Non-tight Collars	3	49
4	Tight Collars	4	33
5	Gunwale Connections	2	21
6	Knife Edges	0	0
7	Miscellaneous Cutouts	8	72
8	Clearance Cutouts	5	39
9	Deck Cutouts	3	23
10	Stanchion Ends	3	94
11	Stiffener Ends	5	35
12	Panel Stiffeners	6	41
12	TOTAL	56	634

Figure 2 shows the 145 variations in configurations included in the 68,586 beam brackets observed in both surveys. The configurations that occur most often in the midship/cargo section of containerships and general cargo ships are the corner bracket configurations 1-C-1, 1-C-25, 1-C-2, and 1-E-1. They also have a high failure rate, ranking number one, two, four and eight, respectively, in the top ten most prevalent failure details. In the first survey, detail 1-C-1 ranked third and detail 1-C-2 ranked eighth in the same category. Many of the group "C" corner bracket failures could be attributed to instability of the bracket plate panel. This was especially true on containerships where long spans of shell framing were supported at the ends with unflanged triangular plate with very high breadth/thickness ratios. It was interesting to note that on general cargo ships where wood framing was attached to the shell framing flanges to protect the cargo there were less failures among the group "C" brackets. This was because the tightly wedged wood framing served as intermediate lateral supports for the shell framing and prevented the flanges from tripping under minor local collisions. The wood framing also assisted by forming a grid on the shell framing. Stability was not the problem with the group "E" flanged-plate brackets, because the shell framing or deck framing member usually cracked or buckled near the bracket connection first. Again, the major cause of these severe loads is collisions. It is realized that accidents do happen, but a lot of preventative measures, such as reinforced areas in the ship's hull designated as tug stations, and the use of heavy duty rubber fenders at piers and loading docks, could be applied.

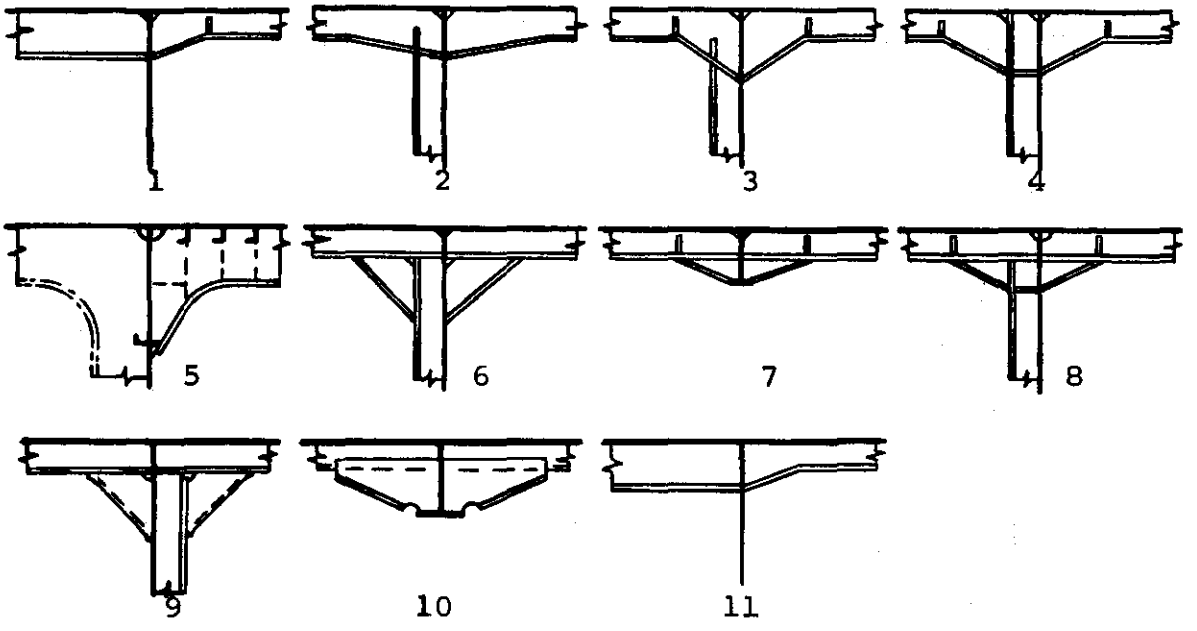
Several failures occurred to the end bracket details 1-H-13 and 1-H-15. These two details served as end brackets for transverse main deck stiffening running from the side shell to the hold openings in main deck. The brackets buckled under excessive loads on main deck where containers were being stowed. The main deck stiffeners had been reinforced with doublers and rider plates for the increase in loads but no attention had been given to the existing brackets.

FIGURE 2

BEAM BRACKETS DETAILS
FAMILY NO. 1

CONTINUOUS

A.



B.

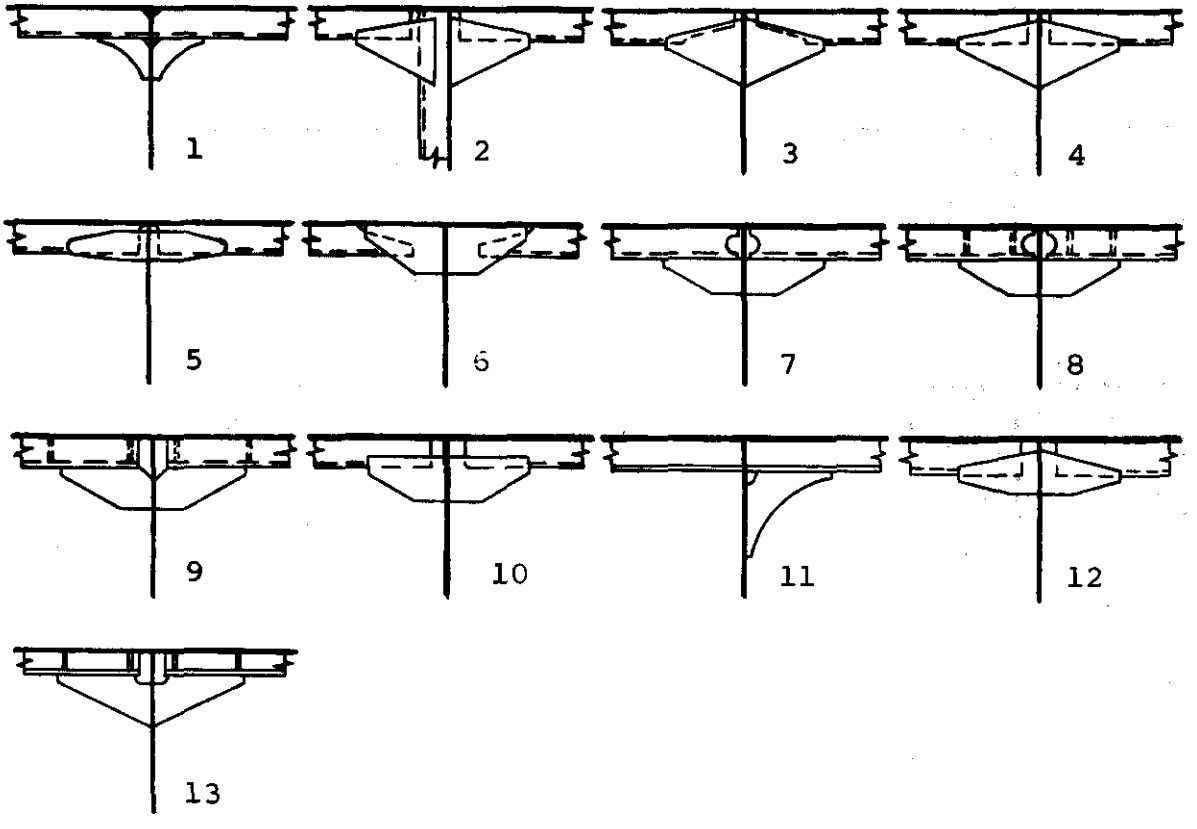
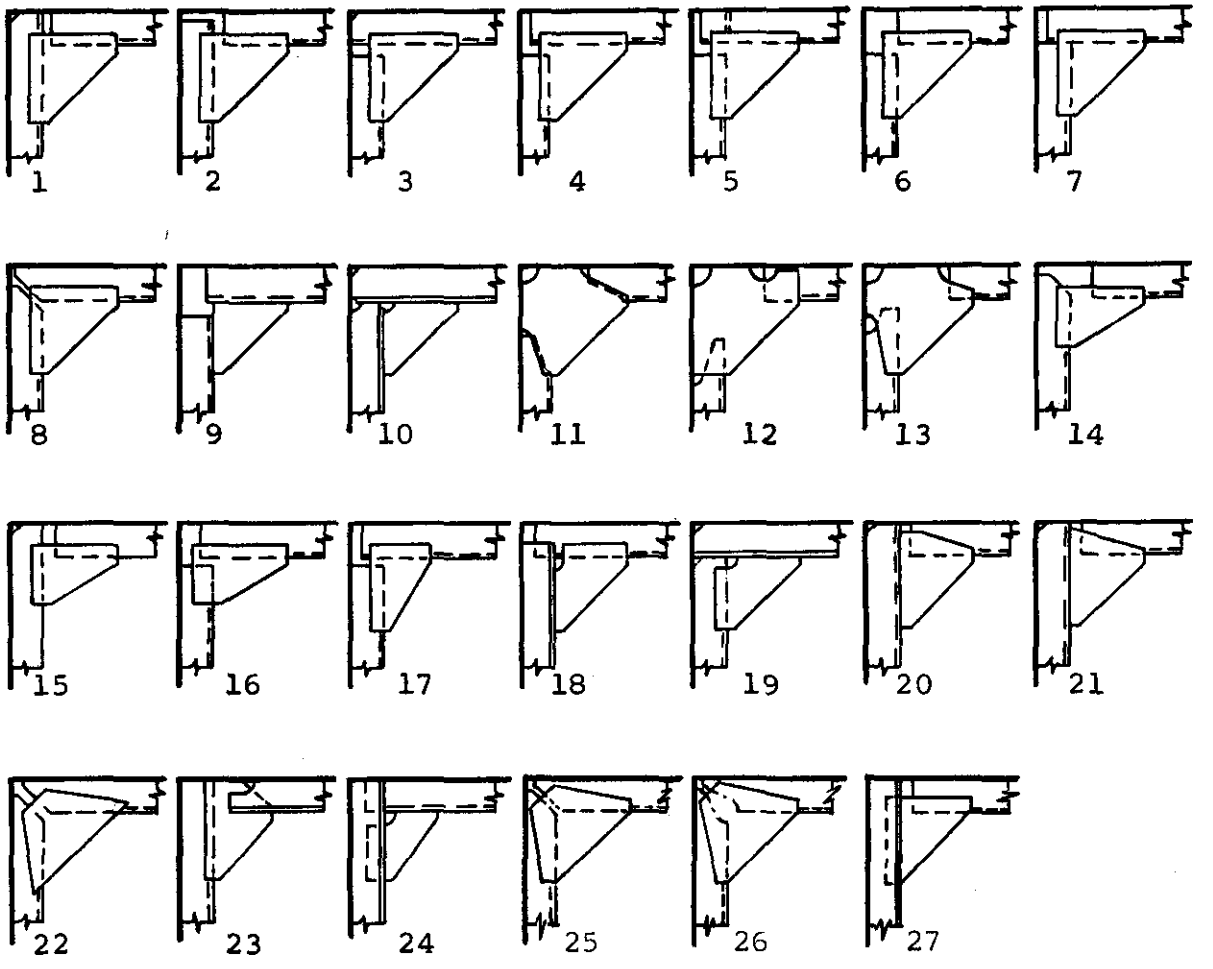


FIGURE 2 - BEAM BRACKETS DETAILS, Family No. 1 (Cont'd)

CORNER

C.



D.

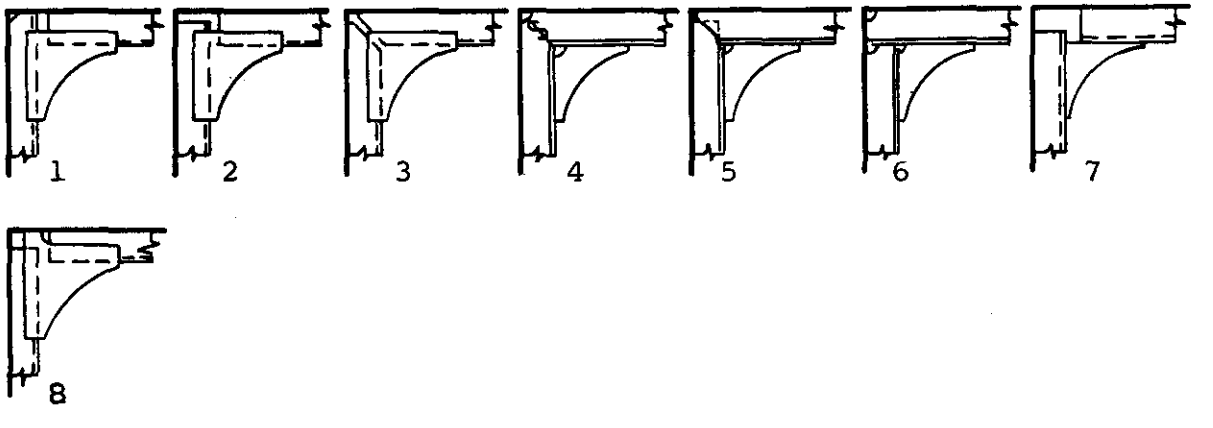
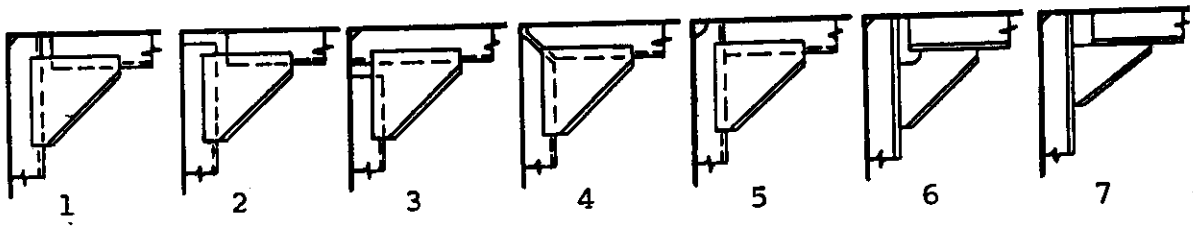
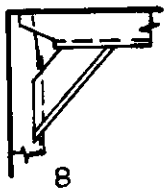


FIGURE 2 - BEAM BRACKETS DETAILS, Family No. 1 (Cont'd)

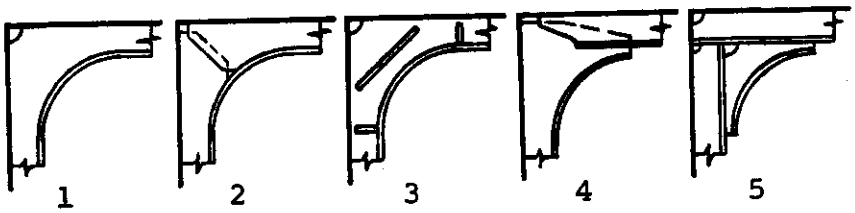
CORNER (Cont'd)

E.





F.



G.

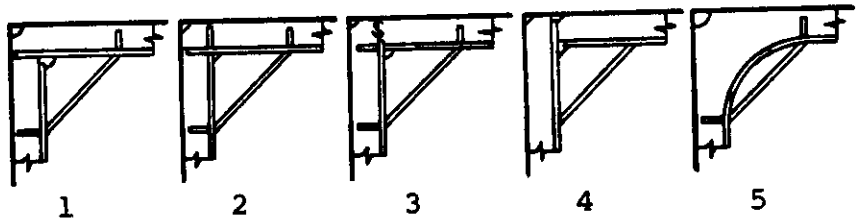
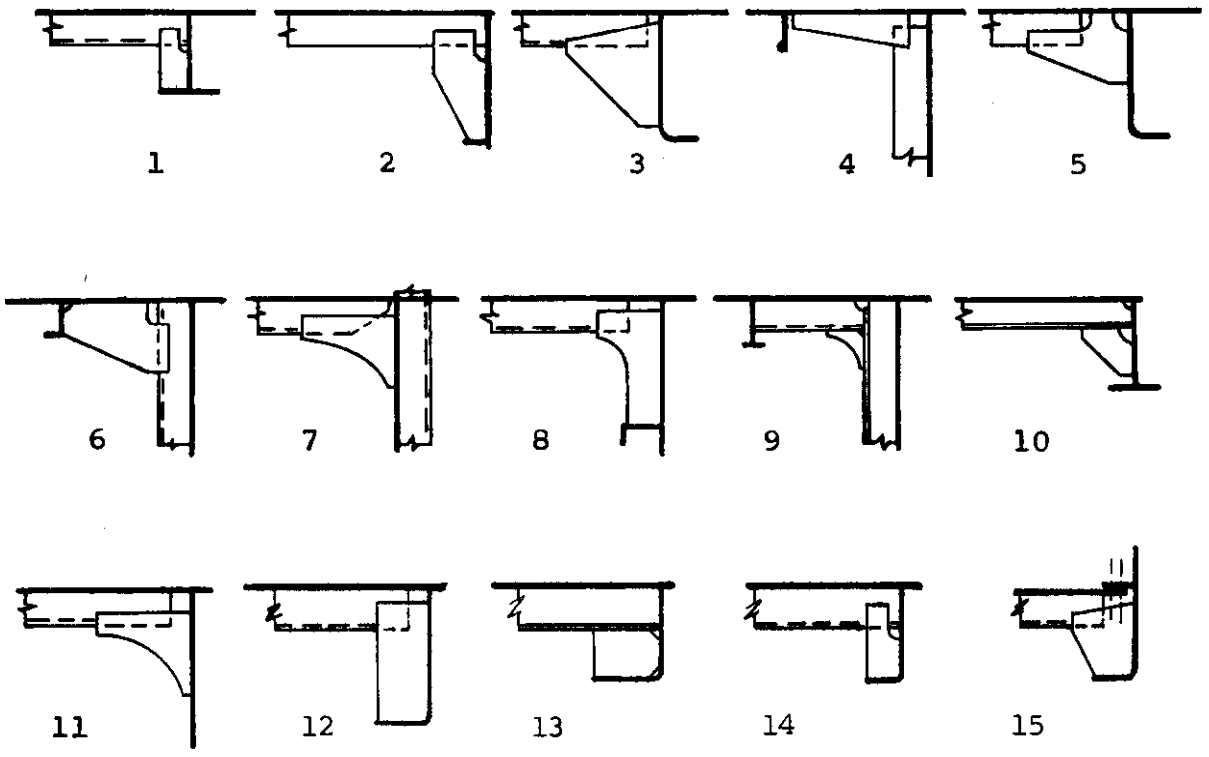


FIGURE 2 - BEAM BRACKETS DETAILS, Family No. 1 (Cont'd)

END

H.



J.

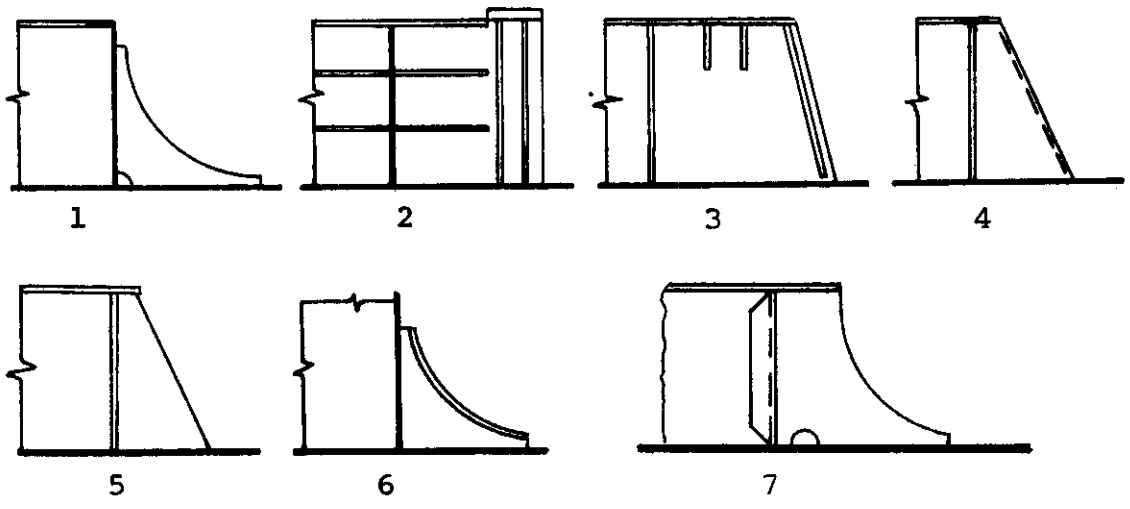
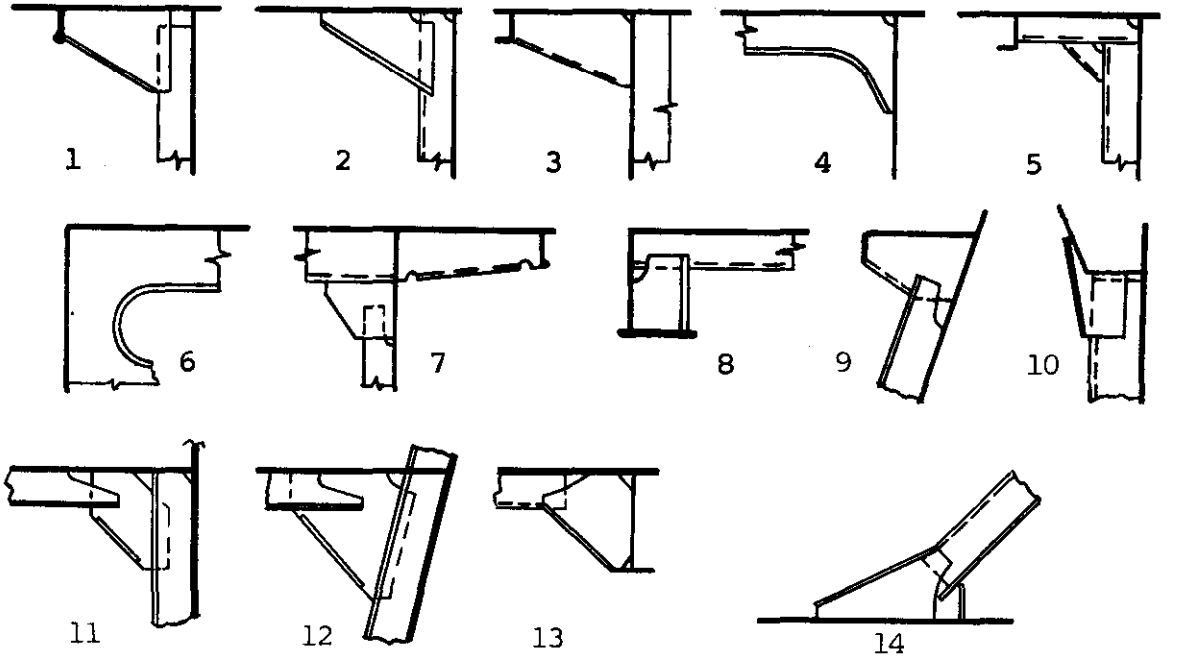


FIGURE 2 - BEAM BRACKETS DETAILS, Family No. 1 (Cont'd)

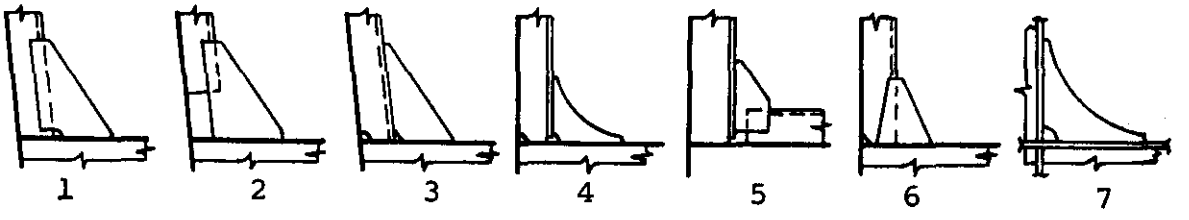
END

K.

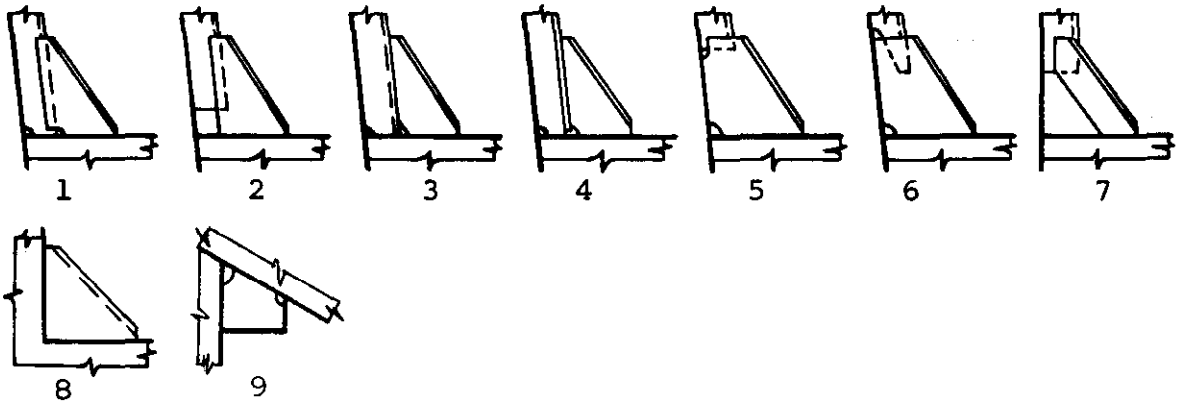


TRANSITION

L.



M.



N.

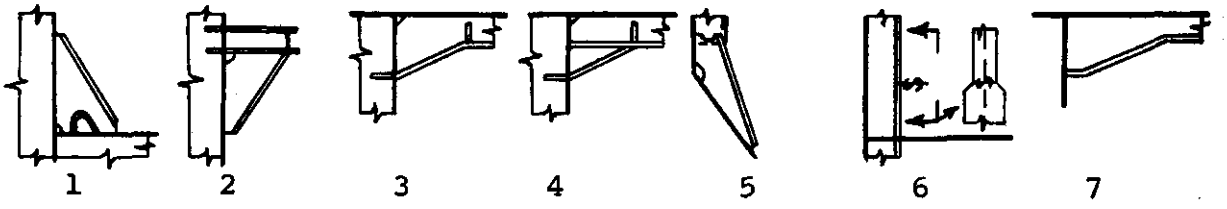
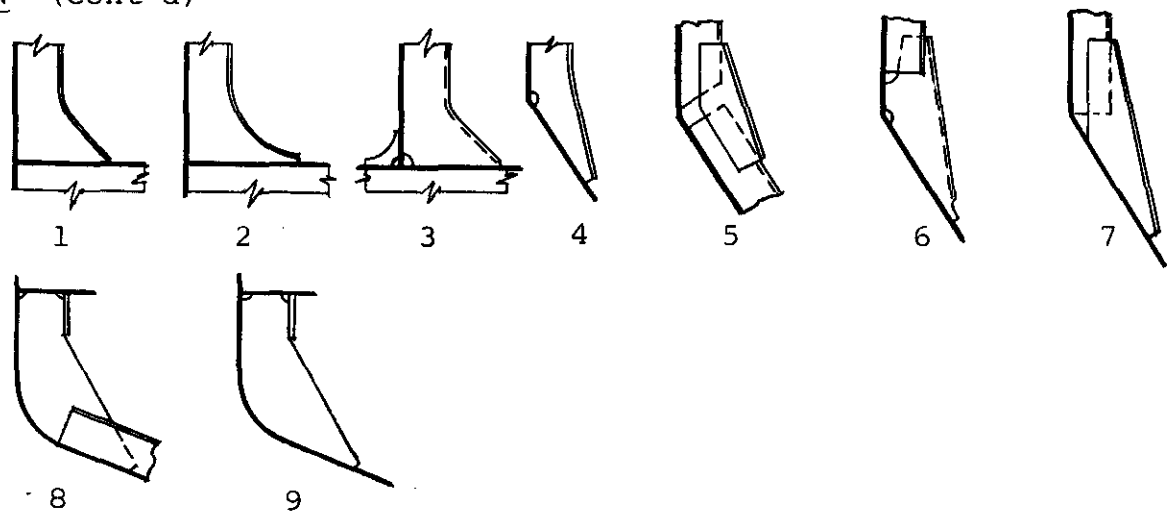


FIGURE 2 - BEAM BRACKETS DETAILS, Family No. 1 (Cont'd)

TRANSITION (Cont'd)

P.



The transition brackets of family group "M" were quite common near the turn of the bilge and, thus, were quite susceptible to corrosion. Proper design, such as drain holes to prevent standing water and elimination of inaccessible areas, coupled with a regularly enforced maintenance program, would have prevented failures in this area.

Table 4 is a summary table of beam brackets observed in the second survey, plus the total observed for both surveys. Although the number of observed details increased by only 35%, the number of failures increased 154%. This was expected since the first survey had shown that the majority of the failures were located in the midship portion of the ship, predominately in structure adjacent to the side shell, and this is where the majority of the beam brackets are located for containerships, general cargo ships and bulk carriers. For instance, the corner brackets of group "C" increased in failures from 2% to 18.3%. The 7.65% failure rate for the midship/cargo section survey of Part II brought the average failure rate up from 1.75% for 50 ships to 3.28% for all 86 ships making beam brackets second to tripping brackets for the highest failure rate.

Figures 3 and 4 are photographs of beam brackets with failures on two different containerships. Figure 3 shows three flanged corner brackets that have remained stable, but the framing that they support has buckled and cracked. Similar failure patterns are shown in Figure 4 where even the bracket itself has started to buckle.

FAMILY NUMBER 2 - TRIPPING BRACKETS

The three groups of tripping brackets, containing 82 different configurations, are shown in Figure 5. Sixteen new variations were found in the second survey with eleven belonging to group "C". Group "C" also continued to have the highest failure percentage rate of the three groups, thus, placing four details on the top ten most prevalent failure list and one detail on the top ten highest percentage failure list. Details 2-C-19, 2-C-11, 2-C-7, and 2-C-20 ranked third, fifth, sixth and tenth, respectively, under most prevalent failures. Details 2-A-20 and 2-C-27 were seventh and tenth under highest percentage failures.

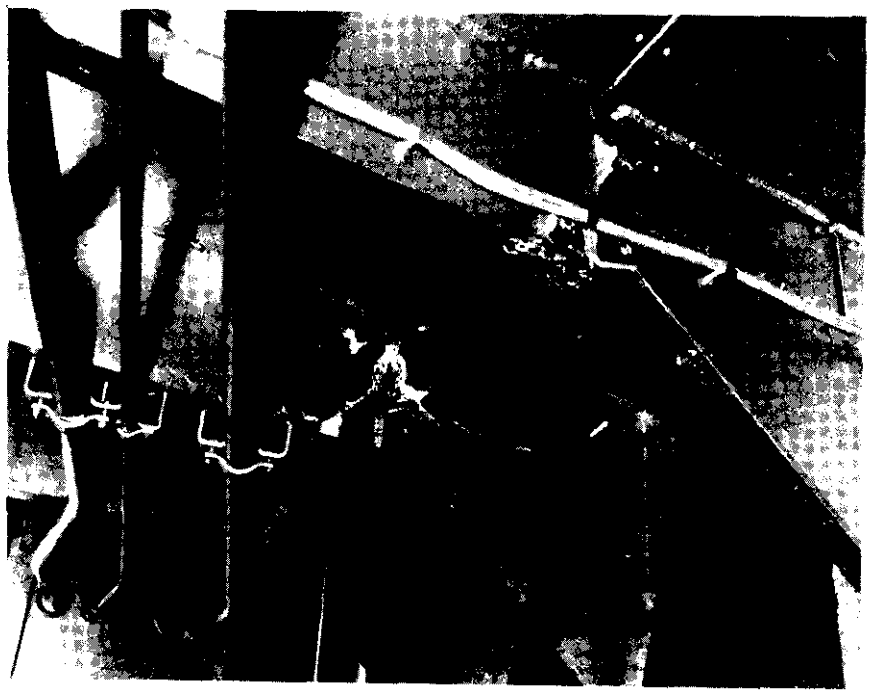
TABLE 4

SUMMARY OF BEAM BRACKETS

FAMILY GROUP	OBSERVED SECOND SURVEY			TOTALS OBSERVED BOTH SURVEYS		
	NUMBER OF DETAILS	NO. OF SOUND DETAILS	% SOUND DETAILS	NUMBER OF DETAILS	NO. OF SOUND DETAILS	% SOUND DETAILS
A	-	-	-	4950	4928	99.6
B	216	213	98.6	4396	4286	97.5
C	6115	4996	81.7	28695	27129	94.5
D	50	50	100.0	3970	3967	99.9
E	3782	3657	96.7	5642	5514	97.7
F	178	176	98.9	1228	1198	97.6
G	74	74	100.0	5114	5114	100.0
H	4166	4120	98.9	5556	5486	98.7
J	214	213	99.5	474	424	89.5
K	1254	1252	99.8	1954	1918	98.2
L	306	305	99.7	1366	1297	94.9
M	1163	1119	96.2	3633	3568	98.2
N	-	-	-	630	593	94.1
P	318	297	93.4	978	912	93.3
TOTAL	17836	16472	92.4	68586	66334	96.7

FIGURE 3

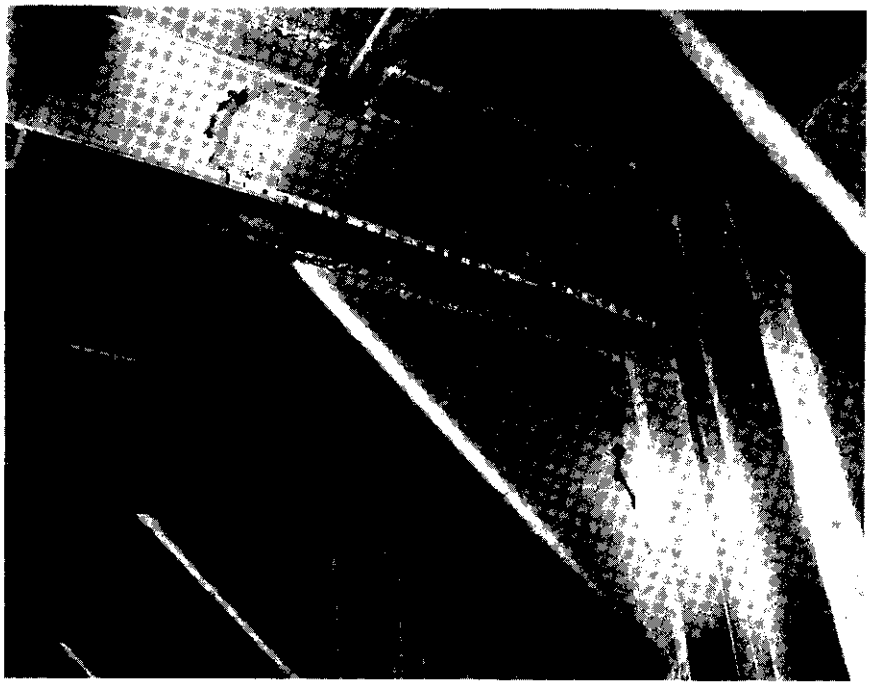
FAILED CORNER BRACKETS ON A CONTAINERSHIP



View of hold showing shell framing bracket connections with framing below fore/aft box girder. The shell framing has been subjected to heavy sea loadings and the loads transferred through the corner brackets have caused the box girder framing to buckle. Note the crack in the web of the framing member in the foreground where the cable clip was welded.

FIGURE 4

FAILED CORNER BRACKET ON A CONTAINERSHIP



Another view of a shell framing bracket connection with a deck stiffener. The peeling paint clearly shows the high stress areas where buckling is about to occur. The weld clearance cutout for the butt weld in the deck above would have been a primary source for a crack if the cutout had not been a smooth cut.

FIGURE 5

TRIPPING BRACKET DETAILS
FAMILY NO. 2

A.

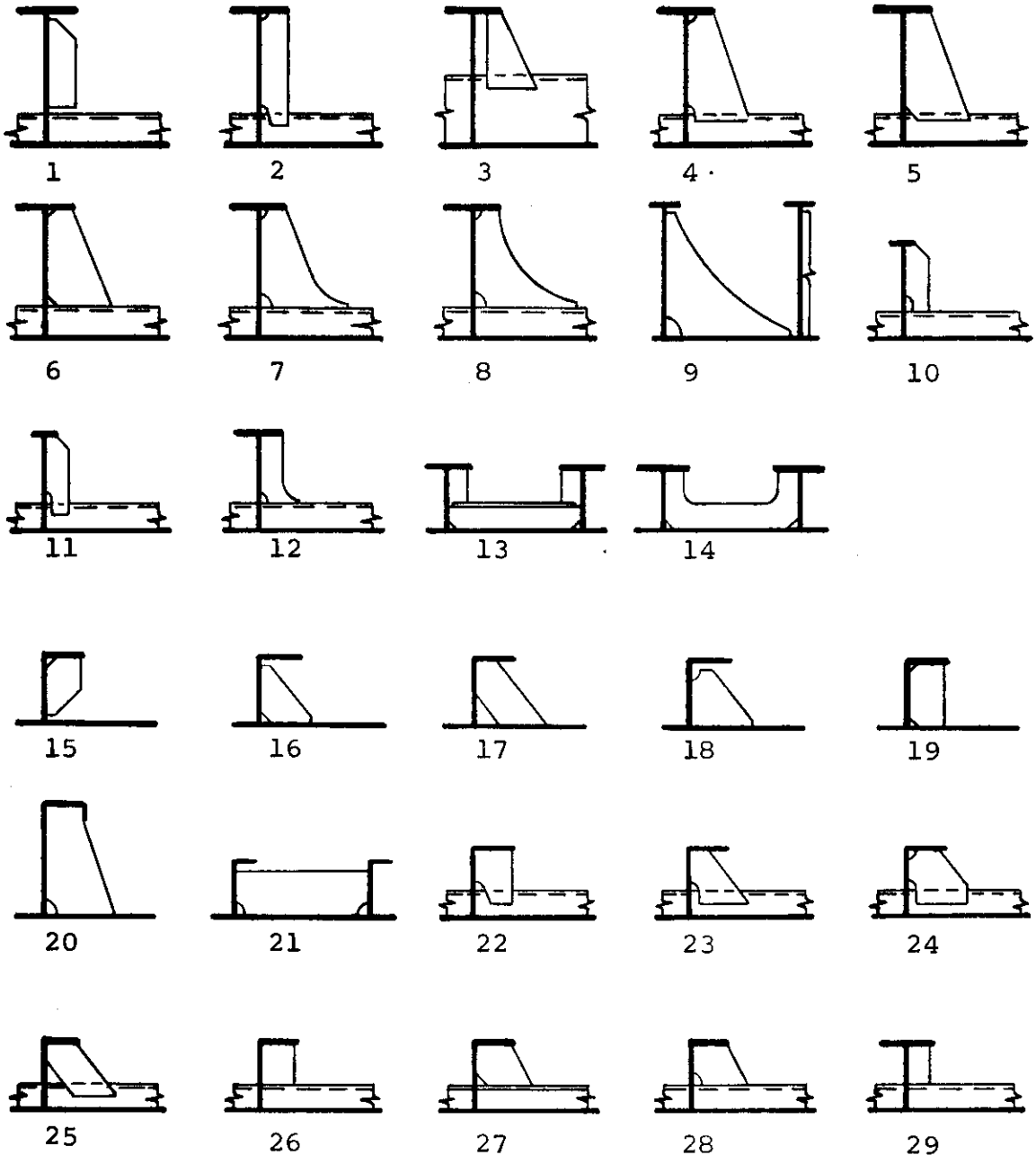
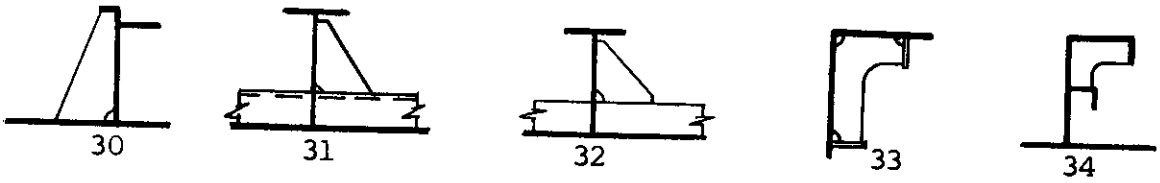


FIGURE 5 - TRIPPING BRACKET DETAILS, Family No. 2 (Cont'd)



B.

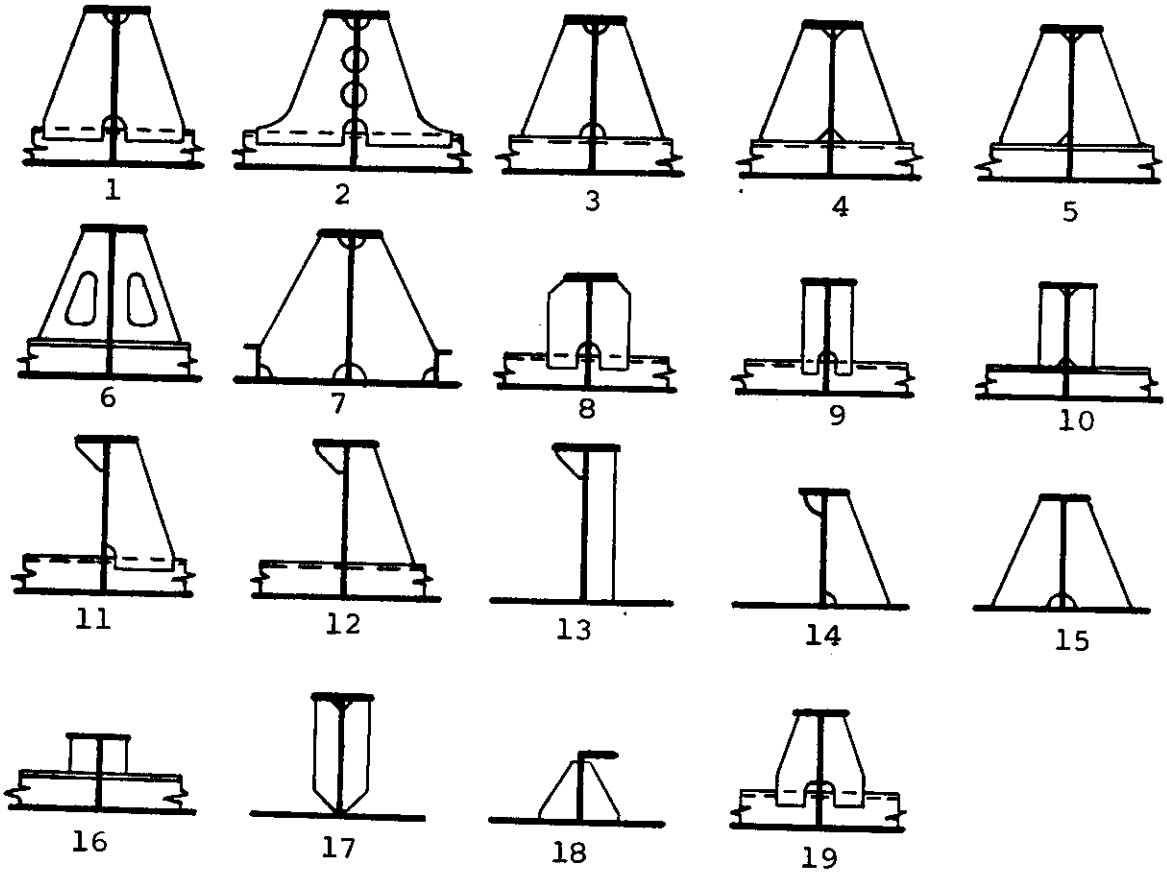
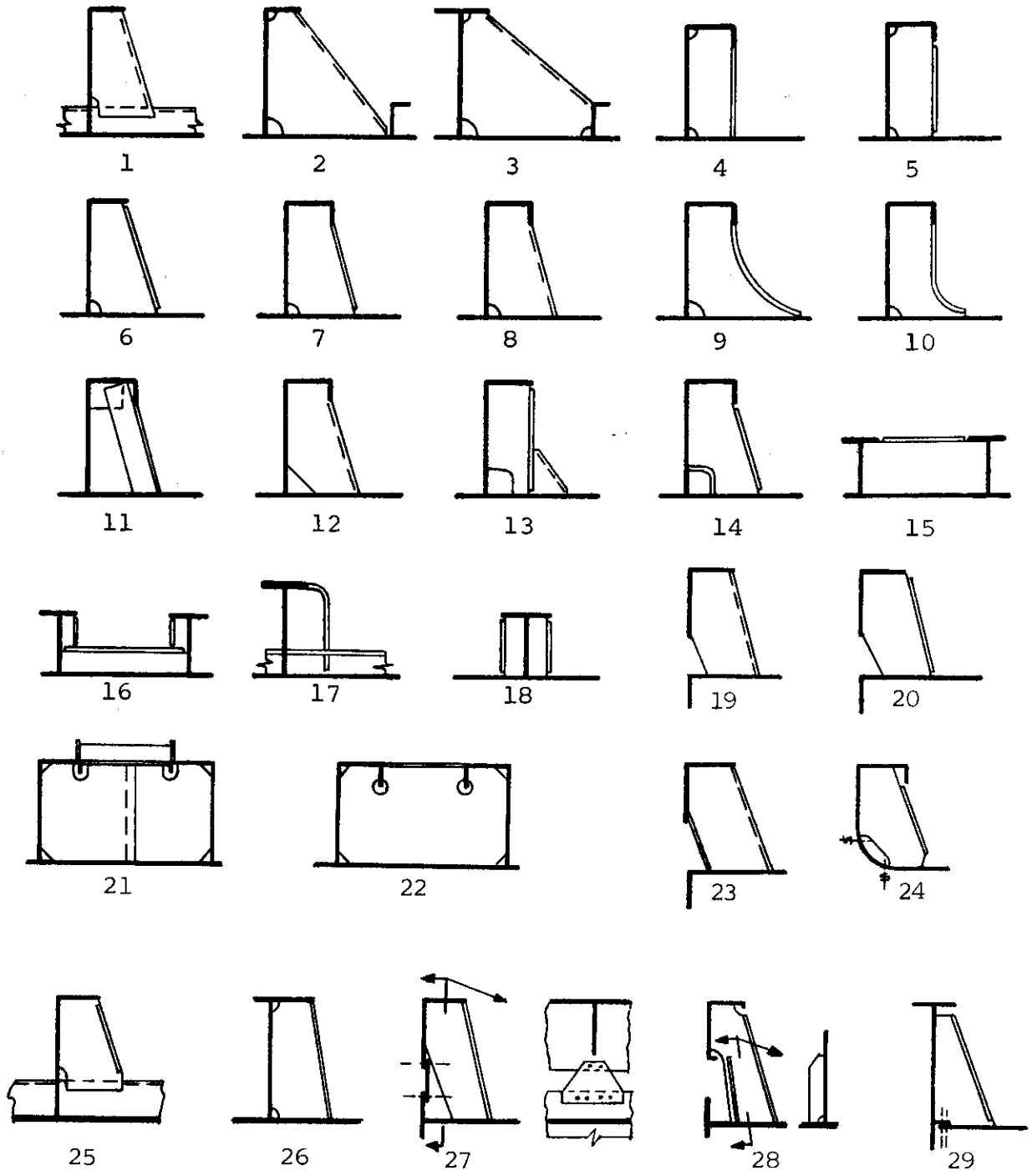


FIGURE 5 - TRIPPING BRACKET DETAILS, Family No. 2 (Cont'd)

c.



Details 2-C-19 and 2-C-20 sustained a high number of failures for several reasons. Poor welding, neglect, cargo collisions, and misuse/abuse were a few causes, but a consistently high percentage of failures occurred where these details were used to secure the booms of general cargo ships when at sea. These details are typical of the tripping brackets used to support the bulwark that runs fore/aft just above the gunwale on both sides of the ship. Tie-down cleats welded to the top of this bulwark make very convenient securing points for the huge booms. When under heavy weather at sea, large shear and tensile forces are applied to the tripping brackets due to the athwartship "G" forces of the heavy booms. Failures even occurred when an extra flange was added to the bracket as in detail 2-C-23. The surveyors did find, however, that on ships where extra tripping brackets and larger scantlings were used under boom tie-downs, no failures occurred.

The high number of failures for detail 2-C-11 resulted primarily from poor fabrication/workmanship. On several general cargo ships, this tripping bracket was used to support the hatch coaming girder on main deck and was partially removed by the ship's crew in order to replace existing pipe that runs alongside the hatch coaming. In replacing the lower half of the tripping bracket, the crew's workmanship was poor. Poor lap welding, sharp notches and very rough cutouts for the pipe quickly developed corrosion and cracks.

Details 2-C-7 and 2-C-8 on both containerships and bulk carriers continue to contain failures when located on the transverse ends of the hatch coamings. Observed failures of details 2-A-20, 2-C-4, and 2-C-26 increase significantly the total list of failures observed for hatch coaming brackets. Heavy seas, welding, neglect and cargo collisions, combined with poor design, have made the task of supporting the hatch side girders a costly one. Additionally, it is necessary to design brackets to carry large lateral loads from rolling when the containers are stacked in four tier heights.[1] Proper design, as shown in detail 2-C-9, should also allow for a smooth transition for the load to travel from the tripping bracket to the back-up structure below. The surveyors noted on several occasions that detail 2-A-20 had been repaired by adding a radiused extension at the toe of the bracket to reduce subsequent failures. This smooth transition provided by the radiused extension is most important when the bracket lines up with the fore/aft hatch side girder. When the fore/aft header, forming the back-up structure for the bracket, reaches the coaming girder there is a significant increase in inertia. Such an abrupt change in stress flow increases crack susceptibility, as was the case 80% of the time.

Table 5 is a total summary of the tripping brackets observed in both surveys. The tripping bracket family had the highest percent of failures with 9.52%, and the second highest number of failures with 1,273 for the second survey. This brought the average failure rate up from 1.52% for the first fifty ships to 4.67% for the total eighty-six ships, making tripping brackets the leader in failure percentage. Much of this can be attributed to the many failures on the bulwark brackets of general cargo ships, and hatch coaming brackets on containerships and bulk carriers, especially in the midship/cargo area.

Figures 6, 7, and 8 are photographs of tripping bracket failures. Figure 6 shows the poor workmanship by the crew on a general cargo ship in the replacement of a pipe adjacent to a main deck hatch coaming. Figures 7 and 8 show failures of tripping brackets on the transverse ends of the hatch coamings on a containership.

---

1. Jordan, C. R.; Ward, W. C., "Structural Details of Ships In Service," presented at Hampton Roads Chapter, Society of Naval Architects and Marine Engineers, March 15, 1978.

TABLE 5

SUMMARY OF TRIPPING BRACKETS

FAMILY GROUP	OBSERVED SECOND SURVEY			TOTALS OBSERVED BOTH SURVEYS		
	NUMBER OF DETAILS	NO. OF SOUND DETAILS	% SOUND DETAILS	NUMBER OF DETAILS	NO. OF SOUND DETAILS	% SOUND DETAILS
A	2083	1953	93.8	12323	12132	98.5
B	126	126	100.0	7046	6991	99.2
C	11163	10020	89.8	14643	13302	90.8
TOTAL	13372	12099	90.5	34012	32425	95.3

FIGURE 6

FAILED TRIPPING BRACKET ON HATCH COAMING OF A GENERAL CARGO SHIP

This is a view of a hatch coaming bracket on main deck. The lower end of each of the brackets were removed by the ship's crew in order to replace the large pipe at the right. Poor workmanship was evident in the replaced bracket as shown by the jagged cutout for the pipe and the sharp notch at the lap weld where a crack started and progressed the entire width of the web. Numerous failures were found among these brackets.

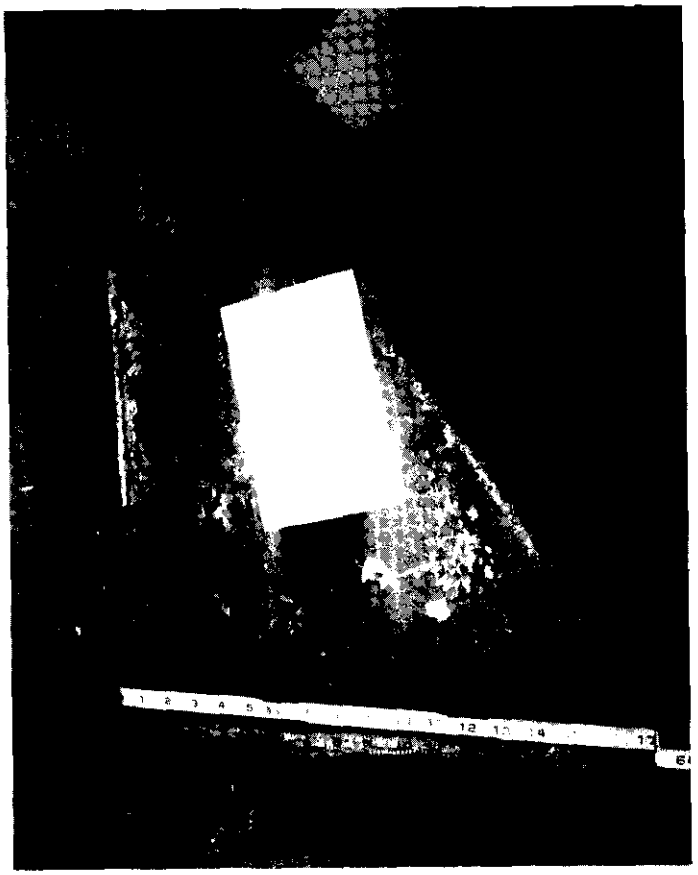
FIGURE 7

FAILED TRIPPING BRACKET ON HATCH COAMING OF A CONTAINERSHIP

View of a transverse hatch coaming bracket at about midship. The weld of the bracket to the deck had been rewelded once and has cracked again. A weld repair of a crack also extends from the corner of a drain cutout to the center of the bracket.

FIGURE 8

FAILED TRIPPING BRACKET ON HATCH COAMING OF A CONTAINERSHIP



This transverse hatch coaming bracket is about two hatches forward of midship. A crack forms a "V" just above the sign and extends around the bracket flange at the weld to the hatch coaming, separating the bracket into two pieces.

FAMILY NUMBER 3 - NON-TIGHT COLLARS

Of the 4,724 non-tight collar details observed in this thirty-six ship survey there were only five failures. Incomplete welding on detail 3-A-16 resulted in two detail failures on a bulk carrier while poor workmanship and bad welding accounted for three failures of detail 3-A-25 on a containership. Thirteen new variations in configurations were observed in this survey, thus resulting in an overall total of forty-nine configurations for the three group family. Figure 9 shows the forty-nine configurations, and Table 6 summarizes the results.

For both surveys, group "A" had 48% of the failures, group "C" had 52% of the failures, and group "B" continued to be failure free. By maintaining a 99.8% rate for sound details in both surveys, the non-tight collar family has the lowest failure rate of all the twelve detail families. One other interesting observation on non-tight collars was noted; although 74% of the details were observed in the midship/cargo section, 79% of the failures occurred in the foreward and aft portions of the ship.

In summary, with proper fabrication, such as smooth, well radiused cutouts and sufficient scantlings on the collar to carry the shear load, united with correct welding techniques, the non-tight collar shall continue to be an economical and dependable structural detail used in building ships.

FAMILY NUMBER 4 - TIGHT COLLARS

Figure 10 contains the thirty-three variations in configurations observed for the family of tight collars. Detail 4-C-7 is the only new configuration identified in this survey. Table 7 is a summary of the number of sound details observed as well as the total observed for both surveys.

Although there were no failures reported in the first survey, there were forty-six or 1.73% failures observed in the midship/cargo area in this survey. Forty-five of the failures belonged to the group "A" configurations and the remaining failure was from group "C". Neglect and collisions were responsible for the forty-five failures of details 4-A-3 and 4-A-6 on three separate general cargo ships. In each case, the tight collar was located where the shell framing member interfaces with the deck. A lack of maintenance resulted in the collars becoming highly corroded in this area. When the shell framing came under heavy loading from collisions, the collars simply buckled due to their reduced thickness.

The only other tight collar failure observed occurred to detail 4-C-1. The detail was located on a containership at the intersection of a shell stringer and a transverse web frame in the fore/aft box girder. The collar and the local web frame were buckled but there was no apparent impact loading on the shell plating. Possibly a large gunwale load caused the subsequent buckle in the web frame.

With the 1.73% failure rate recorded in the second survey, the percent of sound details was lowered from 100% to 99.8%, but the tight collar, as well as the non-tight collar, still remains as one of the most trouble free structural details.

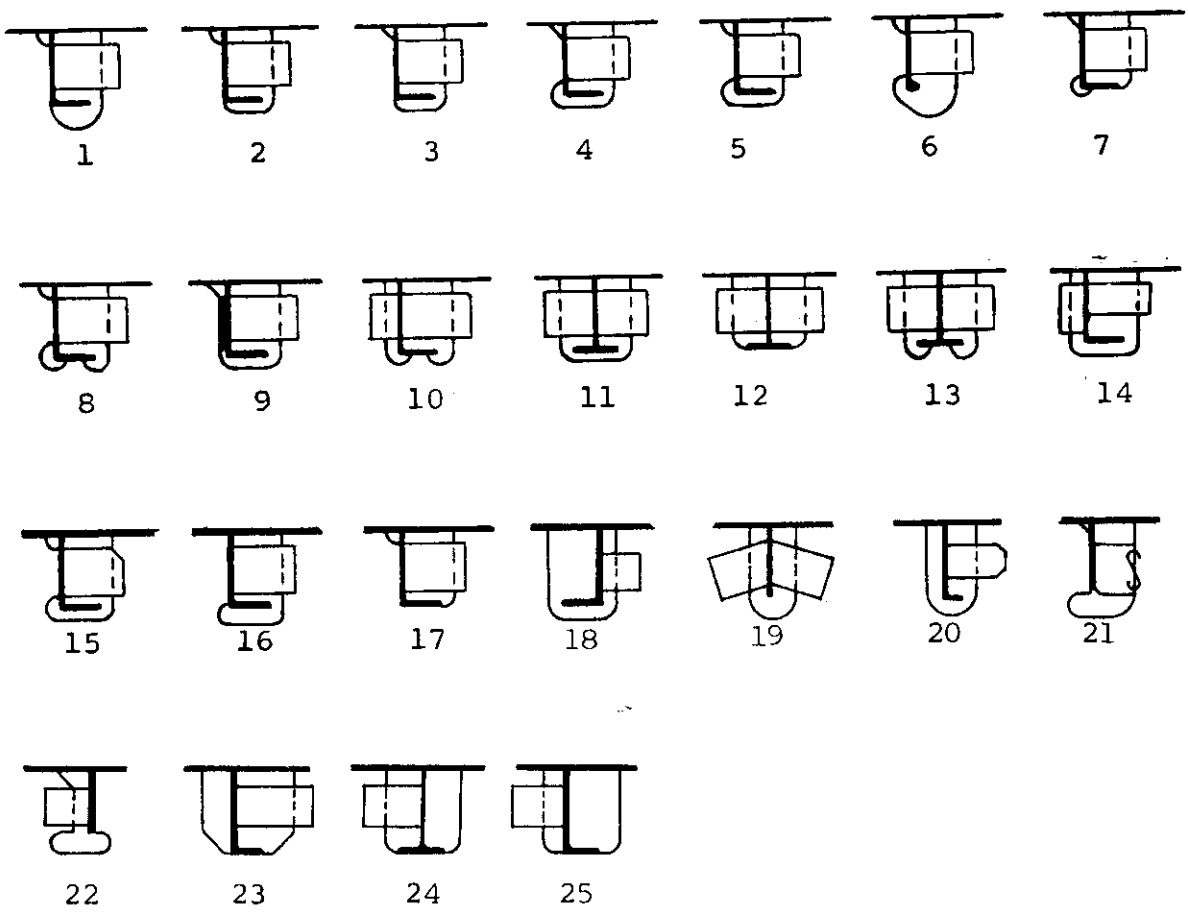
FAMILY NUMBER 5 - GUNWALE CONNECTION

In the second survey, one new variation of riveted gunwale connections was observed. This increased the total number of riveted connections to thirteen,

FIGURE 9

NON-TIGHT COLLAR DETAILS
FAMILY NO. 3

A.



B.

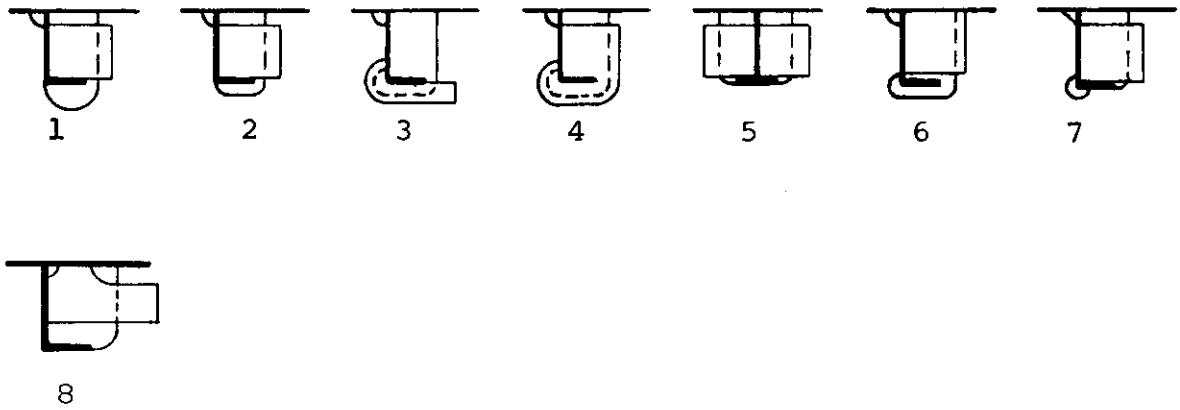


FIGURE 9

NON-TIGHT COLLAR DETAILS
FAMILY NO. 3 (Cont'd)

c.

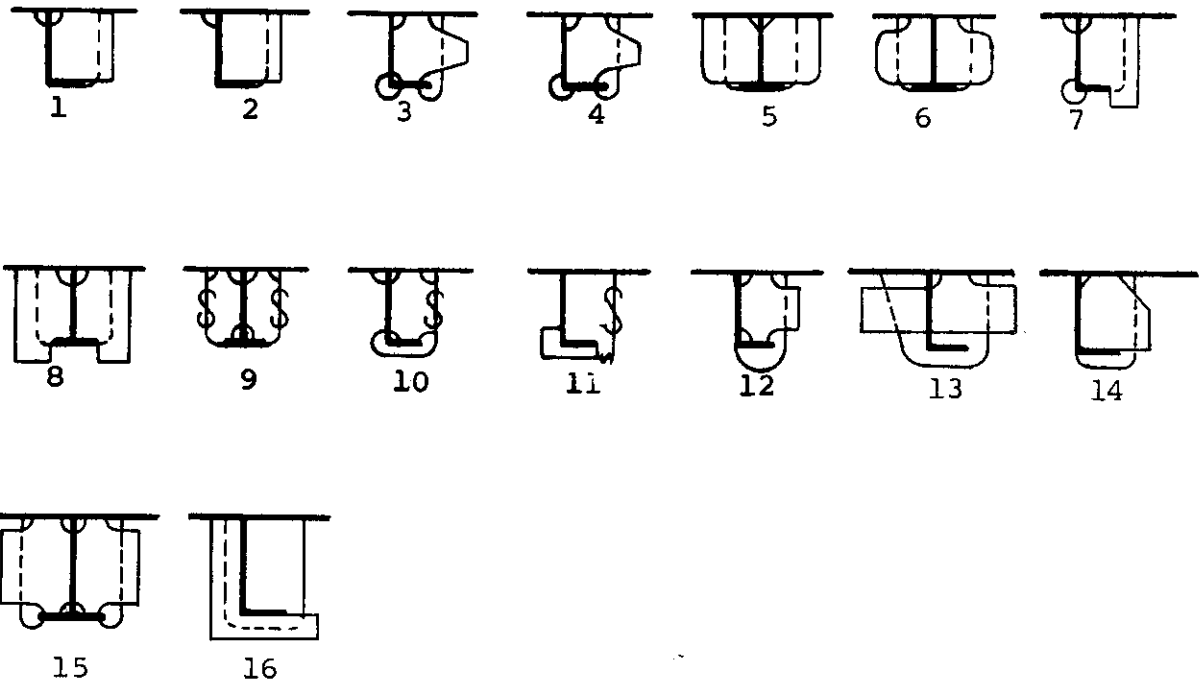


TABLE 6

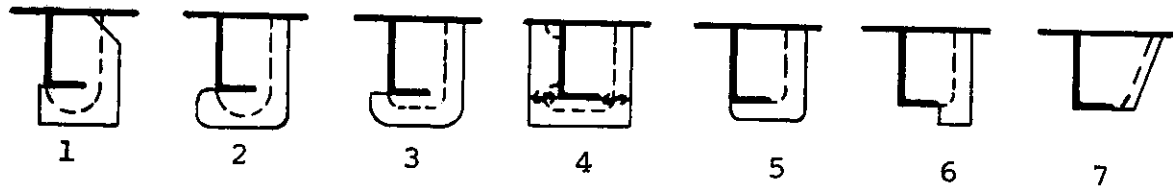
SUMMARY OF NON-TIGHT COLLARS

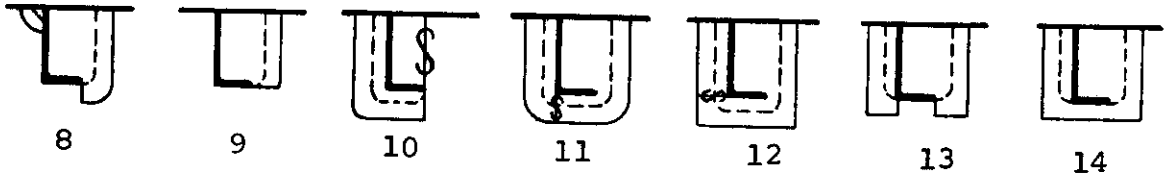
FAMILY GROUP	OBSERVED SECOND SURVEY			TOTALS OBSERVED BOTH SURVEYS		
	NUMBER OF DETAILS	NO. OF SOUND DETAILS	% SOUND DETAILS	NUMBER OF DETAILS	NO. OF SOUND DETAILS	% SOUND DETAILS
A	3406	3401	99.9	9956	9940	99.8
B	903	903	100.0	6603	6603	100.0
C	415	415	100.0	4415	4398	99.6
TOTAL	4724	4719	99.9	20974	20941	99.8

FIGURE 10

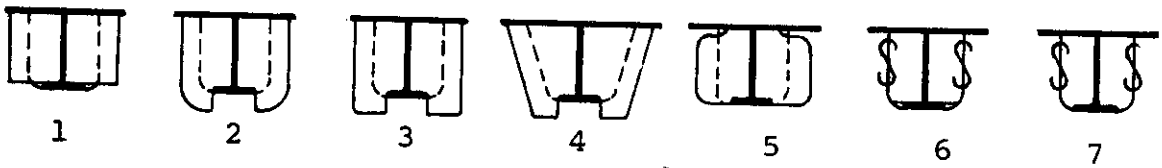
TIGHT COLLAR DETAILS
FAMILY NO. 4

A.

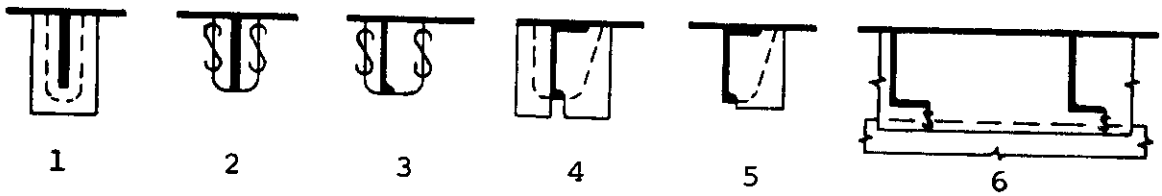




B.



C.



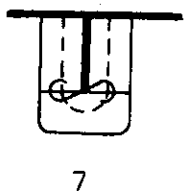
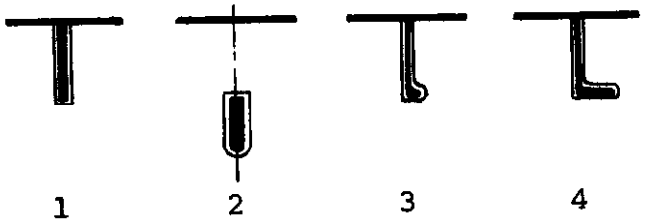


FIGURE 10

TIGHT COLLAR DETAILS
FAMILY NO. 4 (cont'd)

D.



1 2 3 4

TABLE 7

SUMMARY OF TIGHT COLLARS

FAMILY GROUP	OBSERVED SECOND SURVEY			TOTALS OBSERVED BOTH SURVEYS		
	NUMBER OF DETAILS	NO. OF SOUND DETAILS	% SOUND DETAILS	NUMBER OF DETAILS	NO. OF SOUND DETAILS	% SOUND DETAILS
A	1851	1806	97.6	9071	9026	99.5
B	418	418	100.0	4188	4188	100.0
C	193	192	99.5	933	932	99.9
D	192	192	100.0	6462	6462	100.0
TOTAL	2654	2608	98.3	20654	20608	99.8

combined with the welded connections, the total number of configurations becomes twenty-one. The two groups are shown in Figure 11, and all summarized data are given in Table 8.

Only one failure was observed in the second survey as opposed to four found in the first survey. Detail 5-A-1 was the source of a local out-of-plane displacement in the vertically cantilevered portion of the shear strake just above main deck on a containership. This failure was similar to the four in the first survey except the plate displacement was outboard instead of inboard. Collision could not be ruled out, but since the displacement was outboard and located just forward of the aft deckhouse, excessive compressive stresses in the gunwale was a possible cause of failure. Further investigation did not reveal any other problems locally or in the gunwale connection on the other side of the ship. Figure 12 is a photograph of the failure.

As in the first survey, workmanship and welding was excellent on most of the gunwale connections although deterioration by corrosion was evident in some places. A few containerships contained drain holes on main deck very close to the gunwale connection. All the cutouts were reinforced with drain pipes and with proper fabrication/workmanship techniques employed, no cracks were observed. However, one historical crack existed on main deck on a containership that started near the gunwale connection and worked its way inboard. The crack kept reappearing in a butt weld on a doubler plate. The doubler plate was located on top of the fore/aft box girder at the connection of the new mid-body to the original ship. The area had been rewelded about five times leaving a butt weld bead about two inches wide.

In summary, there were only five failures occurring on three different ships for the total eighty-six ship survey. Four of the five failures were suspected to be due to exterior abuse rather than to the internal stresses from ship operations as surmised in the last failure. The total failure rate for gunwale connections is 2.91%.

FAMILY NUMBER 6 - KNIFE EDGES

There were no knife edges found on any of the thirty-six ships. This was expected because as stated in the first survey, "to detect a definite "knife" requires a study of the detail structural plans used in the construction of the ship and in all subsequent structural modifications. This would be extremely time-consuming as well as impossible for a study of this type since the ships do not carry these drawings with them."[1]

FAMILY NUMBER 7 - MISCELLANEOUS CUTOUTS

Miscellaneous cutouts are utilized extensively throughout the length of the ship. They vary in size from an air hole to an access opening but each one has a particular structural function. Figure 13 shows the seventy-two observed shape variations including the seven new ones observed in the second survey. The variations are grouped according to one of the following functional requirements:

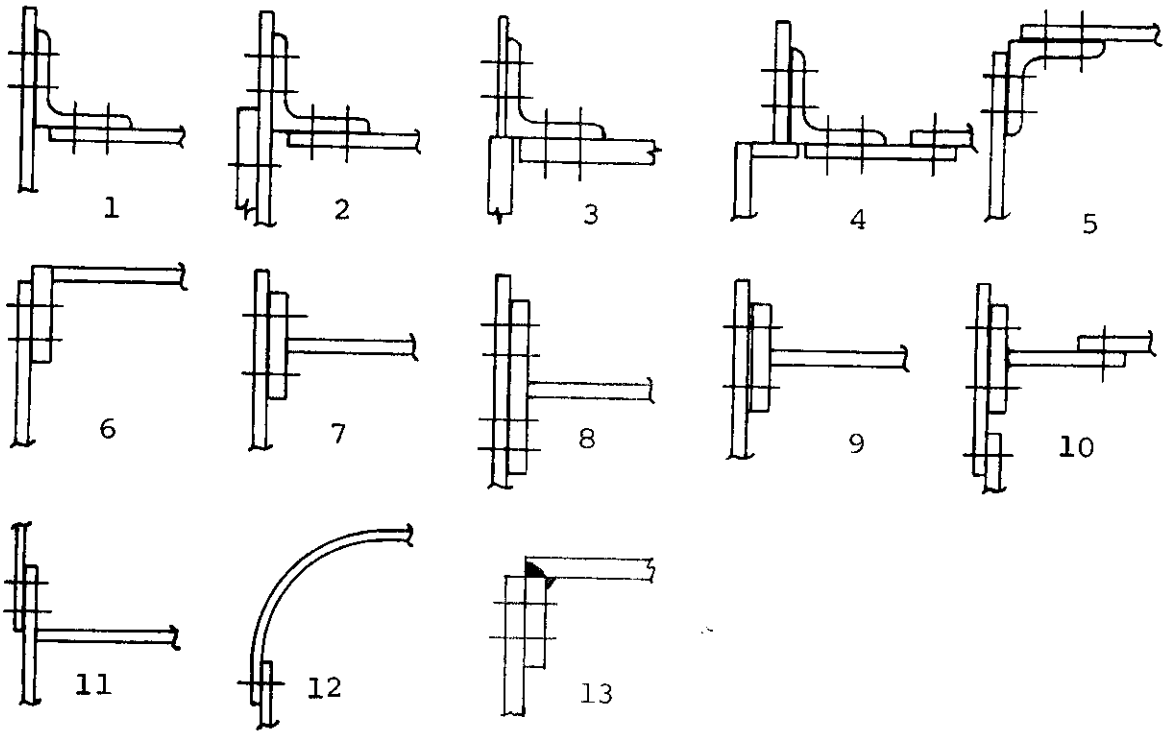
- o Group 7-A access openings
- o Group 7-B air escapes

1. Jordan, C. R.; Cochran, C. S., "In-Service Performance of Structural Details," Ship Structure Committee Report SR-1232, March, 1977

FIGURE 11

GUNWALE CONNECTION DETAILS
FAMILY NO. 5

A.



B.

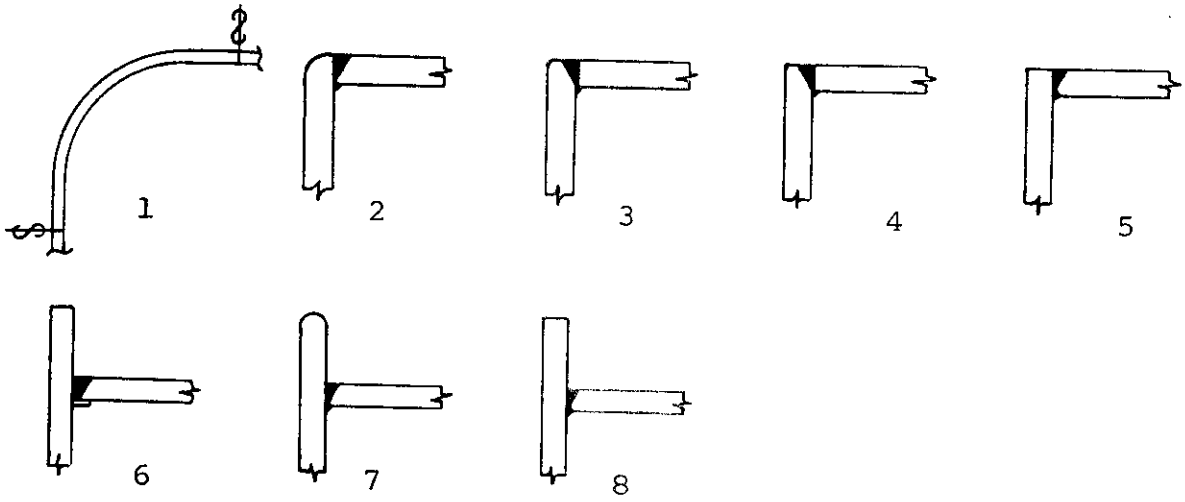


TABLE 8

SUMMARY OF GUNWALE CONNECTIONS

FAMILY GROUP	OBSERVED SECOND SURVEY			TOTALS OBSERVED BOTH SURVEYS		
	NUMBER OF DETAILS	NO. OF SOUND DETAILS	% SOUND DETAILS	NUMBER OF DETAILS	NO. OF SOUND DETAILS	% SOUND DETAILS
A	42	41	97.6	102	99	97.1
B	30	30	100.0	70	68	97.1
TOTAL	72	71	98.6	172	167	97.1

FIGURE 12

FAILED GUNWALE CONNECTION ON A CONTAINERSHIP

This view shows a gunwale connection with the upper portion of the shear strake displaced outboard. Location was near midship just forward of the deckhouse. Collision was not ruled out, but excessive compressive stresses in the gunwale was highly suspected as the cause of failure.

FIGURE 13

MISCELLANEOUS CUTOUT DETAILS
FAMILY NO. 7

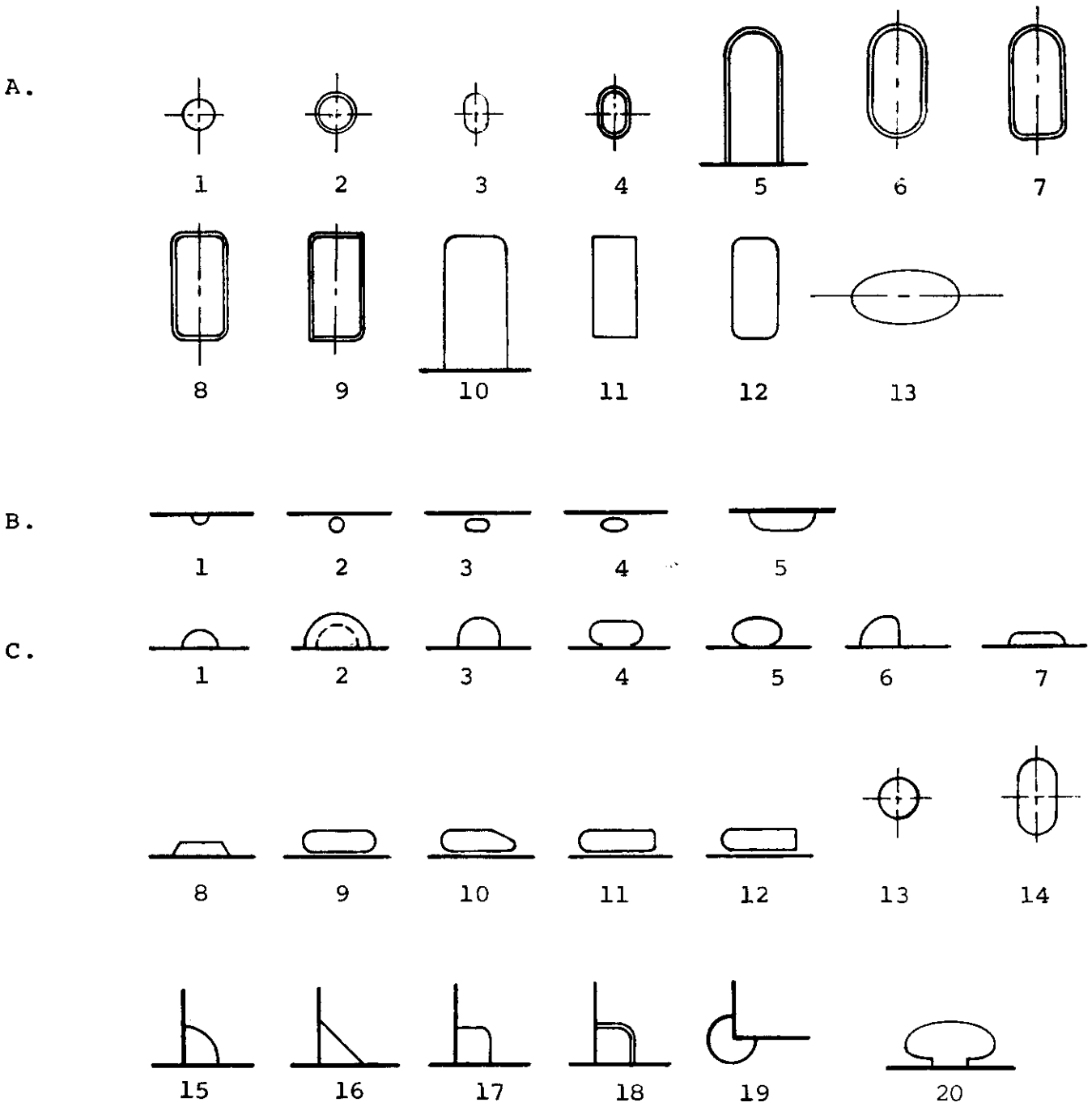
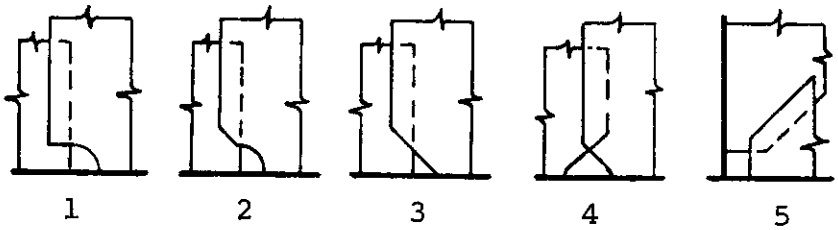
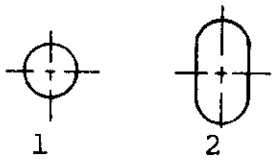


FIGURE 13 - MISCELLANEOUS CUTOUT DETAILS, Family No. 7 (Cont'd)

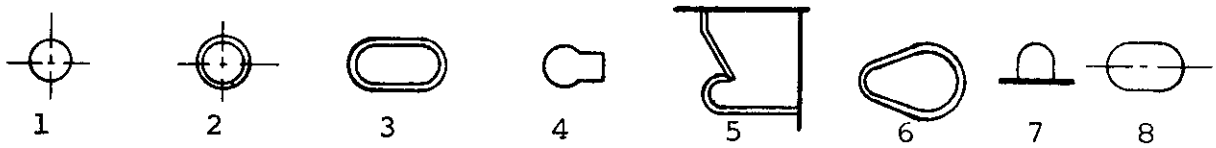
D.



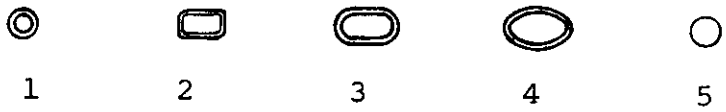
E.



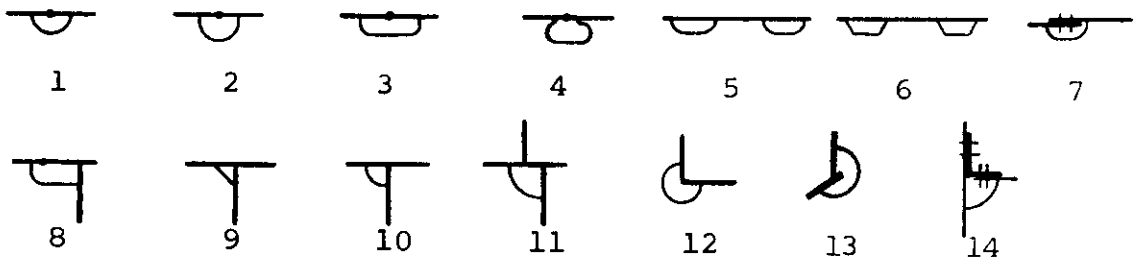
F.



G.



H.



- o Group 7-C drain holes
- o Group 7-D lapped web openings
- o Group 7-E lightening holes
- o Group 7-F pipeways
- o Group 7-G wireways
- o Group 7-H weld clearances

Since each individual detail may have more than one primary function, some of the configurations may appear in more than one group. Table 9 contains a summary of the 296,689 details observed in both surveys.

There was one failure observed for the family of access openings in the second survey. Detail 7-A-10 had a three inch crack in the lower right corner of the cutout. The cutout, used as an access opening in the longitudinal bulkhead of a general cargo ship, should have possibly had a coaming to help protect it against secondary bending in this primary strength member. Many historical cracks were seen around the main deck doorways leading into the deckhouse as mentioned in the first survey, but no failures were recorded since all surveying was restricted to the immediate midship/cargo area.

No failures were reported for air holes, however, their location made them highly susceptible to neglect and subsequent corrosion. One new configuration was recorded as detail 7-B-5.

Three different details contributed to the fifty-one drain hole failures. Details 7-C-1, 7-C-15 and 7-C-16 failures were caused predominantly by rough cutouts and neglect. Figure 14 is a photograph of a typical drain hole that was cracked as a direct result of a rough cutout. This particular drain hole should have been given special attention due to its location in a high stress region. An excellent list of rules for fabrication is provided in "Structural Details of Ships In Service."[1]

Only 360 lapped web openings were viewed in the second survey with no failures reported. The majority of these were found in the fore/aft box girders on a German built containership. The cutouts had smooth, well rounded radii and ample clearance for welding.

Lightening hole details 7-E-1 and 7-E-2 were found in the midship/cargo area of each of the three ship types surveyed, but no failures were observed. In the first survey, of these three ship types the containerships had four failures, while 155 or 97% of the total failures occurred in tankers and combination carriers. Bulk carriers and general cargo ships showed no failures for lightening holes in either survey.

Ninety-one percent of the pipeway failures in group "F" were attributed to cutout configurations, such as 7-F-1, which do not have reinforcing rings around the hole. Other reasons for failures were rough cutouts, defective welds, heavy seas, and improper location of hole cuts in high stress regions. Some good examples of typical pipeway failures are shown in Figures 15 and 16.

Wireways had only seven failures, five were detail 7-G-3. The cracks were due to poor fabrication/workmanship and lack of fusion in welding. Two cracks

1. Jordan, C. R.; Ward, W. C., "Structural Details of Ships In Service," presented at Hampton Roads Chapter, Society of Naval Architects and Marine Engineers, March 15, 1978.

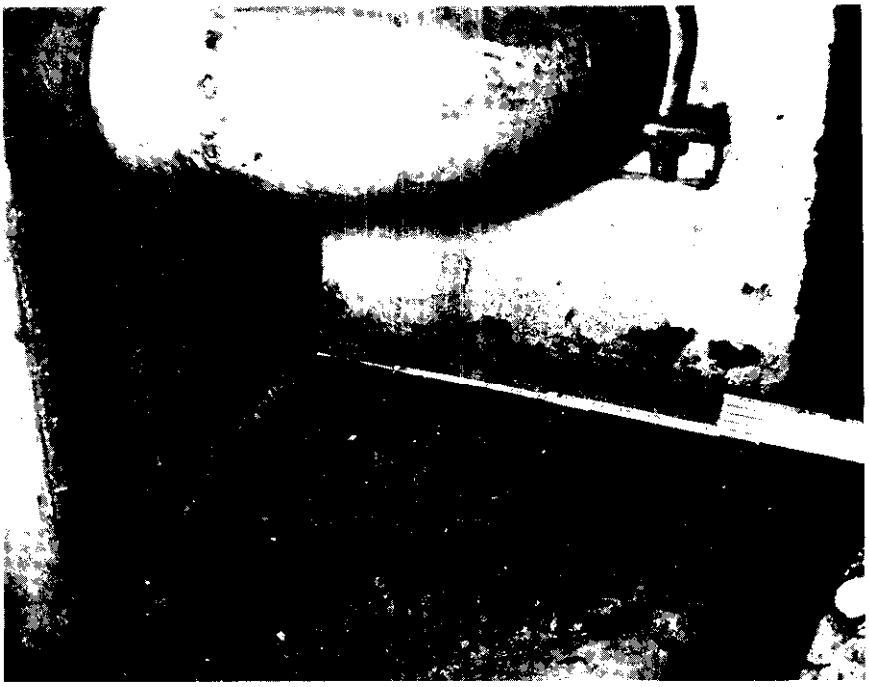
TABLE 9

SUMMARY OF MISCELLANEOUS CUTOUTS

FAMILY GROUP	OBSERVED SECOND SURVEY			TOTALS OBSERVED BOTH SURVEYS		
	NUMBER OF DETAILS	NO. OF SOUND DETAILS	% SOUND DETAILS	NUMBER OF DETAILS	NO. OF SOUND DETAILS	% SOUND DETAILS
A	959	958	99.9	4809	4780	99.4
B	2130	2130	100.0	18940	18912	99.9
C	9111	9060	99.4	59091	58954	99.8
D	360	360	100.0	2550	2531	99.3
E	2041	2041	100.0	19551	19392	99.2
F	2565	2542	99.1	6575	6542	99.5
G	620	613	98.9	10520	10508	99.9
H	26033	25908	99.5	174653	174217	99.8
TOTAL	43819	43612	99.5	296689	295836	99.7

FIGURE 14

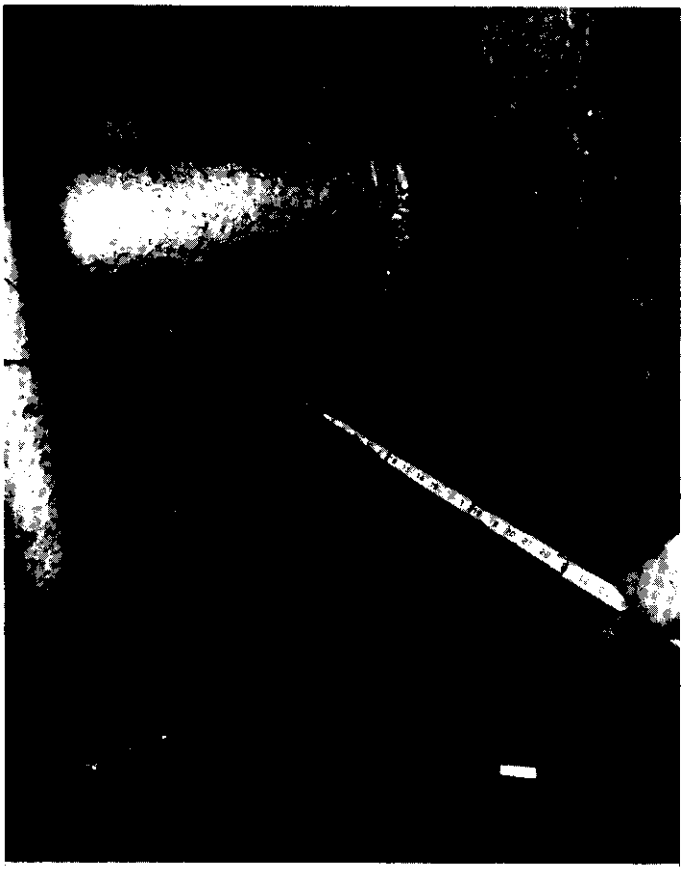
FAILED DRAIN HOLE IN A TRIPPING BRACKET ON A CONTAINERSHIP



This is a view of a cracked drain hole cutout located in a tripping bracket that supports the hatch coaming on a containership. If the cutout had formed a smooth semi-circle instead of the irregular cut that is shown, the crack would probably have not occurred.

FIGURE 15

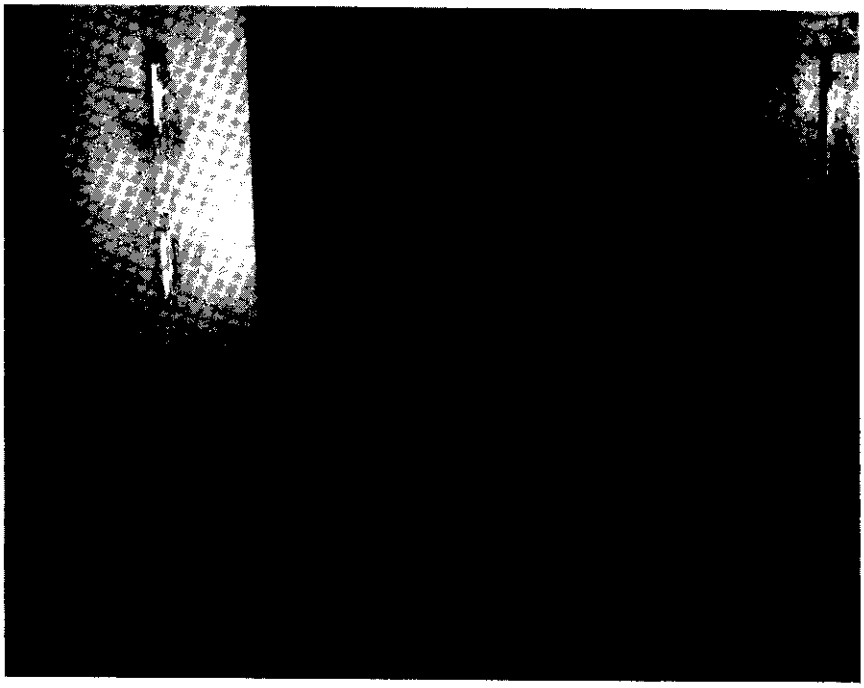
FAILED PIPEWAY CUTOUT IN A HATCH COAMING BRACKET ON A CONTAINERSHIP



View of a pipeway cutout in a tripping bracket at the corner of a hatch coaming on main deck. Notice where previous cracks have been welded around the cutout in both the one and six o'clock positions. In the six o'clock position, the crack had extended to a drainage cutout in the corner. A reinforcing ring has been added to help strengthen the hole in this region of high tensile stress. Also, just above the hand in the picture, can be seen a radiused plate that has been added to the bracket in order to smooth the transition of the bracket with the deck. This is an area where cracks at the toe of the bracket are common.

FIGURE 16

BUCKLED WEB PLATE AROUND PIPEWAY ON A CONTAINERSHIP



View in hold showing shell framing on the left and a transverse bulkhead on the right. The shell has been loaded by heavy seas resulting in some permanent deformation. The peeling paint shows the stress patterns around the hole cut for the pipe and at the intermittent welds on the shell framing. The hole should have been reinforced with a face plate, however, proper design would have required the pipe to go through the bulkhead via the existing wireway cutout below.

were found in a transverse box girder on a containership; and, five were found in the fore/aft box girder of a bulk carrier which had been converted from a Navy missile ship.

As in the first survey, weld clearances experienced more failures than any other group in this family. Configurations 7-H-9, 7-H-1, 7-H-10, 7-H-13, 7-H-11, 7-H-2 and 7-H-3 contained the defects in numerically descending order. Elongated cracks originating at the cutouts were the only failure modes and no one factor predominated the long list of failure causes. However, one new variation in configuration, detail 7-H-13, consistently showed a high percentage of failures on bulk carrier sister ships. The cutouts were in the transverse web frames in the wing tanks where the vertical and sloping hold bulkheads intersected. Although workmanship and welding were excellent, cracks existed at both the top and bottom of this cutout in an area of high stress.

Figures 17 and 18 are pictures of two weld clearance cuts with failures. Both failures were a direct result of poor fabrication and welding. In Figure 17, the existing weld clearance cutout was extended to meet a replaced shell framing member. The cutout was made smooth. However, because of the location and a bad weld, a failure was inevitable. Figure 18 shows a large crack extending from a cutout similar to 7-H-1 in a main loading carrying girder on a general cargo ship.

As was found in the first survey, no one group of miscellaneous cutouts could be singled out as having more failures than the others. Three groups had 100% sound details and each of the remaining five groups had less than a 1% failure rate. The second survey had 207 failures for a 0.47% failure rate which brought the totals up to 853 failures and a 0.29% failure rate for both surveys. This is a very low failure rate, but, by having 853 failures, the family is ranked third on the most prevalent failure list.

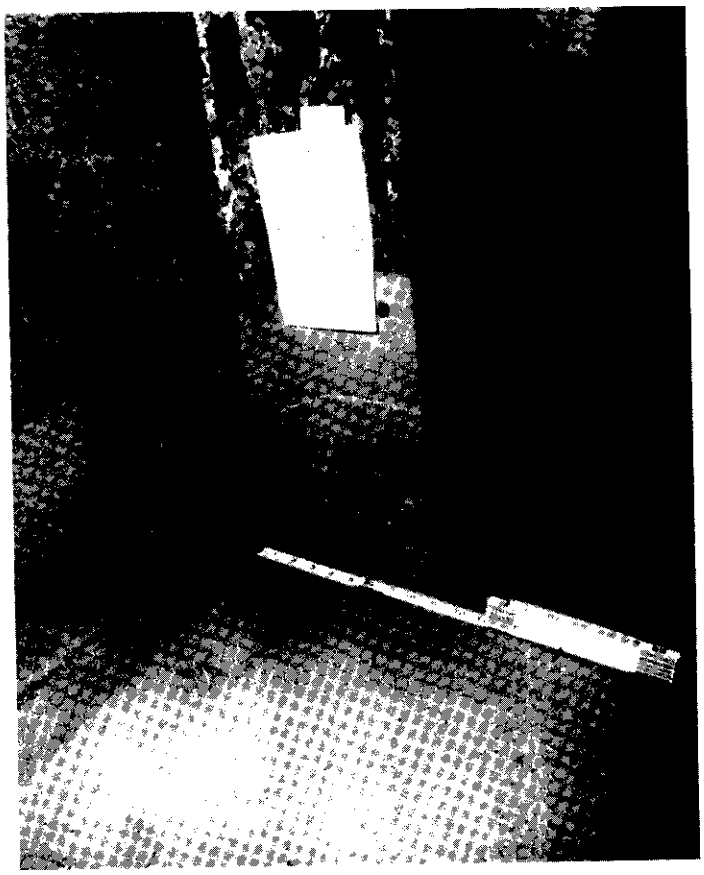
FAMILY NUMBER 8 - CLEARANCE CUTOUTS

The purpose of clearance cutouts is to maintain continuity of one member through another. There are thirty-nine variations in configuration for this family as shown in Figure 19. Details 8-A-3, 8-B-7, 8-E-13, and 8-E-14 are new configurations identified in this survey. The details are grouped according to geometrical shape or attachment to the impeding structural member. Results for this grouping are summarized in Table 10.

In the second survey, there were no failures observed in groups "A" and "D". Group "D" listed 593 failures in the first survey, but only eight of those were found aboard one of the three ship types investigated in the second survey. Detail 8-B-2 was the lone failure for group "B" and it could have been avoided with proper workmanship. Group "C" had three failures contributed to fabrication and welding and two failures contributed to high tensile and shear stresses around a stiffener cutout on a self-unloader gate on a bulk carrier. Twelve of the sixteen failures in group "E" were found in the wing tanks of a 90,000 ton bulk carrier. Only a few of the wing tanks were made accessible to the surveyors, however, the shipowner stated the cutouts had a history of problems throughout the ship. The owner felt that a lack of protective coating on the edges of the cutout during fabrication had resulted in stress corrosion, causing cracks in the radiused corners.

FIGURE 17

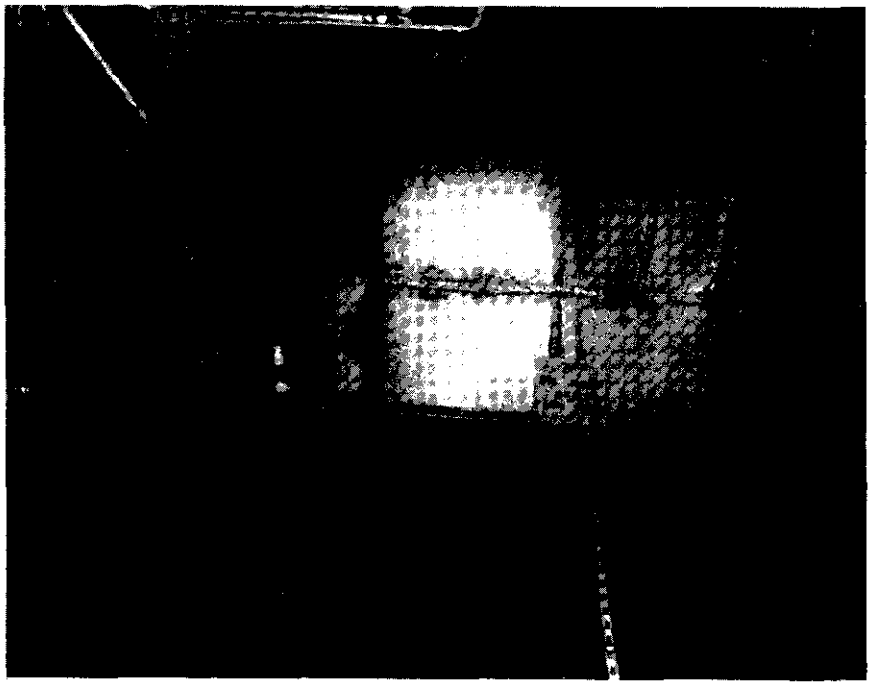
FAILED WELD CLEARANCE CUTOUT ON A CONTAINERSHIP



This picture in the cargo hold of a containership shows the end connections of two shell framing members that have been replaced. The existing weld clearance cut was extended to meet the new framing member. The welding for this particular framing member was so bad that a crack had started in the center of the web.

FIGURE 18

FAILED WELD CLEARANCE CUTOUT ON A GENERAL CARGO SHIP



View in cargo hold looking up at a longitudinal girder under main deck. A crack extends from the butt weld clearance cutout to the transverse header on the right, and from the same cutout for a distance of about two feet on the left. The crack is mostly in the heat affected zone of the weld except for a small length at the left. Note pillar supporting girder at the far left. The cutout had been extended to reach the butt weld in main deck.

FIGURE 19

CLEARANCE CUTOUTS DETAILS
FAMILY NO. 8

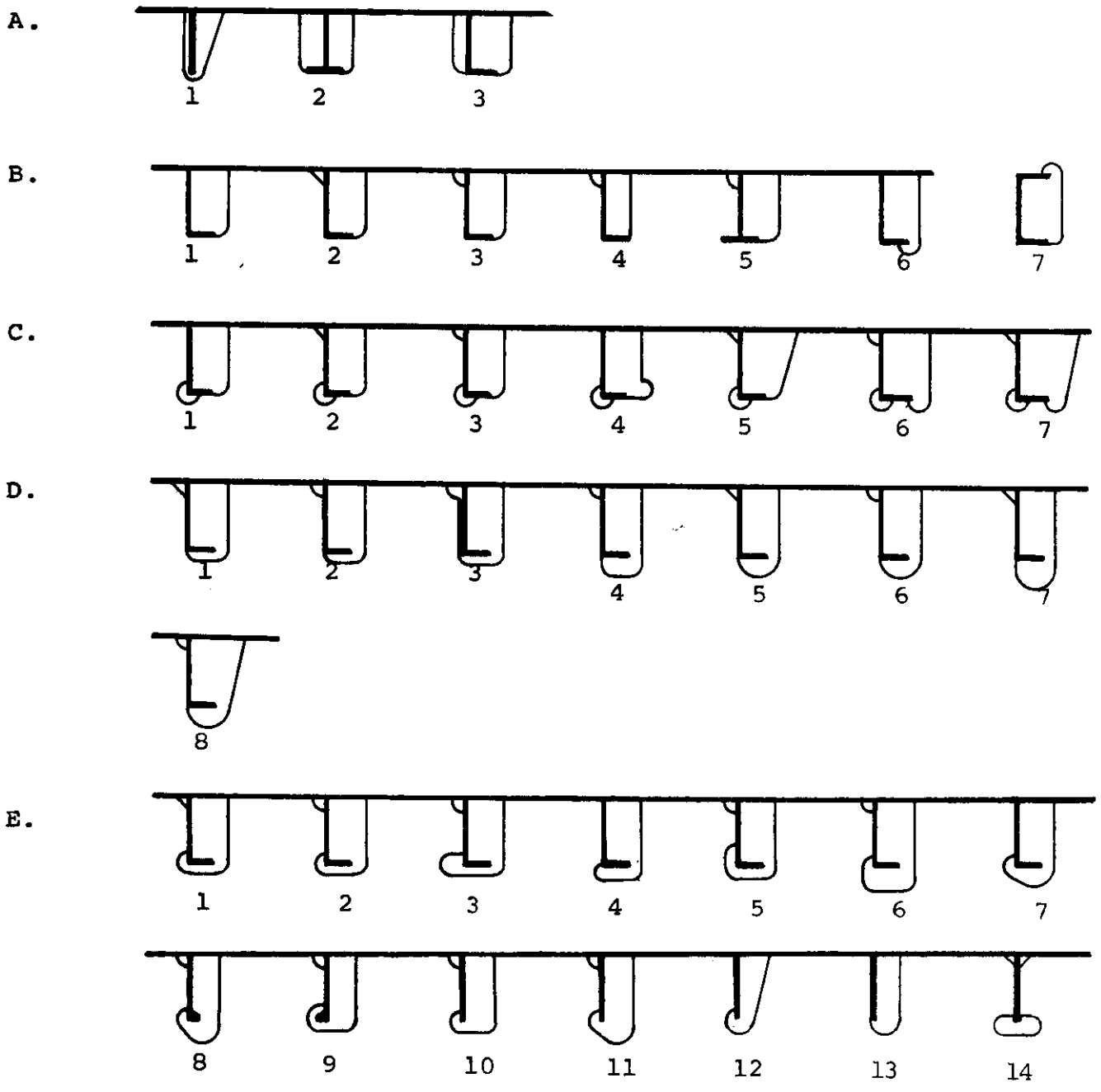


TABLE 10

SUMMARY OF CLEARANCE CUTOUTS

FAMILY GROUP	OBSERVED SECOND SURVEY			TOTALS OBSERVED BOTH SURVEYS		
	NUMBER OF DETAILS	NO. OF SOUND DETAILS	% SOUND DETAILS	NUMBER OF DETAILS	NO. OF SOUND DETAILS	% SOUND DETAILS
A	252	252	100.0	672	636	94.6
B	537	536	99.8	6757	6726	99.5
C	773	768	99.4	9813	9733	99.2
D	1026	1026	100.0	15106	14513	96.1
E	6209	6193	99.7	24959	24856	99.6
TOTAL	8797	8775	99.7	57307	56464	98.5

Figure 20 shows an attempt to repair a crack in the web plating at the heel of a through angle stiffener on a longitudinal bulkhead. The previous crack has been welded shut and a flat bar stiffener added to prevent future cracks; but, as shown in the picture, a crack has appeared again, this time in the heat affected zone of the weld.

In summary, there were only twenty-two failures observed for the family of clearance cutouts in the second survey. This was only about three percent of the 821 failures found in the first survey, however, 752 of those first survey failures were from tankers and combination carriers. The remaining sixty-nine failures on containerships, general cargo ships, and bulk carriers, represents a failure rate of 0.36% which is in line with the 0.25% failure rate for survey number two.

FAMILY NUMBER 9 - DECK CUTOUTS

Sketches of the three groups of deck cutouts are presented in Figure 21. There were twenty-one variations in configurations with no new variations observed in the second survey. Groups "A" and "B" are small deck openings normally used for access, and group "C" configurations are deck cuts at corners of large hatch openings. Table 11 is a summary of the collected data for the second survey and both surveys combined.

One hundred percent of the deck cuts in group "A" were functionally sound. In fact, there was only one failure among the group "A" configurations in the first survey. However, group "B", even with a coaming around the hole to help give some extra support, was the source of twelve failures. Eight of those failures were found in the main deck of a single bulk carrier. Thirty-two percent of the cargo hold access openings (detail 9-B-2) contained three and four inch cracks in their corners. The ship came into Newport News Shipbuilding for emergency repairs with a cargo of coal which was loaded on board in the Hampton Roads area. An interview with the Captain revealed that the cracks had appeared in the strength deck after "the worst storm I've seen in fifteen years," while crossing the Atlantic on the trip over. In addition to the rough seas, small radiused corners and corrosion were contributing factors to the failures.

Three of the five failures in the group "C" cutouts were caused by severe impact loadings, presumably while handling cargo. Corrosion was evident at the sharp cracks and buckles in the corners of several hatch cuts similar to detail 9-C-4. Detail 9-C-4 was also responsible for the remaining failures in group "C". One was on a general cargo ship and the other was on a relatively new containership. In both cases, in the curve of detail 9-C-4 there was a butt weld where the thicker deck plating near the gunwale joined a thinner panel of deck plating which extended to the centerline and beyond. The butt weld was too rough with a notch, which resulted in a crack in the weld. The crack on the containership had even extended beyond the hatch coaming. This is probably one of the worst places for a crack to appear due to the high primary stresses that "flow" around these cutouts.

In summary, deck cutouts are second to gunwale connections for least number of failures for both surveys, but, also like gunwale connections, any crack, no matter how small, could have catastrophic results.

FAMILY NUMBER 10 - STANCHION ENDS

Figure 22 shows ninety-four observed stanchion end variations which includes the fifteen new ones observed in the second survey. The variations are grouped

FIGURE 20

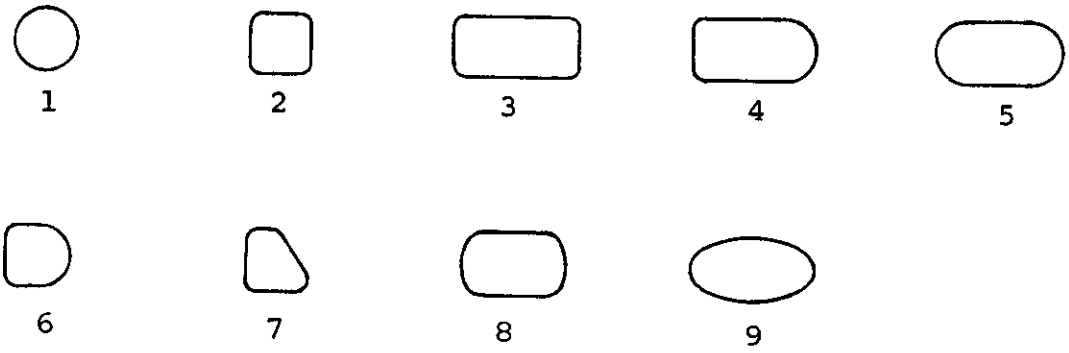
FAILED CLEARANCE CUTOUT ON A CONTAINERSHIP

The view is looking aft at a clearance cutout in a transverse web frame for a longitudinal bulkhead stiffener. The cutout, similar to detail 8-C-3, has had a previous crack welded shut and a flat bar stiffener added in an effort to prevent future cracks. However, a new crack has started at the heel of the angle and traveled in the heat affected zone of the weld all the way to the face plate around the arch.

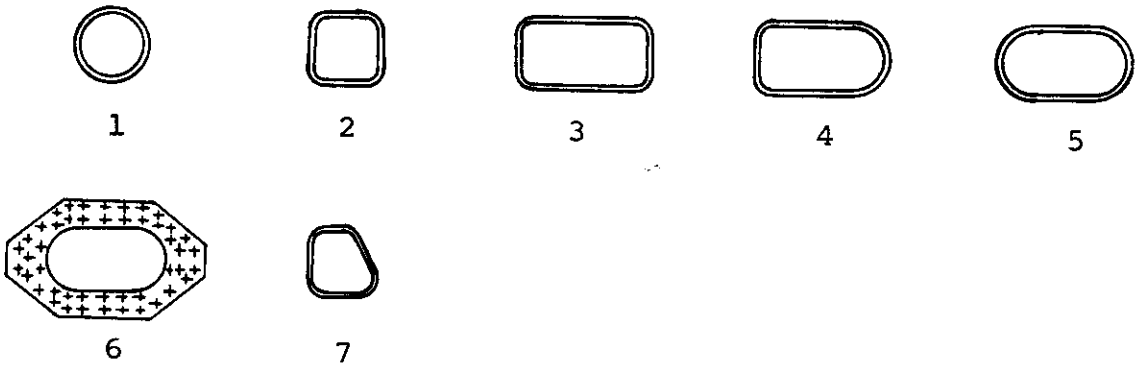
FIGURE 21

DECK CUTOUT DETAILS
FAMILY NO. 9

A.



B.



C.

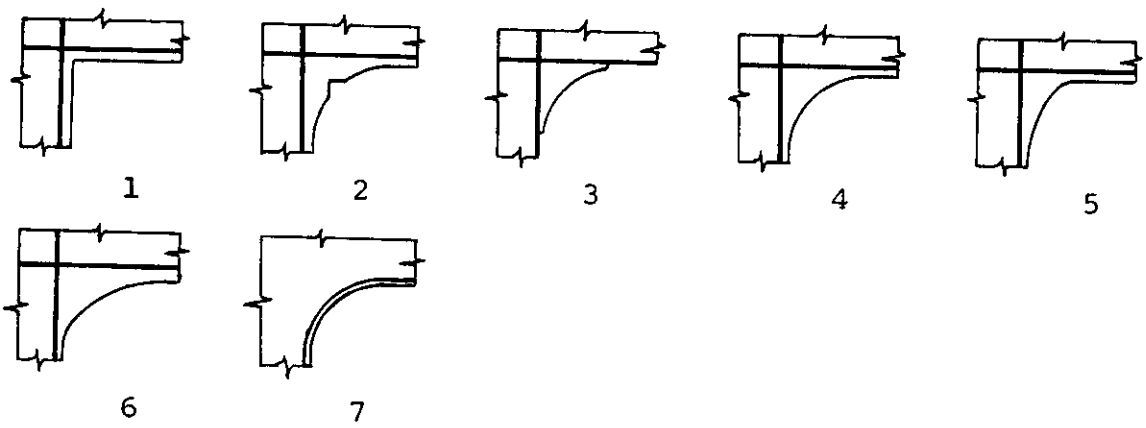


TABLE 11

SUMMARY OF STRUCTURAL DECK CUTS

FAMILY GROUP	OBSERVED SECOND SURVEY			TOTALS OBSERVED BOTH SURVEYS		
	NUMBER OF DETAILS	NO. OF SOUND DETAILS	% SOUND DETAILS	NUMBER OF DETAILS	NO. OF SOUND DETAILS	% SOUND DETAILS
A	321	321	100.0	2951	2950	100.0
B	472	460	97.5	2962	2945	99.4
C	711	706	99.3	1621	1610	99.3
TOTAL	1504	1487	98.9	7534	7505	99.6

FIGURE 22

STANCHION END DETAILS
FAMILY NO. 10

A.

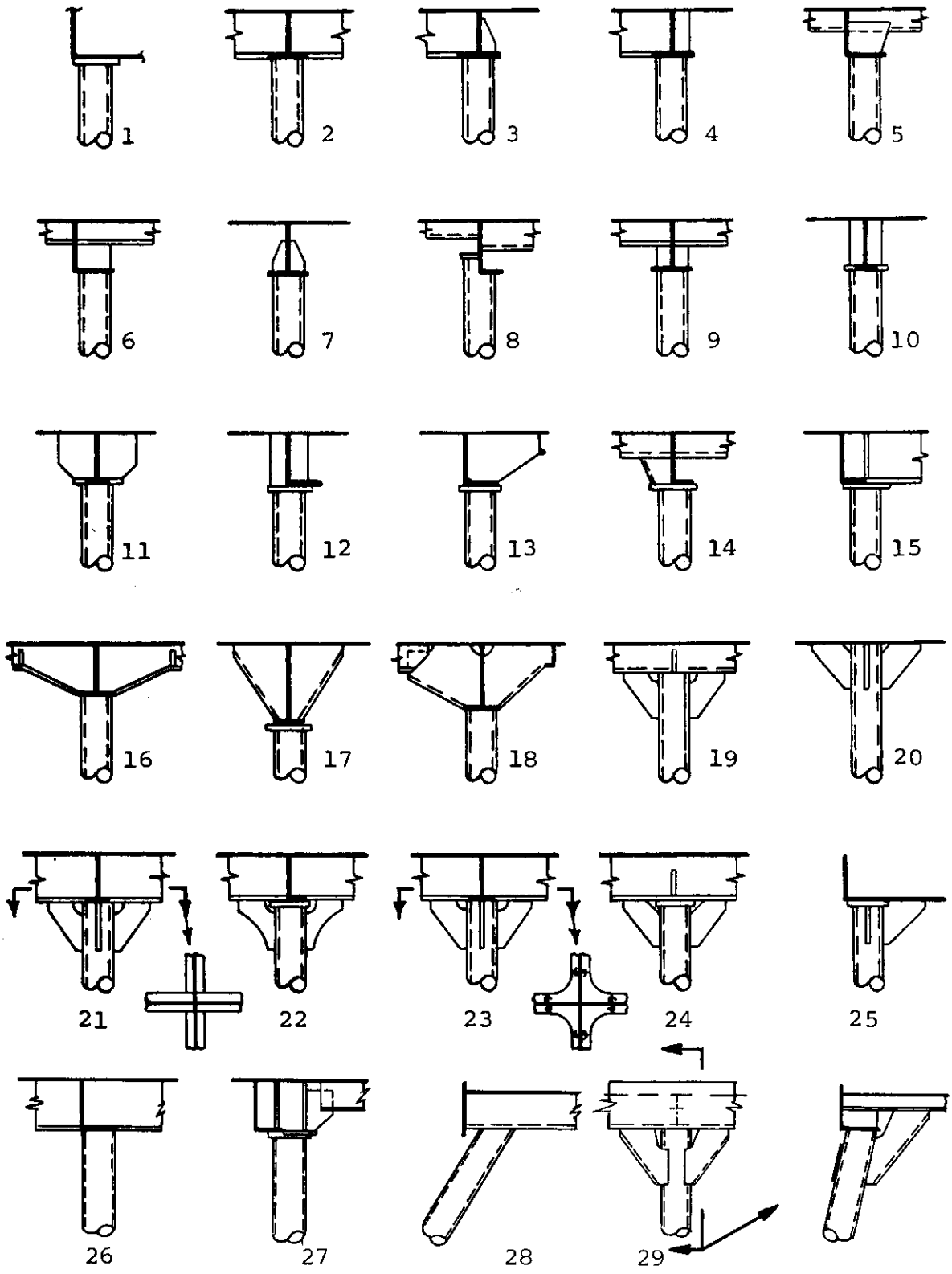


FIGURE 22 - STANCHION END DETAILS, Family No. 10 (Cont'd)

B.

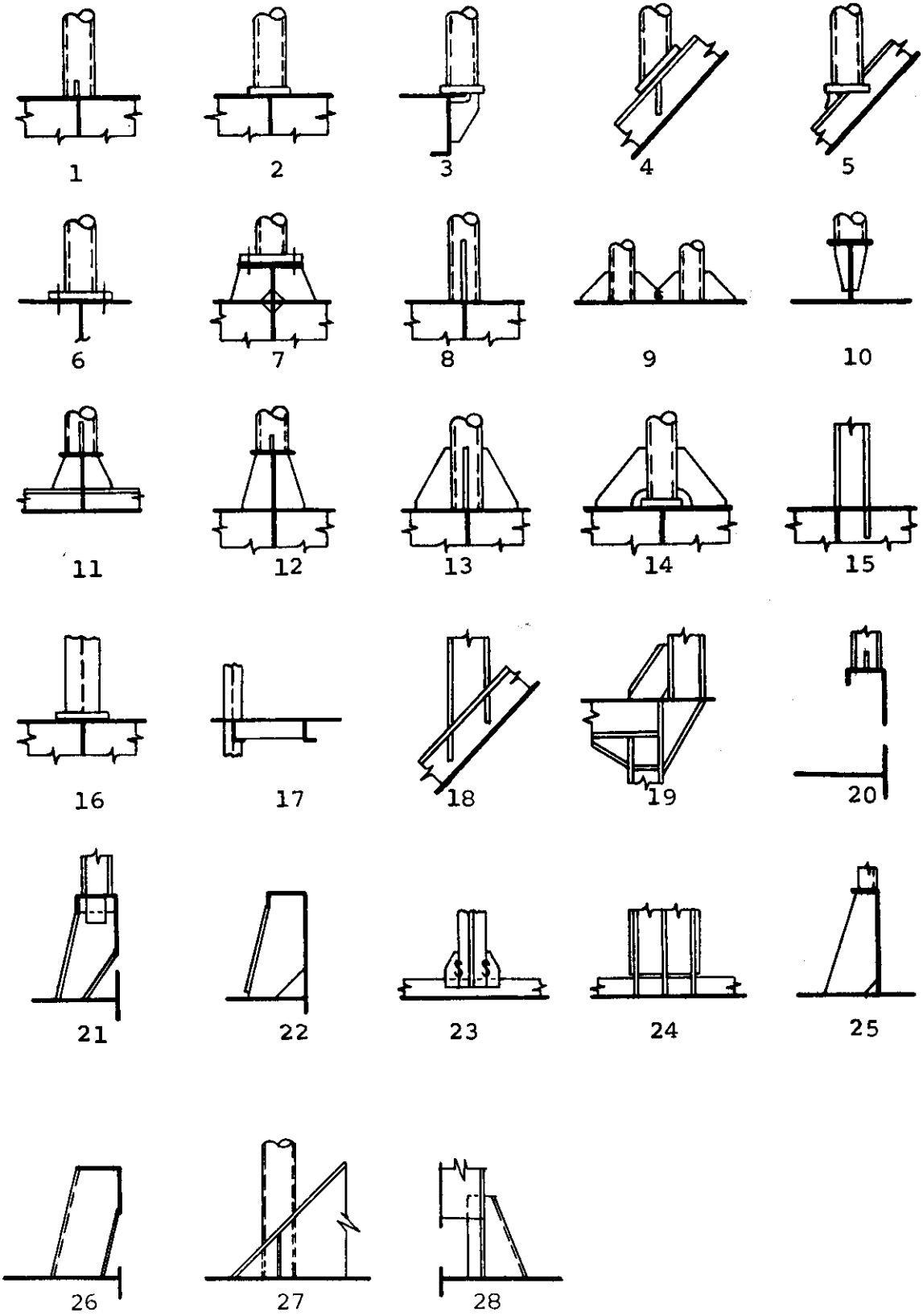


FIGURE 22 - STANCHION END DETAILS, Family No. 10 (Cont'd)

C.

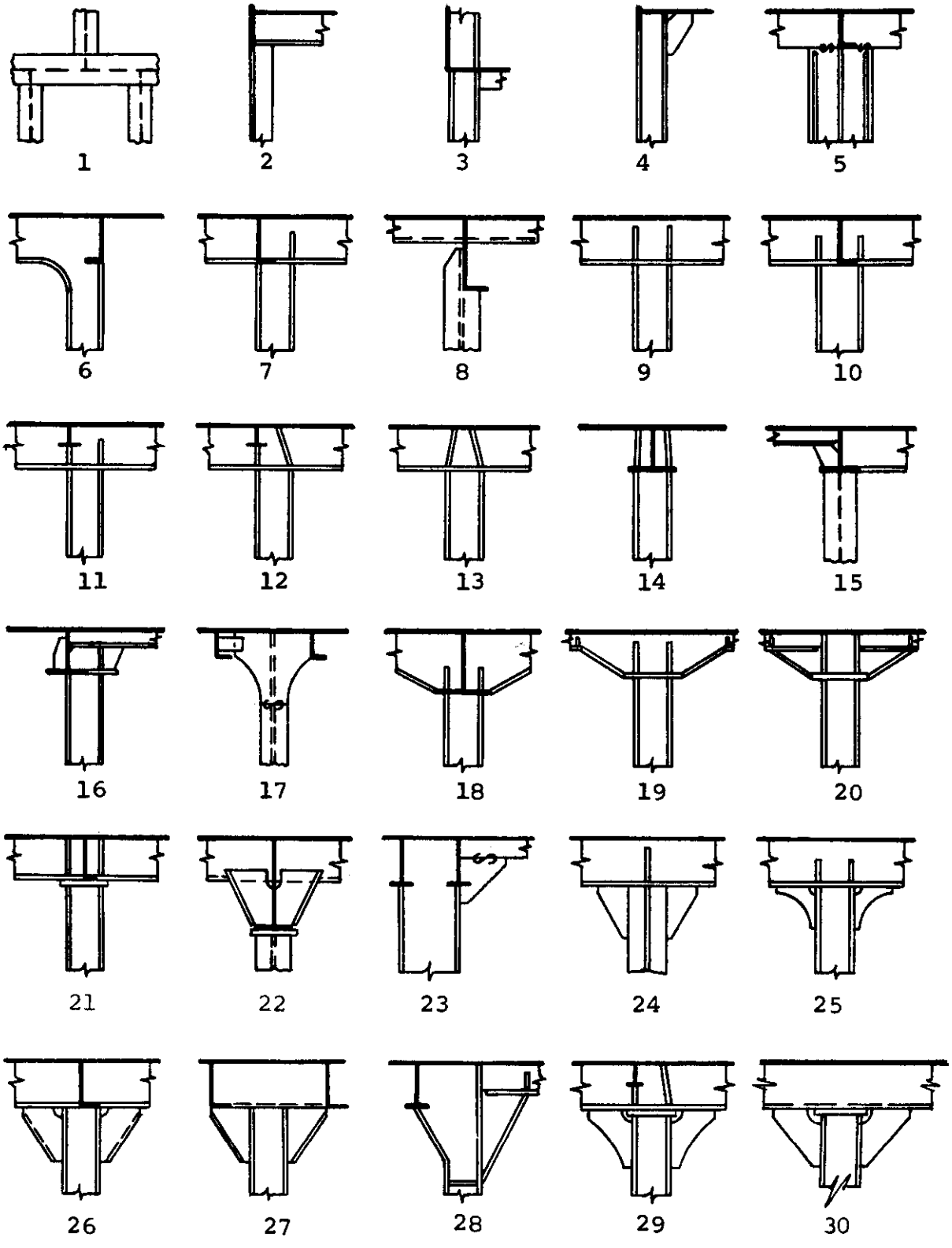
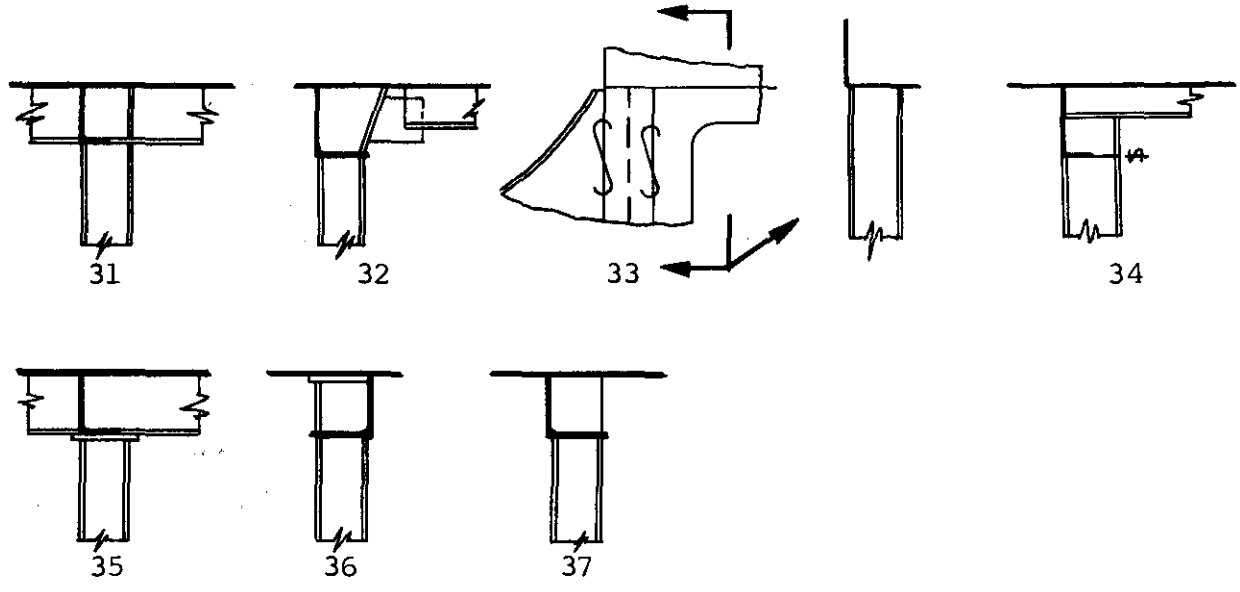


FIGURE 22 - STANCHION END DETAILS, Family No. 10 (Cont'd)

C. Cont'd



into one of the following categories:

- o Group 10-A connections at the top of the circular stanchions
- o Group 10-B stanchion bottom connections
- o Group 10-C connections at the top of "H" stanchions

Table 12 contains a summary of 7,090 stanchion ends observed in both surveys.

The "V" notch design of detail 10-B-9 that resulted in many failures at the bottoms of container stands in the first survey were not observed in the second survey. Most of the container stands were joined to the deck similar to detail 10-B-2 and were 100% sound. However, stanchions supporting the deckhouse on containerships and general cargo ships continued to be a problem. Fifty percent of the total stanchion failures in the second survey were in either the top or bottom connections of these supports. Proper design would have provided tension brackets and tapered chocks to relieve the tensile and compressive stresses produced by the relative motions or "flexing" between the main deckhouses and the side shell. Figure 23 is a photograph of a deckhouse support stanchion similar to detail 10-B-26. Detail 10-B-26 was responsible for six of the twelve failures and details 10-B-28 and 10-C-33 accounted for the remainder.

Details 10-A-25 and 10-A-29 show the top end connections of four stanchions that hold up a cargo handling control platform above main deck on a general cargo ship. Since there were no braces on this frame to help carry the lateral loads on the platform when the ship is rolling, the moment formed in the corners at the top of the stanchions causing the chocks or brackets to puncture the thin walls of the stanchions. Other failures were caused by impact loads from cargo handling in details 10-B-15 and 10-C-35. The chocks in detail 10-C-7 had buckled due to a high breadth/thickness ratio.

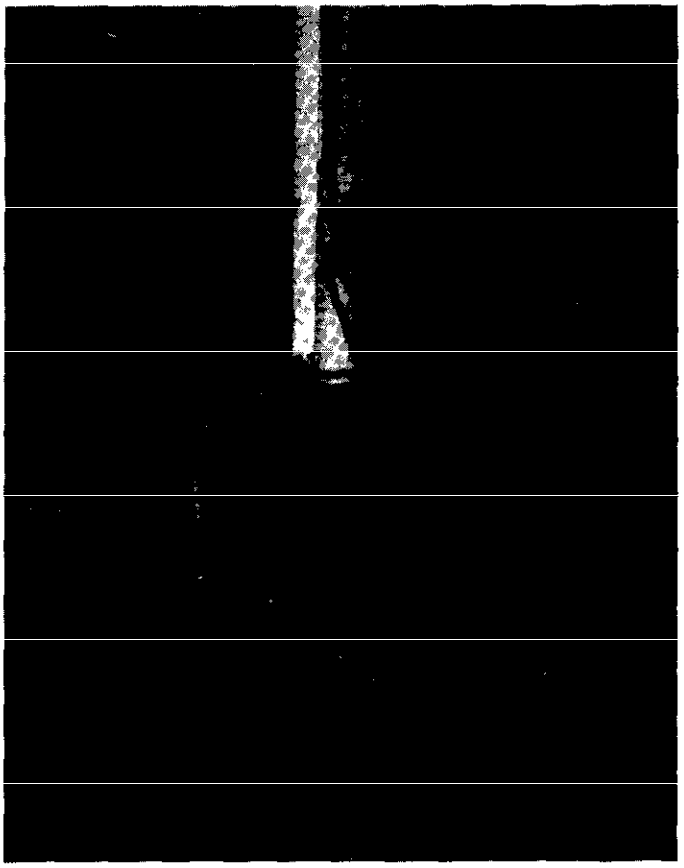
TABLE 12

SUMMARY OF STANCHION ENDS

FAMILY GROUP	OBSERVED SECOND SURVEY			TOTALS OBSERVED BOTH SURVEYS		
	NUMBER OF DETAILS	NO. OF SOUND DETAILS	% SOUND DETAILS	NUMBER OF DETAILS	NO. OF SOUND DETAILS	% SOUND DETAILS
A	199	192	96.5	2239	2187	97.7
B	291	281	96.6	3431	3378	98.5
C	330	323	97.9	1420	1403	98.8
TOTAL	820	796	97.1	7090	6968	98.3

FIGURE 23

A CORNER SUPPORT STANCHION FOR THE MAIN DECKHOUSE ON A CONTAINERSHIP



This view shows the corner deckhouse stanchion attachment to the main deck bulwark. This connection continues to be a problem area with cracks in the welds at the bottom of the stanchion, at the top of the bracket, under the bulwark face plate, and at the bracket connection to main deck. Poor design, such as the sniped flanged on the bulwark bracket, has been the leading cause of failures.

Seventy-five percent of the stanchion failures in the second survey belong to the newly identified variations in end connections. It appears design was the leading cause of failures, followed by collisions from handling cargo and misuse/abuse. In general, fabrication was excellent.

FAMILY NUMBER 11 - STIFFENER ENDS

The stiffener ends included in this family are the ends of load-carrying structural angles or tees that are attached to panels of plating. Thirty-five variations, including three new ones observed in the second survey, were placed in one of the five groups shown in Figure 24. Numerical data for the five groups are summarized in Table 13.

There were sixty-nine failures in the 9,969 stiffener ends observed in the second survey with a failure rate of 0.69%. This was only 0.05% less than the failure rate for the first survey. Fifty-seven of the failures were in group "A" and the remaining twelve were in group "B". Groups "C", "D" and "E" had 100% sound details.

Forty-five of the failures belong to detail 11-A-9. Neglect was the leading cause of failures, followed by shear and design. In some compartments of a general cargo ship, corrosion had eaten through the bulkheads where water had been standing on the deck. Quite often water was trapped by detail 11-B-6 causing severe corrosion. However, a failure was found on a containership where the use of detail 11-B-6 could have prevented it. A stiffener end similar to detail 11-A-3 was jammed into the shell plating which created a crack about an eighth of an inch deep and an inch long. If a clip had been added, the failure should not have occurred.

Figures 25, 26 and 27 are photographs of end failures on back-up headers for container support foundations on the main deck of a containership. Foundation headers were not included as candidates for the family of stiffener ends, but these pictures were taken to show that many of the same failures and failure causes exist for these structural members as well as for stiffener ends and panel stiffeners. Figures 25 and 26 show a few cracks and poor welding. Figure 27 shows a header under main deck that was cracked along one-third of its depth at its connection with a longitudinal bulkhead. The headers in Figures 26 and 27 were undersized for the in-service loads they received.

FAMILY NUMBER 12 - PANEL STIFFENERS

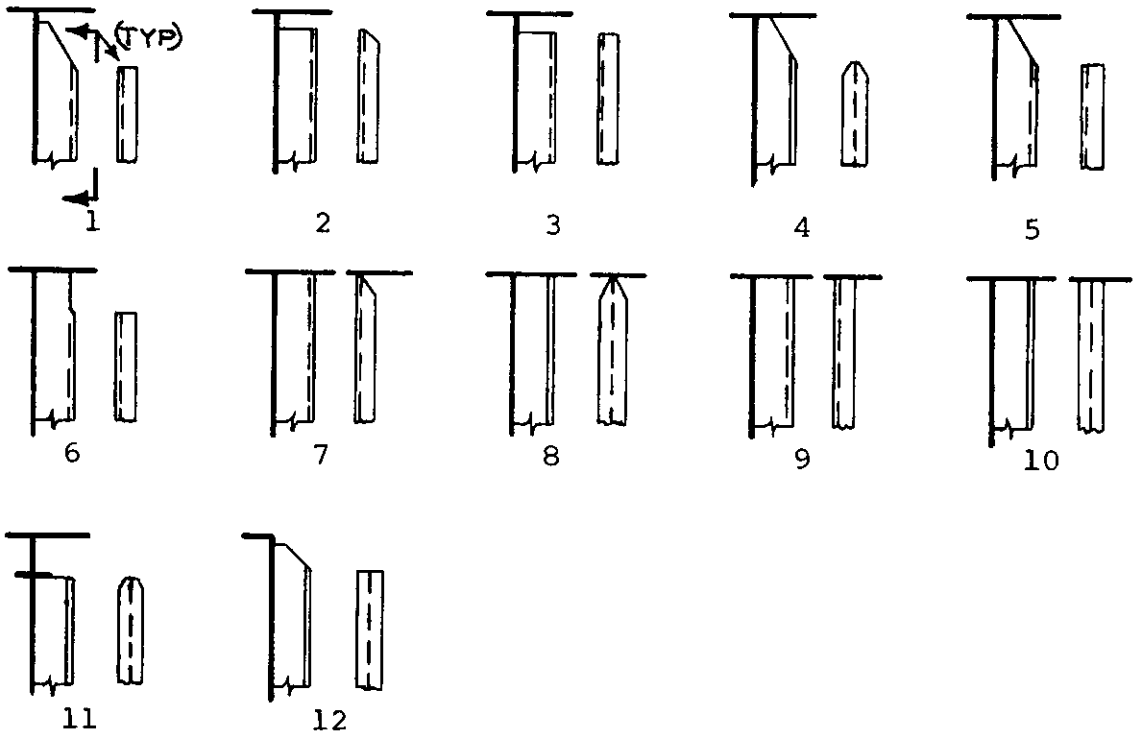
In this family, panel stiffeners are defined as structural angles, tees, or flat bars welded to large panels of plate for the purpose of preventing local instability of the plate. They are not designed as direct load-carrying members. There was only one new configuration found in survey number two, which brings the total to forty-one as shown in Figure 28. Table 14 is a numerical summary, by family group, of the configurations shown in Figure 28.

The panel stiffeners had 527 failures which is a failure rate of 3.82% in the second survey. This failure rate is very high compared to the 0.65% failure rate recorded in the first survey. One possible explanation could be attributed to the more than two hundred panel stiffener failures by corrosion found on one general cargo ship. The captain explained that for five years during the Vietnam War, the ship carried nothing but ammunition and explosives. During that time, no maintenance, including painting, was performed by the crew due to the volatile

FIGURE 24

STIFFENER END DETAILS
FAMILY NO. 11

A.



B.

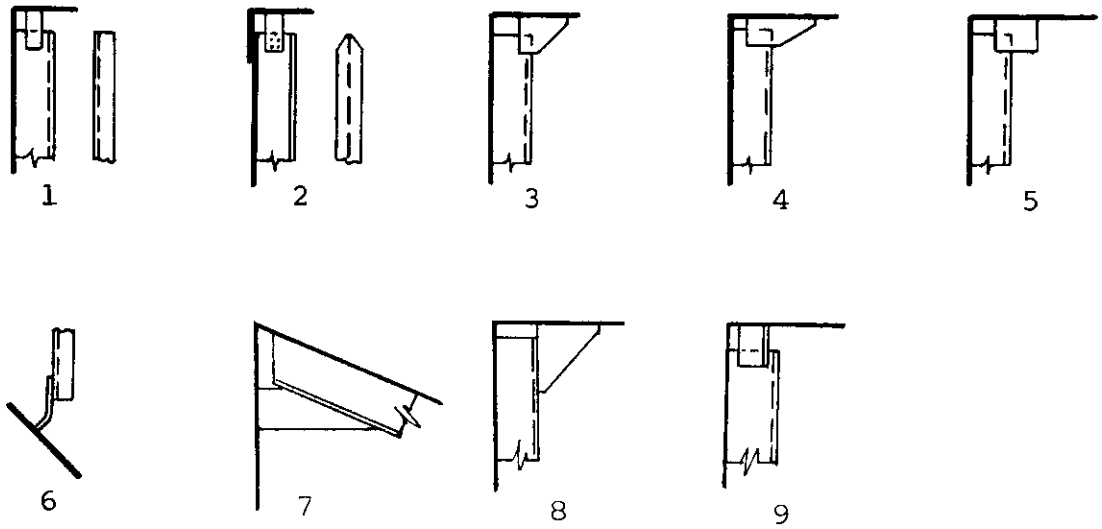
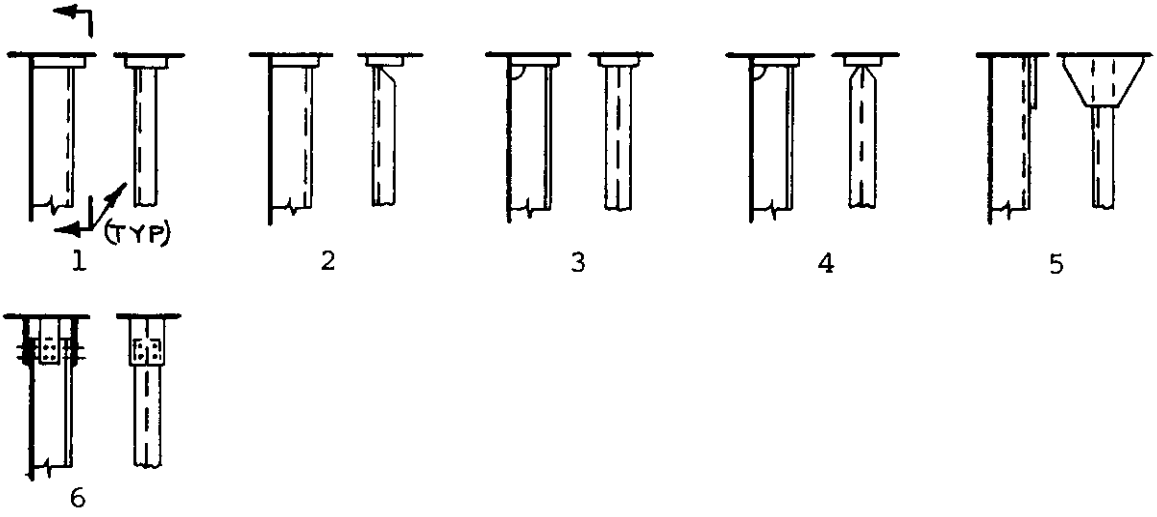
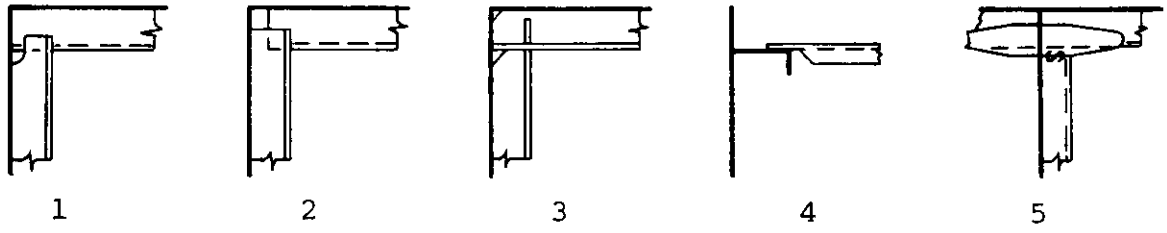


FIGURE 24 - STIFFENER END DETAILS, Family No. 11 (Cont'd)

C.



D.



E.

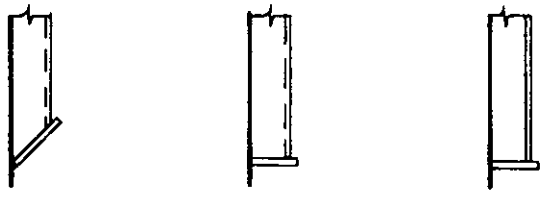


TABLE 13

SUMMARY OF STIFFENER ENDS

FAMILY GROUP	OBSERVED SECOND SURVEY			TOTALS OBSERVED BOTH SURVEYS		
	NUMBER OF DETAILS	NO. OF SOUND DETAILS	% SOUND DETAILS	NUMBER OF DETAILS	NO. OF SOUND DETAILS	% SOUND DETAILS
A	6479	6422	99.1	28559	28360	99.3
B	2962	2950	99.6	6332	6284	99.2
C	215	215	100.0	825	818	99.2
D	205	205	100.0	4675	4631	99.1
E	108	108	100.0	338	338	100.0
TOTAL	9969	9900	99.3	40729	40431	99.3

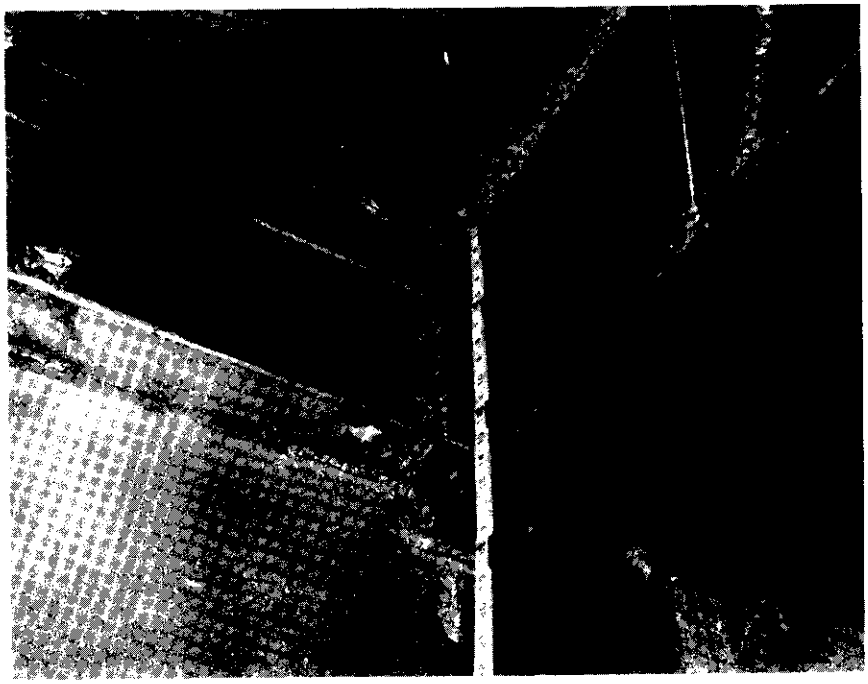
FIGURE 25

CRACKED WELD ON FOUNDATION HEADER ON A CONTAINERSHIP

View in starboard box girder looking up at a fore/aft foundation header ending on a transverse bulkhead. A crack has developed in the flange weld as shown. Excessive weld material has been used intermittently instead of a continuous bead.

FIGURE 26

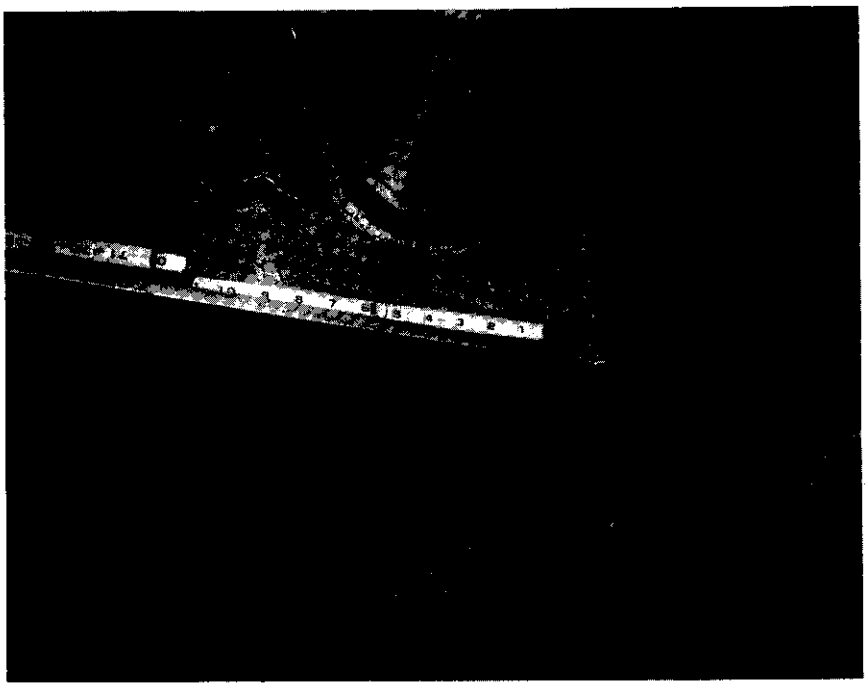
FAILED FOUNDATION HEADER ON A CONTAINERSHIP



View is in port box girder looking up at a fore/aft header connection to a transverse bulkhead. The header backs up a support foundation for containers on main deck. A chock has been added at the support point as shown in upper right corner of photograph. The weld is cracked along the entire depth of the header's web. A weld at the flange on the main deck stiffener in the upper left, and the weld strike on the transverse bulkhead just below the header at the bottom center of the photograph indicates poor welding techniques.

FIGURE 27

FAILED FOUNDATION HEADER ON A CONTAINERSHIP

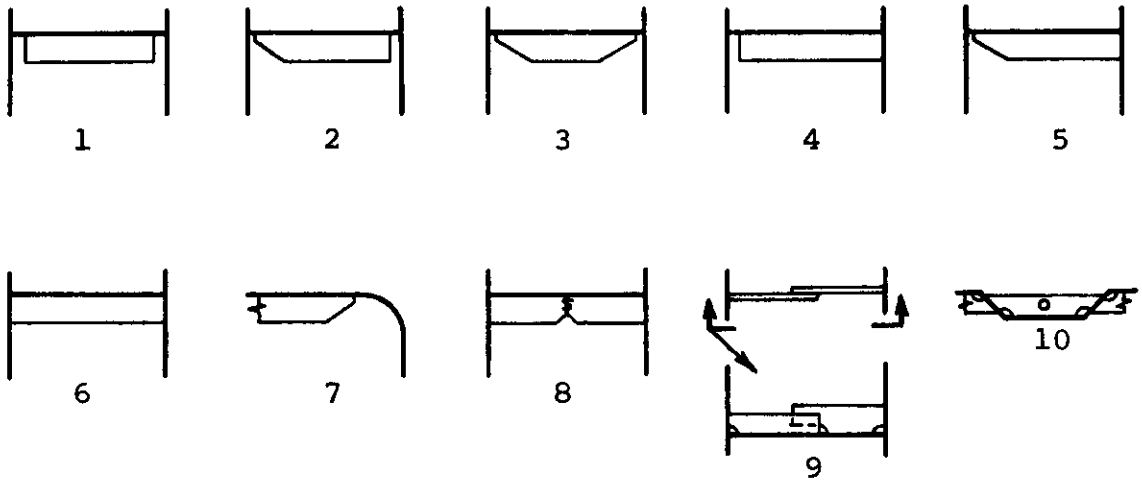


View looking aft showing connection of transverse header under main deck with longitudinal bulkhead at the right. This header carried loads from a container tie-down foundation nearby. Light can be passed through the crack for one-third the depth of the header.

FIGURE 28

PANEL STIFFENER DETAILS
FAMILY NO. 12

A.



B.

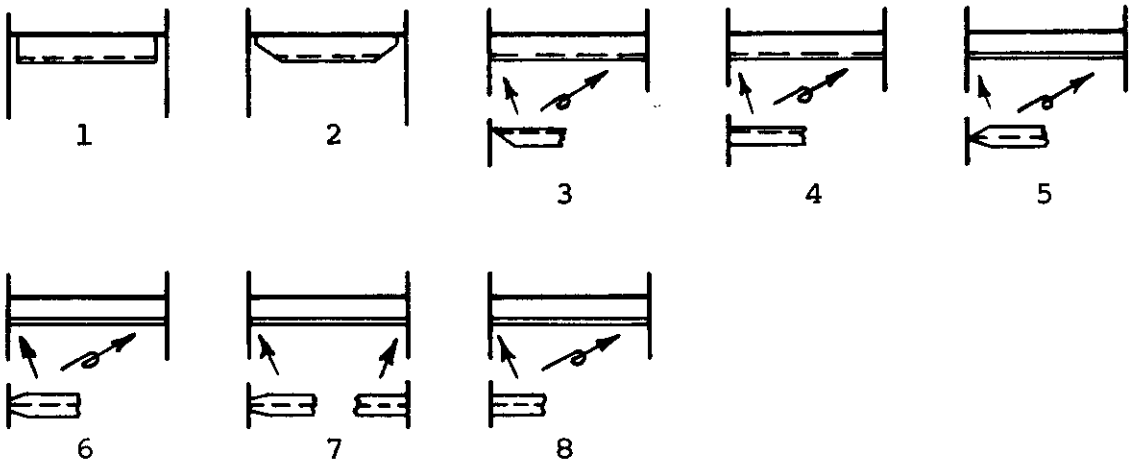
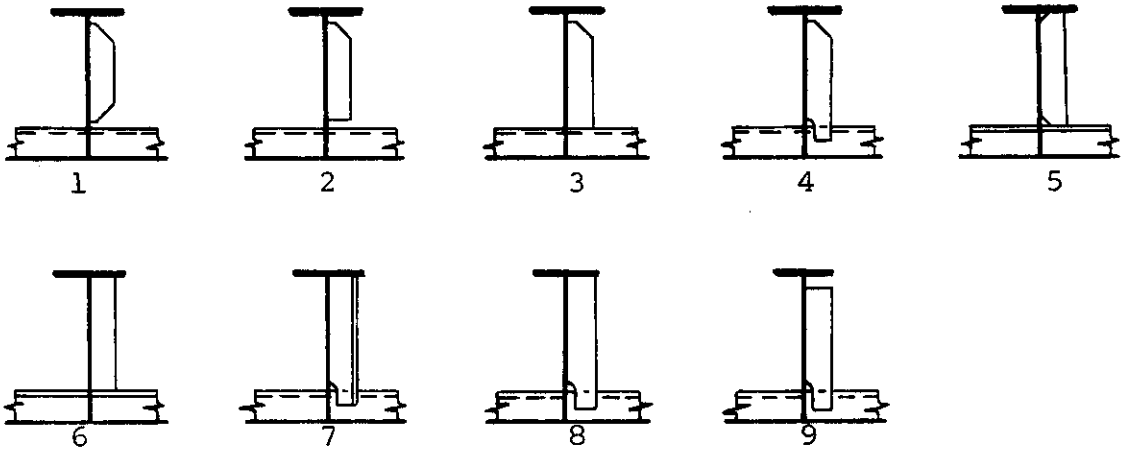
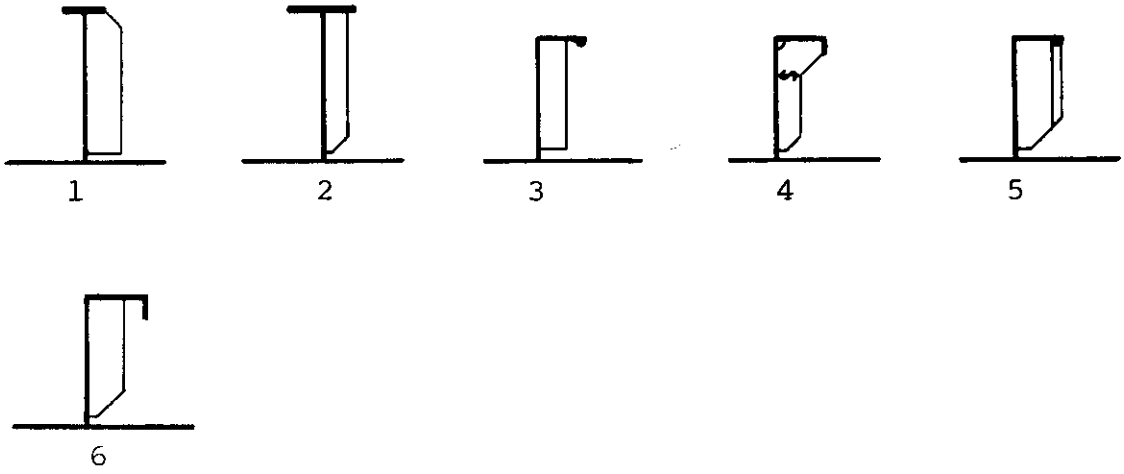


FIGURE 28 - PANEL STIFFENER DETAILS, Family No. 12 (Cont'd)

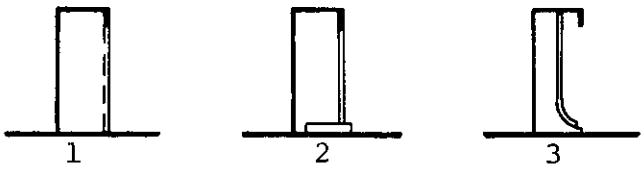
C.



D.



E.



F.

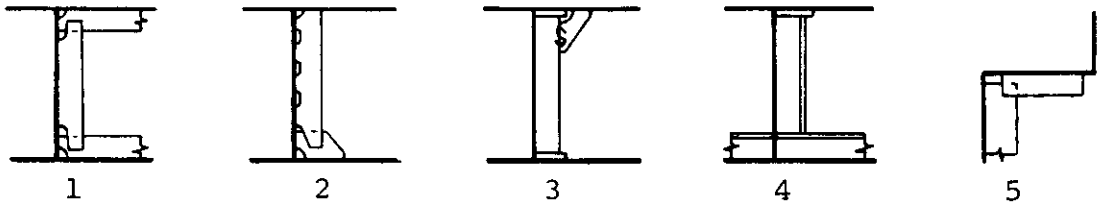


TABLE 14

SUMMARY OF PANEL STIFFENERS

FAMILY GROUP	OBSERVED SECOND SURVEY			TOTALS OBSERVED BOTH SURVEYS		
	NUMBER OF DETAILS	NO. OF SOUND DETAILS	% SOUND DETAILS	NUMBER OF DETAILS	NO. OF SOUND DETAILS	% SOUND DETAILS
A	6199	5999	96.8	19299	19014	98.5
B	4420	4150	93.9	14030	13742	97.9
C	1097	1094	99.7	16237	16194	99.7
D	1867	1813	97.1	3237	3083	95.2
E	81	81	100.0	511	501	98.0
F	143	143	100.0	523	515	98.5
TOTAL	13807	13280	96.2	53837	53049	98.5

nature of the cargo. In addition, since the war no maintenance work has been done because of a "full delivery schedule" and only "necessary" repairs will be accomplished.

Eighty-one percent of the failures recorded in the second survey were on general cargo ships. Groups "A" and "B" led the failure list with 200 and 270 failures, respectively. Group "C" had three failures, while group "D" had fifty-four failures that were found mainly on the main deck hatch coamings. Groups "E" and "F" were failure free.

Many of the failures in this family were caused by corrosion, impact from large objects, and misuse/abuse. On the general cargo ship mentioned above, corrosion was the prevalent cause of so many failures on details 12-A-3 and 12-B-2. Fifty-six percent of the panel stiffener configurations that had failures in the second survey had at least one failure due to impact loading, presumably by cargo. Stiffeners with sniped ends with no restraints to help keep the flange from tripping were especially vulnerable. Details 12-A-6 and 12-A-10 had many failures due to misuse/abuse. These panel stiffeners often had holes drilled in them to attach cables for holding down cargo. One such stiffener is shown in the photograph in Figure 29.

Figure 30 shows cracked intermittent welds on a horizontal panel stiffener. These cracks were caused by a buckled transverse web frame just above an archway in the box girder of a containership.

In summary, the panel stiffener failures observed in the last thirty-six ships surveyed, decreased the percentage of sound details from 99.3% for the first fifty ships to 98.5% for the total eighty-six ships in both surveys. These failures were caused by collisions from handling cargo, misuse/abuse, and in one extreme case where a general cargo ship received only "necessary" repairs.

SNYTHESIS BY SHIP TYPE

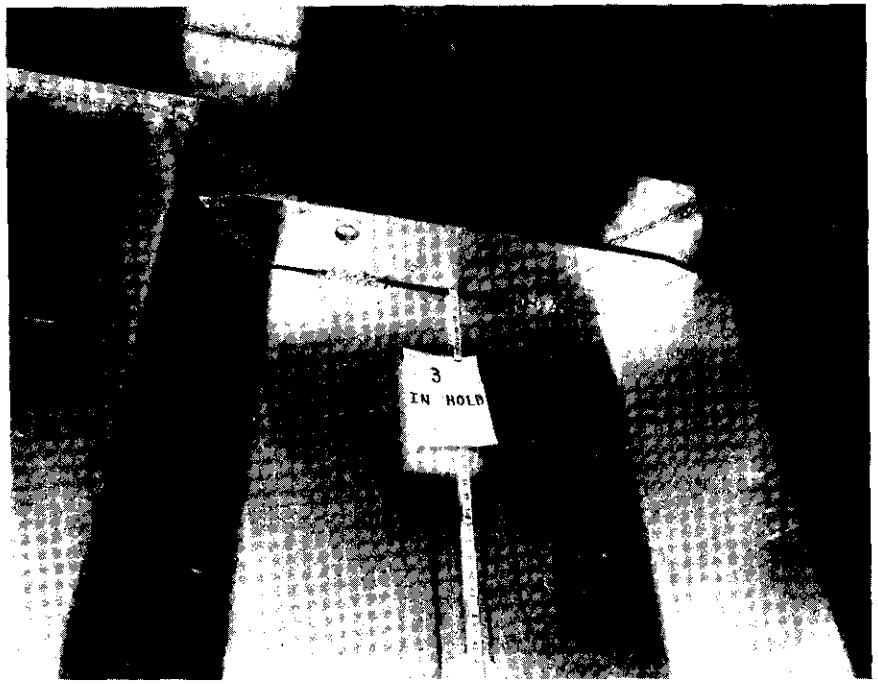
The previous section discusses "Snythesis by Family Groups," for the individual detail configurations of the family groups and how they performed in service. In this section, emphasis will be placed on the detail families and family groups and their performance in individual ship types. All of the data observed in the total eighty-six ship survey will be synthesized according to individual ship types. This method, used in "Structural Details of Ships In Service,"[1] enables design/repair offices to determine, at a glance, failure trends of structural detail families on specific ships.

The number of surveys for each ship type varied from two to twenty-four, therefore, comparable data are provided by normalizing the survey data. Seven ships, as was used in reference 1 below, will be used to normalize the data in order to continue that synthesis already accomplished on the first fifty ships. The normalized data are presented in Table 15 and Figures 31 through 41, with the ship types represented by capital letters in the following order:

1. Jordan, C. R.; Ward, W. E., "Structural Details of Ships In Service," presented at Hampton Roads Chapter, Society of Naval Architects and Marine Engineers, March 15, 1978.

FIGURE 29

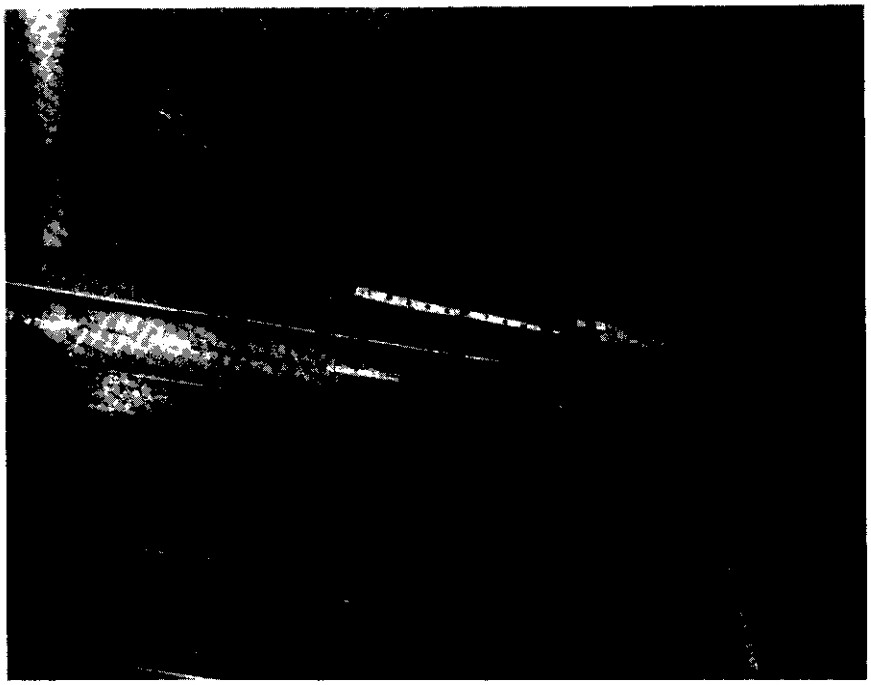
FAILED PANEL STIFFENER ON A GENERAL CARGO SHIP



Photographer is standing in the cargo hold looking up at a panel stiffener on a longitudinal corrugated bulkhead. The weld cracks were due to poor welding and possibly buckling of the bulkhead while the ship was in a seaway. The hole drilled in the stiffener is sometimes used to tie down cargo. This often produces failures.

FIGURE 30

PANEL STIFFENER FAILURE ON A CONTAINERSHIP



View in starboard box girder looking forward shows a container tie-down foundation header under main deck and an archway in the transverse web frame. Not shown in the photograph was a crack in the weld of the header web to the transverse web. The load, which was too much for the transverse web, caused a buckle and "popped" the intermittent welds on the horizontal panel stiffener just above the archway. The flanges of the continuous foundation header have been sniped.

TABLE Nº 15 SUMMARY OBSERVED DETAILS NORMALIZED BY SHIP TYPE–DETAIL FAMILY

DET. FAMILY	SHIP TYPE	NORMALIZED DETAILS								NORMALIZED DETAILS								DET. FAMILY
		TOTALS		OBSERVED			FAILURES			TOTALS		OBSERVED			FAILURES			
		OBSERVED	FAILURES	FWD	MID-SHIPS	AFT	FWD	MID-SHIPS	AFT	OBSERVED	FAILURES	FWD	MID-SHIPS	AFT	FWD	MID-SHIPS	AFT	
BEAM BRACKETS	A	4496	80	1260	2212	1024	26	49	5	1309	0	175	731	403	0	0	0	TIGHT COLLARS
	B	7840	21	952	6188	700	0	21	0	4508	0	532	3038	938	0	0	0	
	C	8586	413	1744	5004	1838	56	315	42	1270	0	198	757	315	0	0	0	
	D	7440	268	854	5018	1568	20	245	3	1037	19	126	687	224	0	19	0	
	E	6405	39	840	4095	1470	25	14	0	1750	0	140	1330	280	0	0	0	
	F	7817	2	832	5367	1618	0	2	0	2504	0	342	1501	661	0	0	0	
	G	4058	124	539	2418	1101	12	103	9	3403	0	178	2800	425	0	0	0	
TOTALS		46642	947	7021	30302	9319	139	749	59	15781	19	1691	10844	3246	0	19	0	
TRIPPING BRACKETS	A	2390	60	105	2040	245	0	60	0	14	0	0	14	0	0	0	0	GUNWALE CONNECTION
	B	4004	13	420	2940	644	6	7	0	14	0	0	14	0	0	0	0	
	C	3257	181	222	2697	338	0	181	0	14	0	0	14	0	0	0	0	
	D	2345	303	70	2093	182	3	300	0	14	0	0	14	0	0	0	0	
	E	455	0	35	385	35	0	0	0	14	7	0	14	0	0	7	0	
	F	3151	1	397	1976	778	0	0	1	14	0	0	14	0	0	0	0	
	G	3575	47	318	2848	409	1	44	2	14	1	0	14	0	0	1	0	
TOTALS		19177	605	1567	14979	2631	10	592	3	98	8	0	98	0	0	8	0	
NON-TIGHT COLLARS	A	4106	15	630	2006	1470	0	1	14	20225	139	2643	10827	6755	70	13	56	MISC. CUTOUTS
	B	4676	0	378	3360	938	0	0	0	23338	185	2506	15050	5782	50	122	13	
	C	1549	2	128	1158	263	1	1	0	20015	89	2497	12093	5425	17	60	12	
	D	506	11	14	156	336	0	0	11	18158	80	2674	10360	5124	0	56	24	
	E	1015	11	280	490	245	11	0	0	44065	0	5740	27335	10990	0	0	0	
	F	3041	0	381	2038	622	0	0	0	34347	45	3749	22812	7786	3	33	9	
	G	1281	3	129	797	355	3	0	0	57820	81	2633	48736	6451	4	74	3	
TOTALS		16174	42	1940	10005	4229	15	2	25	217968	619	22442	147213	48313	144	358	117	

TABLE Nº 15 (CON'T.) SUMMARY OBSERVED DETAILS NORMALIZED BY SHIP TYPE–DETAIL FAMILY

DET. FAMILY	SHIP TYPE	NORMALIZED DETAILS								NORMALIZED DETAILS								DET. FAMILY
		TOTALS		OBSERVED			FAILURES			TOTALS		OBSERVED			FAILURES			
		OB-SERVED	FAIL-URES	FWD	MID-SHIPS	AFT	FWD	MID-SHIPS	AFT	OB-SERVED	FAIL-URES	FWD	MID-SHIPS	AFT	FWD	MID-SHIPS	AFT	
CLEARANCE CUTOUTS	A	7267	34	1278	3259	2730	25	6	3	2712	18	823	839	1050	0	0	18	STIFFENER ENDS
	B	8190	508	868	6062	1260	17	491	0	3220	7	1050	1204	966	7	0	0	
	C	5277	8	694	3410	1173	1	5	2	3639	15	659	1877	1103	2	9	4	
	D	2058	18	336	966	756	3	15	0	4345	32	504	2581	1260	0	29	3	
	E	10500	0	665	8190	1645	0	0	0	1820	0	735	315	770	0	0	0	
	F	54	0	0	0	54	0	0	0	5903	15	770	3990	1143	1	11	3	
	G	11108	210	775	9213	1120	3	205	2	5573	80	872	3683	1018	5	73	2	
TOTALS		44454	778	4616	31100	8738	49	722	7	27212	167	5413	14489	7310	15	122	30	
STRUCT. DECK CUTS	A	371	4	105	196	70	0	4	0	4644	35	1208	1773	1663	16	14	5	PANEL STIFFENERS
	B	854	10	126	602	126	0	10	0	4270	11	742	2422	1106	0	11	0	
	C	621	1	134	376	111	0	1	0	3104	63	263	2246	595	0	59	4	
	D	626	3	70	444	112	0	3	0	4037	209	294	2945	798	0	185	24	
	E	1505	0	385	490	630	0	0	0	3815	0	560	2275	980	0	0	0	
	F	995	0	124	669	202	0	0	0	9583	31	607	7358	1618	0	31	0	
	G	926	1	70	700	156	0	0	1	7850	12	775	5670	1405	2	10	0	
TOTALS		5898	19	1014	3477	1407	0	18	1	37303	361	4449	24689	8165	18	310	33	
STANCHION ENDS	A	832	5	333	9	490	0	5	0									
	B	854	28	322	168	364	0	28	0									
	C	474	12	216	112	146	1	7	4									
	D	983	23	210	381	392	0	23	0									
	E	1435	0	525	525	385	0	0	0									
	F	1610	0	319	887	404	0	0	0									
	G	619	2	285	70	264	1	1	0									
TOTALS		6807	70	2210	2152	2445	2	64	4									

PERCENT FAILURE VERSUS SHIP TYPE

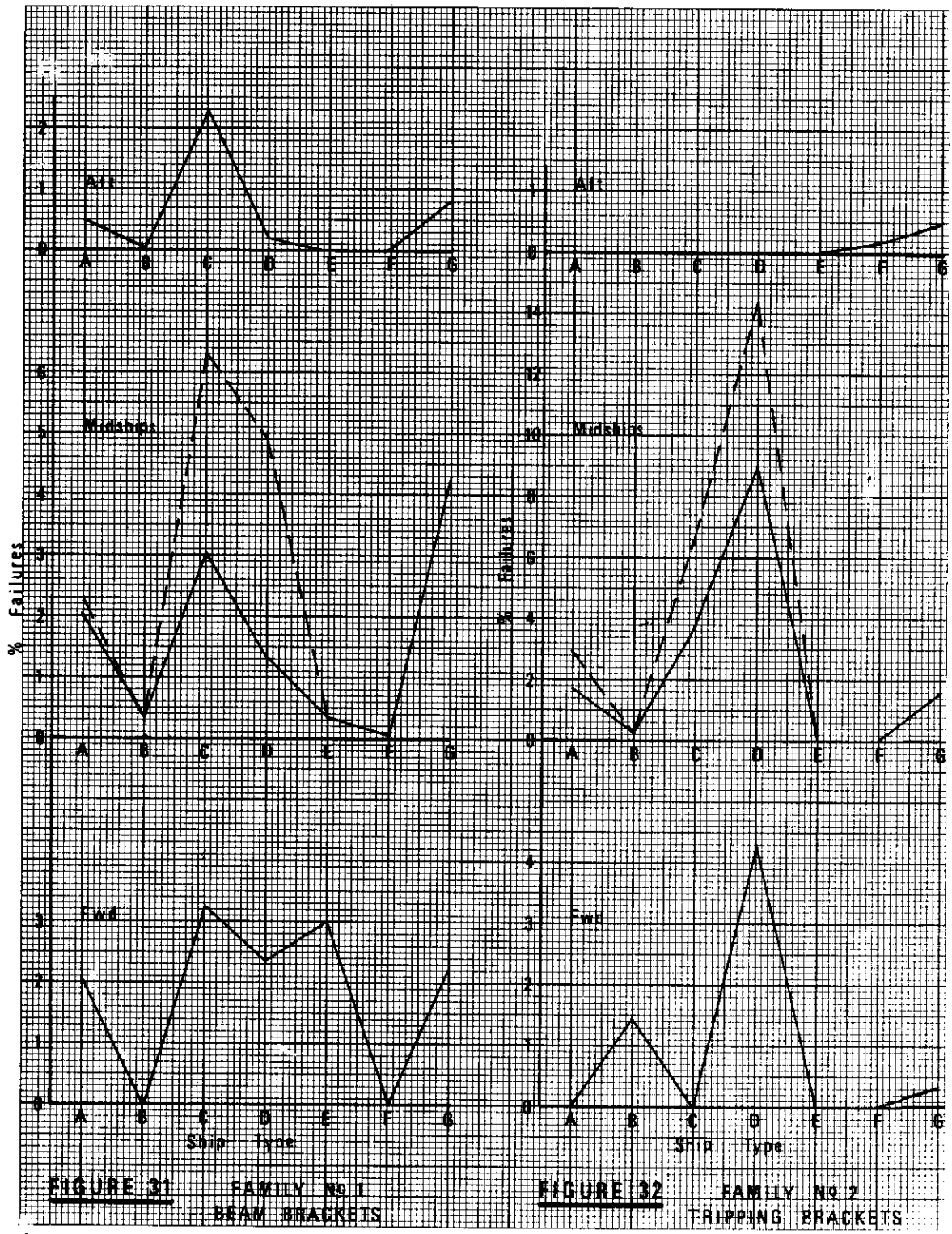
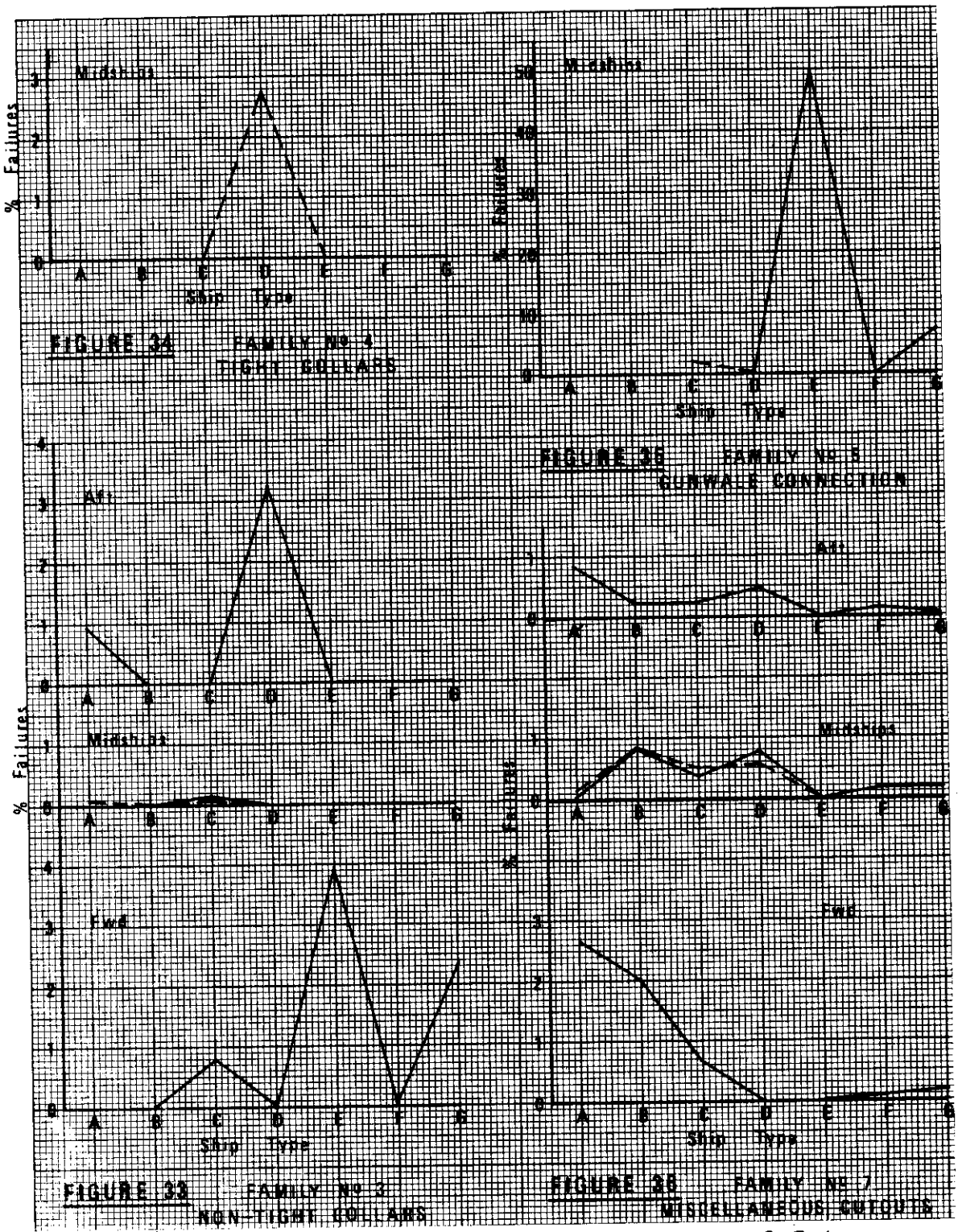


FIGURE 31 FAMILY No. 1 BEAM BRACKETS

FIGURE 32 FAMILY No. 2 TRIPPING BRACKETS

SHIP TYPES :
A – Bulk Carriers
B – Combination Carriers
C – Containerships
D – General Cargo Ships
E – Miscellaneous Ships
F – Naval Ships
G – Tankers

PERCENT FAILURE VERSUS SHIP TYPE



SHIP TYPES : A – Bulk Carriers
B – Combination Carriers
C – Containerships
D – General Cargo Ships
E – Miscellaneous Ships
F – Naval Ships
G – Tankers

PERCENT FAILURE VERSUS SHIP TYPE

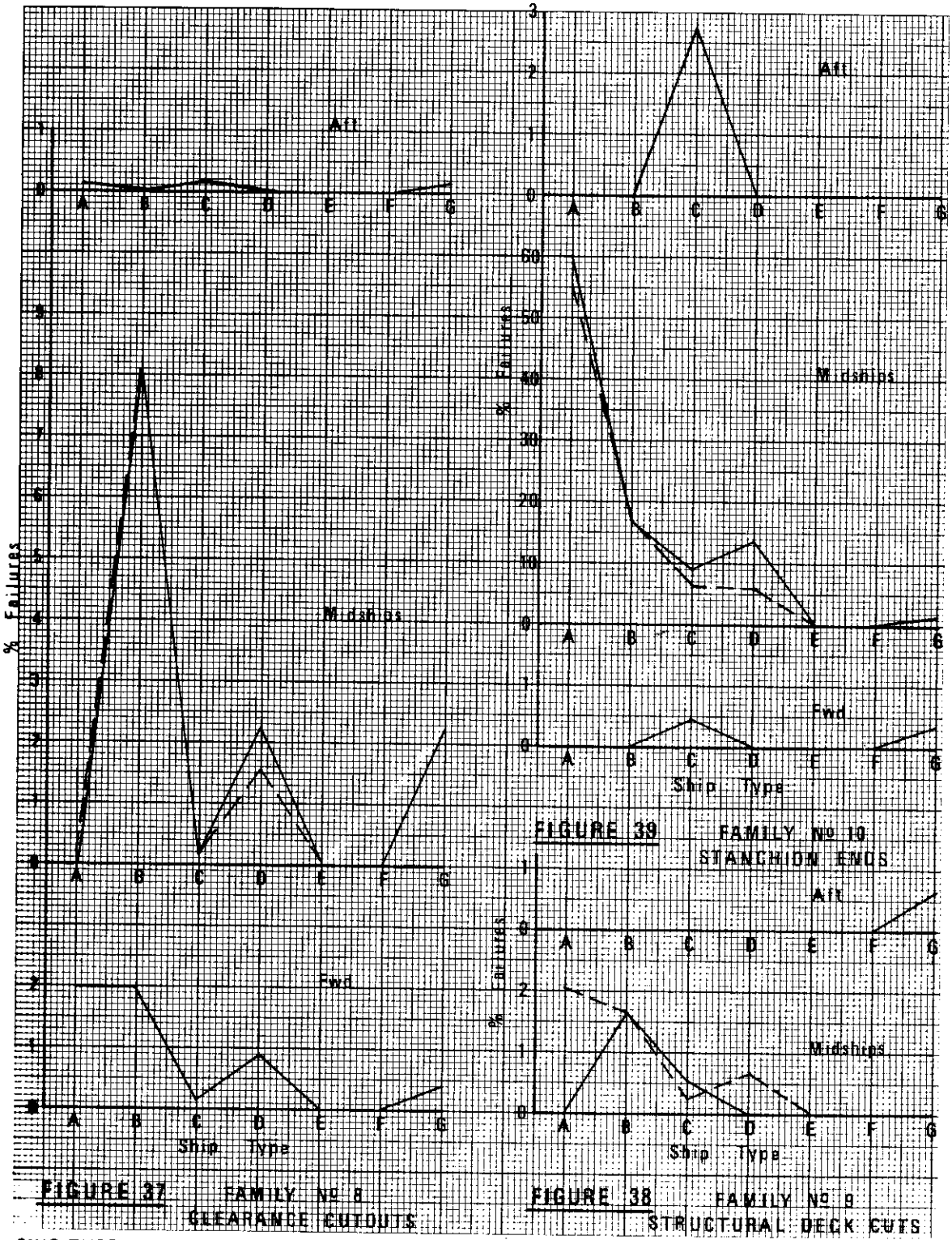


FIGURE 37 FAMILY Nº 8 CLEARANCE CUTOUTS

FIGURE 38 FAMILY Nº 9 STRUCTURAL DECK CUTS

FIGURE 39 FAMILY Nº 10 STANCHION ENDS

SHIP TYPES : A – Bulk Carriers
B – Combination Carriers
C – Containerships
D – General Cargo Ships
E – Miscellaneous Ships
F – Naval Ships
G – Tankers

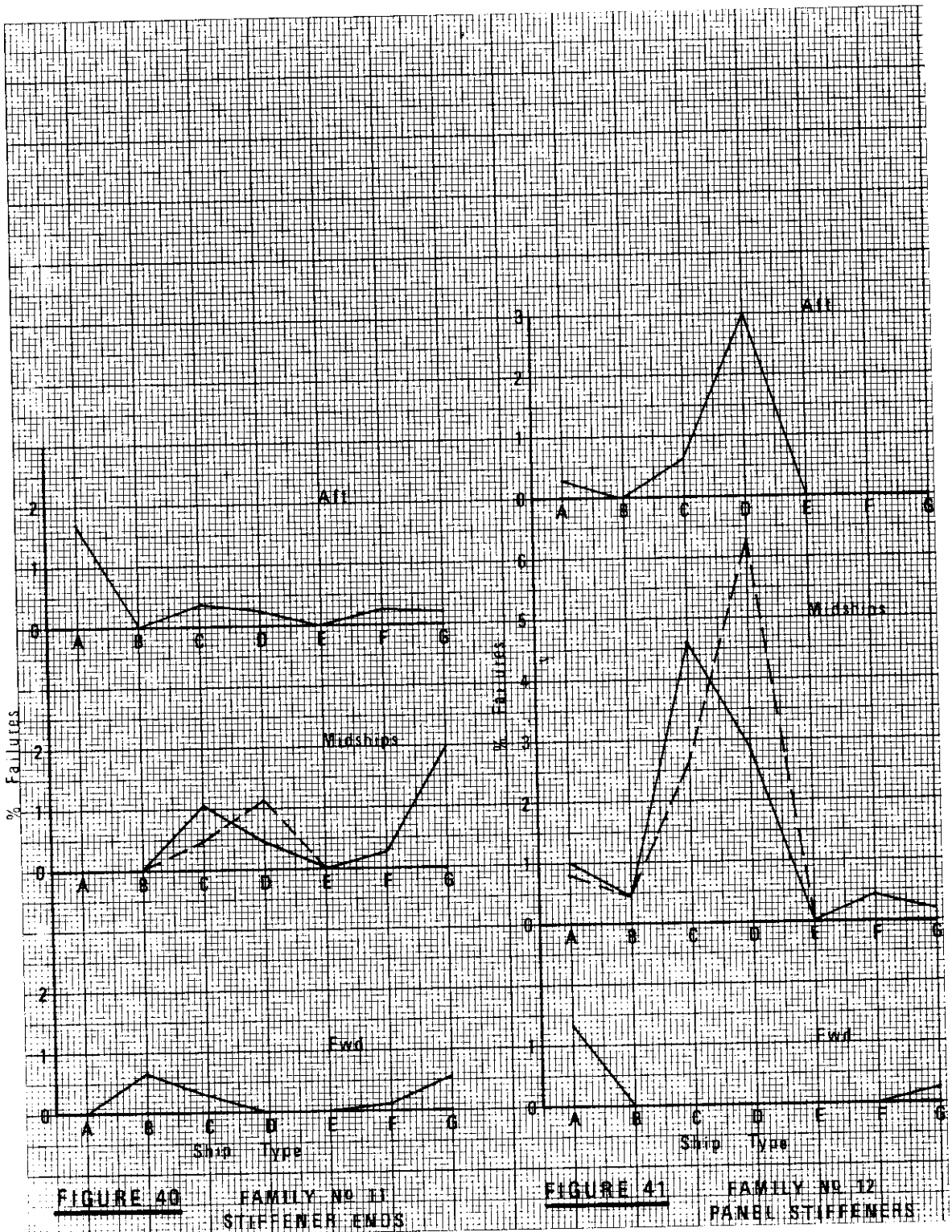


FIGURE 40 FAMILY Nº 11 STIFFENER ENDS

FIGURE 41 FAMILY Nº 12 PANEL STIFFENERS

SHIP TYPES :
A – Bulk Carriers
B – Combination Carriers
C – Containerships
D – General Cargo Ships
E – Miscellaneous Ships
F – Naval Ships
G – Tankers

A - Bulk Carriers
B - Combination Carriers
C - Containerships
D - General Cargo Ships
E - Miscellaneous Ships
F - Naval Ships
G - Tankers

The following is a list of the total number of ships surveyed. An asterisk denotes that twelve ships were surveyed in the midship/cargo section only:

* 16 - Bulk Carriers
5 - Combination Carriers
* 24 - Containerships
* 17 - General Cargo Ships
2 - Miscellaneous Ships
9 - Naval Ships
13 - Tankers
86 - TOTAL NUMBER OF SHIPS SURVEYED

Data in the forward and aft sections of all ships, plus the data in the midship section of the combination carriers, miscellaneous ships, naval ships, and tankers were taken from the first survey. Data for the midship section of bulk carriers, containerships and general cargo ships were taken from both surveys.

Table 15 is a normalized data summary of the observed details and failures for each detail family. The data is listed by ship type and general location in the ship, i.e., forward of the cargo section (fwd); within the cargo section (midships); and aft of the cargo section (aft).

Figures 31 through 41, were derived from Table 15 and are plots of the percent failures versus ship type for each detail family. Separate plots are provided for each of the three general ship locations - fwd, midships, and aft. The percentage given on each plot represents the failure percentage of the details observed in that general area of the ship only. The solid line in the plots represent data gathered from the first survey, and the broken line (shown only in the midship plots) represents data gathered from ships in both surveys.

Table 16 is a failure percentage tabulation for each ship type for individual family groups by general ship location. The data in this table shows percentages of actual observed data and has not been normalized. In order to attain the failure percentages, the authors divided the observed failures by the total details observed in each of the three general ship locations.

Using Figures 31 through 41, an engineer/designer could quickly establish failure trends for detail families on a particular ship type. Table 16 shows failures in the individual family groups and their location. Appendix A provides more specific data on detail variations and should aid the designer in finding failure modes and causes.

Family Number 1 - Beam Brackets

Twenty-three percent (145) of the 634 configurations observed in both surveys were in this family. The largest number of beam brackets appeared on containerships;

TABLE Nº 16 SUMMARY PERCENT FAILURES OF DETAIL FAMILY GROUPS BY SHIP TYPE & SHIP LOCATION

FAMILY GROUP NO.	SHIP TYPE & LOCATION																		
	A			B			C			D			E			F			G		
	FWD	MID-SHIPS	AFT	FWD	MID-SHIPS	AFT	FWD	MID-SHIPS	AFT	FWD	MID-SHIPS	AFT	FWD	MID-SHIPS	AFT	FWD	MID-SHIPS	AFT	FWD	MID-SHIPS	AFT
1-A												3.33								6.56	
1-B		1.16												1.25						3.17	0.48
1-C			2.35		0.03		2.51	7.60	2.67		10.89								2.40		0.89
1-D			0.36								0.48										
1-E							1.25	6.28			1.18										0.42
1-F	4.29							0.53	22.50										3.75	2.06	
1-G																					
1-H	4.14	0.69					3.33			6.67	1.49	3.33									
1-J		8.96			24.00			17.69			0.67						20.00				
1-K		0.30						0.88		6.67										14.62	20.00
1-L		5.56					11.08	0.27	1.33		6.67		17.50						5.71		
1-M		6.80			0.57			4.57	0.18		3.64										0.83
1-N		22.50															0.43				
1-P		7.76																		17.73	
2-A		2.50		2.50				3.54		4.00									0.24	0.88	0.74
2-B					0.25			0.56										0.32	0.59	2.15	
2-C		3.71			1.43			9.02			15.59									2.86	
3-A		0.19						0.13				2.86							8.33		
3-B																					
3-C			2.58				10.00					6.67	3.75								
4-A											2.97										
4-B																					
4-C								0.47													
4-D																					

TABLE Nº 16 (CON'T.) SUMMARY PERCENT FAILURES OF DETAIL FAMILY GROUPS BY SHIP TYPE & SHIP LOCATION

FAMILY GROUP NO.	SHIP TYPE & LOCATION																			
	A			B			C			D			E			F			G	
	FWD	MID-SHIPS	AFT	FWD	MID-SHIPS	AFT	FWD	MID-SHIPS	AFT	FWD	MID-SHIPS	AFT	FWD	MID-SHIPS	AFT	FWD	MID-SHIPS	AFT	FWD	MID-SHIPS	AFT
5-A								7.14												10.0	
5-B														100.00							
7-A								0.53			5.39						1.20		2.73		
7-B								0.46									1.10				
7-C				0.53				1.19	0.28		0.60	6.40				0.33	0.19	0.22		0.05	
7-D			12.31					0.30												0.15	
7-E					3.82			0.31												1.55	
7-F		1.80						0.67	1.56		0.25										1.32
7-G		1.16						0.69										0.11			0.16
7-H	3.85	0.12	0.70	3.04	0.35	0.40	0.91	0.36	0.25		0.56	0.04					0.02	0.06	0.12	0.07	
8-A											13.33										
8-B					5.00			0.56	0.91											0.50	0.67
8-C		0.05					0.43	0.18	0.14											10.29	
8-D					8.33			1.13												6.20	
8-E	10.00	0.41	0.67	10.00				0.06		0.83									0.91	0.62	
9-A																					0.67
9-B		5.26			1.00			1.03			1.32										
9-C					3.75			0.15			0.69										
10-A							0.59	4.00	12.00		16.60										
10-B		60.00			25.00			7.02			1.69								0.71	2.00	
10-C		60.00						4.00			2.09										

TABLE Nº 16 (CON'T.) SUMMARY PERCENT FAILURES OF DETAIL FAMILY GROUPS BY SHIP TYPE & SHIP LOCATION

FAMILY GROUP NO.	SHIP TYPE & LOCATION																			
	A			B			C			D			E			F			G		
	FWD	MID-SHIPS	AFT	FWD	MID-SHIPS	AFT	FWD	MID-SHIPS	AFT	FWD	MID-SHIPS	AFT	FWD	MID-SHIPS	AFT	FWD	MID-SHIPS	AFT	FWD	MID-SHIPS	AFT
11-A			1.67	0.71			0.37	0.44	0.14		1.26	0.25				0.14	0.18	0.40	0.59	3.18	
11-B								0.61	1.03		0.96									0.80	20.00
11-C																	2.80				
11-D								0.79												1.93	
11-E																					
12-A	2.73	1.27	0.51		0.63			0.33			4.37	1.61					1.18				
12-B								1.83	0.98		9.44						0.11		1.88		
12-C		0.39									14.29	15.00								0.20	
12-D								6.25													
12-E								3.32													
12-F								1.70	2.22												

tankers had the smallest number. The number of beam brackets that are used in the midship section of bulk carriers decreased by 59% of that used in the first survey, and the average failures decreased by 55%. However, the percentage failure rate remained about the same, as shown in Figure 31.

There were failures observed on all ship types. Containerships continued to maintain their lead for observed failures, followed by general cargo ships and tankers. Of the failures, 79% occurred in the midship area, 15% forward, and 6% aft. The eight percent increase in the midship area, as explained in the first section of this report, could be expected since the second survey was confined to the exact area on the three ship types where the majority of the failures occurred in the first survey. As shown in Figure 31, each of the ship types had beam bracket failures in the forward section of the ship, except for combination carriers and tankers. In the midship section, the percentage of failures greatly increased for containerships and general cargo ships, which placed them ahead of tankers in failure percentage. Containerships had the most failure problems in the aft section of the ship.

Family Number 2 - Tripping Brackets

Distribution of tripping brackets varied from 2.37% on miscellaneous ships to 20.88% on combination carriers, with the largest number of failures occurring in the midship area of general cargo ships. In the forward section of the ship, failures were confined to three ship types; combination carriers, general cargo ships, and tankers. However, in the midship section, only miscellaneous ships and naval ships remained failure free. General cargo ships increased their lead in percentage failures in the midship area to 14.33%. All of the failures on general cargo ships in the midship area were in group 2-C (Table 16). Appendix A and the discussion on tripping brackets in the first section, indicate that the majority of the general cargo ship failures in family/group 2-C were contributed by the bulwark and hatch coaming supports. Tripping bracket failures in the aft section of the ship were limited to naval ships and tankers.

Family Number 3 - Non-Tight Collars

Peak failure trends in this family appear in the forward area of miscellaneous ships, midship area of containerships, and aft area of general cargo ships. The failure peaks appear very small in the midship area. This is because there were only two failures observed in the sixteen bulk carriers and five failures observed in the twenty-four containerships surveyed which, after normalizing, amounted to a 0.05% and 0.09% failure rate, respectively.

Family Number 4 - Tight Collars

This family was free of failures except for the midship area of general cargo ships. There was one failure observed on one of the twenty-four containerships surveyed, but even after normalizing (using seven ships) only a fraction of a failure would appear in Table 15.

Family Number 5 - Gunwale Connections

Failures in gunwale connections were observed in only three ship types. The midship area of containerships sustained 2.08% failures; the midship area of miscellaneous ships sustained 50% failures; and the midship area of tankers sustained 7.14% failures.

Family Number 6 - Knife Edge Crossings

There were no knife edge crossings observed.

Family Number 7 - Miscellaneous Cutouts

This family contained 50% of all the observed details and 17% of all the failures listed in Table 15. All of the ship types, except miscellaneous and general cargo ships, experienced failures throughout. General cargo ships had no failures forward, and miscellaneous ships had no failures at all. Peak failure trends appeared in the forward and aft sections of bulk carriers, and in the midship section of combination carriers. As indicated in "Structural Details of Ships in Service,"[1] all of the failures in the forward and aft sections of the bulk carriers occurred in details 7-D-2 and 7-H-5. The lightening hole cutout, detail 7-E-2, and the weld clearance cutout, detail 7-H-1, accounted for all of the failures in the midship section of the combination carriers. The midship section of the containershi had failures in each of the eight groups of miscellaneous cutouts.

Family Number 8 - Clearance Cutouts

The largest number of clearance cutouts were used in tankers, miscellaneous ships and combination carriers. Naval ships had the least and they were found in the aft section only. As shown in Figure 37, bulk and combination carriers had the highest failure percentage in the forward section of the ship. Detail 8-E-2 accounted for all of the bulk carrier failures and detail 8-E-7 for the combination carrier failures. In the midship section, detail 8-D-6 was responsible for the 8.1% failure rate on the combination carriers. The failure rate for bulk carriers, containerships, and general cargo ships, changed very little from the first survey, as shown in the midship plot of Figure 37. Very few clearance cutout failures were observed in the aft section of any of the ship types.

Family Number 9 - Structural Deck Cuts

This family was free of failures in the forward section of all ship types and only tankers experienced failures in the aft section. However, the second survey revealed a few problem areas in the midship area of bulk carriers and general cargo ships. The failures in detail 9-B-2 produced a higher failure rate in the midship area of bulk carriers as compared to combination carriers in the first survey. Details 9-B-5 and 9-C-4 were responsible for the few failures in the midship area of the general cargo ships.

Family Number 10- Stanchion Ends

Containerships and tankers were the only two ship types to sustain stanchion end failures in the forward section of the ships. At midship, the bulk carriers continued to lead the other ship types in percentage failures with a 55.56% rate. The only stanchion end failures in the aft section of any of the ship types occurred in detail 10-A-1 on a containership.

Family Number 11 - Stiffener Ends

Peak failure trends in this family appear in the forward area of combination

1. Jordan, C. R.; Ward, W. C.; "Structural Details of Ships In Service," presented at Hampton Roads Chapter, Society of Naval Architects and Marine Engineers, March 15, 1978.

carriers, midship area of tankers, and aft area of bulk carriers. After the data from both surveys were combined, the percentage of failures in the midship area of containerships was reduced to 0.48%; and, the percentage of failures in the midship area of general cargo ships was increased to 1.12%.

Family Number 12 - Panel Stiffeners

Distribution of panel stiffeners varied from 8.32% on containerships to 25.69% of naval ships, with the largest number of failures occurring in the midship area of the general cargo ships. Only bulk carriers and tankers showed failures in the forward section of the ships. Peak failure percentage appears in the aft section of general cargo ships.

SUMMARY OF RESULTS

Using the same survey techniques and data analysis procedures developed in the Ship Structure Committee Project SR-1232, "Structural Details Failure Survey,"[1] an additional twelve bulk carriers, twelve containerships, and twelve general cargo ships were surveyed in the midship/cargo area. During a fourteen month period, repair yards and loading facilities were visited on all three coasts of the United States in order to obtain eligible candidates for the survey.

The second survey produced eighty-one new detail variations for the twelve existing structural detail families. This brings the total number of configurations for the eighty-six ship survey to 634 distinct detail variations. Table 17 is a listing for the second survey of the twenty detail variations that had either the most observed failures or highest percentage of failures. Table 18 is a summary listing the total number of details and detail failures observed for each family in the second survey as well as for both surveys combined.

A total of 117,374 details were observed with a total of 3,555 failures, yielding a failure rate of 3.03% for the second survey. In the first fifty-ship survey, the 3,301 failures of the 490,210 details observed, resulted in a failure rate of 0.67%. By combining the data in the two surveys, the results show 6,856 failures for 607,584 observed details or a failure rate of 1.13%.

The twelve detail families continued to follow many of the trends established in the first survey. Although some individual family failure percentages increased or decreased due to a number of reasons, the majority remained the same. Some observations on the twelve families performance in the second survey as compared to that in the first survey follows:

o Some of the same beam bracket details appeared on the ten most prevalent list in both surveys. Overall percentage of failures increased in the second survey. The failure percentage in the midship of bulk carriers remained the same.

o Tripping brackets showed an increase in failure percentage with increased failures on all three ship types, bulk carriers, containerships and general cargo ships. All of the failures in the midship area of general cargo ships continued to be in family/group 2-C.

1. Jordan, C. R.; Cochran, C. S., "In-Service Performance of Structural Details," Ship Structure Committee Report SSC-272, dated 1978.

TABLE 17

TOP TEN FAILED DETAILS

RANK	MOST PREVALENT			HIGHEST PERCENTAGE		
	DETAIL NUMBER	NO. OF FAILURES	% FAILURES	DETAIL NUMBER	NO. OF FAILURES	% FAILURES
1	1-C-1	538	19.2	10-A-29	2	100.0
2	1-C-25	359	27.8	10-C-33	4	100.0
3	2-C-19	330	18.8	10-A-28	3	75.0
4	1-C-2	204	12.6	1-P-8	8	66.7
5	2-C-11	196	17.8	5-A-1	1	50.0
6	2-C-7	195	8.2	7-H-13	12	50.0
7	12-B-2	160	47.2	2-A-20	54	49.1
8	1-E-1	125	4.0	12-B-2	160	47.2
9	12-A-3	105	3.9	10-B-26	6	42.9
10	2-C-20	98	12.6	2-C-27	50	42.4

TABLE 18

SUMMARY OF DATA FOR 12 DETAIL FAMILIES

FAMILY NO.	DETAIL FAMILY NAME	OBSERVED SECOND SURVEY			TOTALS OBSERVED BOTH SURVEYS		
		NO. DETAILS	NO. FAILURES	% FAILURES	TOTAL NO. DETAILS	TOTAL NO. FAILURES	% FAILURES
1	Beam Bracket	17836	1364	7.65	68586	2252	3.28
2	Tripping Bracket	13372	1273	9.52	34012	1587	4.67
3	Non-Tight Collar	4724	5	0.11	20974	33	0.16
4	Tight Collar	2654	46	1.73	20654	46	0.22
5	Gunwale Connection	72	1	1.39	172	5	2.91
6	Knife Edges	0	0	-	0	0	-
7	Miscellaneous Cutouts	43819	207	0.47	296689	853	0.29
8	Clearance Cutouts	8797	22	0.25	57307	843	1.47
9	Deck Cutouts	1504	17	1.13	7534	29	0.38
10	Stanchion Ends	820	24	2.93	7090	122	1.72
11	Stiffener Ends	9969	69	0.69	40729	298	0.73
12	Panel Stiffeners	13807	527	3.82	53837	788	1.46
	TOTALS	117374	3555	3.03	607584	6856	1.13

o Non-tight collars maintained a very high sound detail percentage.

o The percent of sound details for tight collars was lowered from 100% to 99.8%, due to a few failures on three general cargo ships in the second survey.

o The workmanship and welding continued to be excellent on gunwale connections with only one new failure reported.

o No knife edge crossings were observed in either survey.

o As in the first survey, no one group of miscellaneous cutouts could be singled out as having more failures than the others. Weld clearance cutouts continued to lead the failure list, and each of the eight groups had less than a one percent failure rate.

o The family of clearance cutouts had a failure rate of 0.25% in the midship area of bulk carriers, containerships, and general cargo ships, as compared to a failure rate of 0.36% for the same three ship types in the first survey.

o The percentage of failures for deck cutouts increased slightly as a result of failures sustained on a bulk carrier during a severe storm.

o The stanchion ends supporting the corners of the deckhouses continued to be a problem. Seventy-five percent of the stanchion end failures in the second survey were new detail variations.

o The family of stiffener ends had almost the same failure percentage in both surveys. However, the failure percentage in the midship area of containerships decreased slightly, while the failure percentage in the midship area of the general cargo ships increased by about the same amount.

o Panel stiffeners showed a much higher percentage of failure due to one general cargo ship that had an extreme maintenance problem.

Appendix A is a tabulation of the numerical data for each detail variation observed in both surveys. The appendix for projects SR-1232 and SR-1258 were combined to provide the maximum available information on the 607,584 details observed in the eighty-six ship survey. On each detail figure is shown the location of cracks and buckles as indicated with a (-) and (+), respectively.

CONCLUSIONS AND RECOMMENDATIONS

This report analyzes and evaluates data collected from on board inspections of thirty-six ships. The data collected on twelve bulk carriers, twelve containerships and twelve general cargo ships, were combined with the data from Project SR-1232[1] to expand the data base in the midship sections of these three ship types. Besides confirming many of the failure trends established in the first fifty ship survey, distinctive service performances were identified for the twelve typical structural detail families in the second survey. The data from the two surveys were summarized to provide the maximum available information for ready use by design and repair offices.

---

1. Jordan, C. R.; Cochran, C. S., "In-Service Performance of Structural Details," Ship Structure Committee Report SSC-272, dated 1978.

A total of 117,304 details were observed with a total of 3,555 failures, which produced a failure rate of 3.03% for the second survey. The failure rate for the first fifty ship survey was 0.67%. The 2.36% higher failure rate was probably due to the location selected for the second survey. Since the first survey disclosed that eighty-two percent of the detail failures occurred in the midship section of the ships, the second survey was confined to this problem area to confirm or refute the high failure rate. Thus, by concentrating in an area of high detail failure, and then summarizing the results, without including the data from areas with many sound details such as the forward and aft sections of the ship, a failure rate higher than the first survey resulted.

Failures continued to be attributed to either one or a combination of five categories - design, fabrication, welding, maintenance, and operation. In "Structural Details of Ships In Service,"[1] the authors' analyze each of these failure causes and provide not only how and why each of these items cause problems, but how to eliminate these failures by the use of proper techniques. Additional recommended reference material is also provided in that paper.

Data in the forward and aft sections of all ships, plus the data in the midship section of the combination carriers, miscellaneous ships, naval ships and tankers were taken from the first survey. Data for the midship section of bulk carriers, containerships and general cargo ships were taken from both surveys. This brings the total number of midship surveys for each of these three ship types to sixteen bulk carriers, twenty-four containerships, and seventeen general cargo ships. Any failure trends established for the structural details in the midship/cargo area of these three ship types could be regarded as being more representative of what actually occurs, as opposed to the ship types where failure trends have been established after having surveyed only a few ships.

The information collected in the two surveys provides an adequate data base for statistical evaluation of each family or family group. Evaluation of the effect of ship type on these groups or on all individual detail configurations is less reliable because of the smaller number of samples. The three ship types mentioned above, plus naval ships and tankers have enough candidates for evaluation, but combination carriers and miscellaneous ships have only five and two surveyed ships, respectively. Perhaps combination carriers should have been continued in the second survey instead of containerships, since there were already twelve containership candidates in the first survey. Also, it was noticed that twelve candidates were enough to establish accurate failure trends since the failure percentage rate for each detail family changed very little after adding the data from the second twelve containerships surveyed. As for miscellaneous ships, the category is too broad to establish any significant analyses with regard to individual ship types.

Projects of this type should be a continuing effort to provide feedback to design and repair offices for increased confidence in existing design methods as well as for future improvements. As more ships are surveyed, there is less need for estimated data as used in the first survey. Eventually, a substantial data base is formed from which meaningful statistical analyses can be conducted to provide useful information to ship owners as well as design offices. For instance, ship owners could use the information to evaluate the economics of ship maintenance, or the money saved by adding tug stations, etc. Design offices could use the analyses to select the proper detail configuration for a particular design situation and the waterfront trades could use the data as an adjunct in teaching proper fabrication and welding techniques.

---

1. Jordan, C. R.; Ward, W. C., "Structural Details of Ships In Service," presented at Hampton Roads Chapter, Society of Naval Architects and Marine Engineers, March 15, 1978.

ACKNOWLEDGEMENTS

The authors are grateful to the personnel of the shipyards and repair yards who participated in this survey by allowing the surveyors access to their facilities. A special word of appreciation is extended to the owners and operators who permitted the survey of their ships and provided valuable information during the on board interviews. Also, the authors wish to thank the members of the ad hoc Project Advisory Committee of the National Research Council for giving their time and support to this project.

APPENDIX

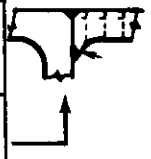
Compilation of Performance Data for 634 Observed Structural Detail Variations

This appendix contains a table of failure data arranged by family groups for each of the detail variations observed in projects SR-1232 and SR-1258. Only observed data for the various ship types are presented. The "Failure Mode" and "Failure Cause" columns are postulated by the use of appropriate identification numbers listed in "Notes" (C) and (D) at the bottom of each table. With each detail figure, the location of cracks and buckles is indicated with an arrowhead and a (-) and (+), respectively. A design office or repair facility can use this reference material in selecting the most economical and appropriate configuration for a particular loading condition and structural arrangement.

The following is a list of the total number of ships surveyed in both projects. An asterisk denotes that twelve ships were surveyed in the midship/cargo section only:

*16 - Bulk Carriers
5 - Combination Carriers
*24 - Containerships
*17 - General Cargo Ships
2 - Miscellaneous Ships
9 - Naval Ships
13 - Tankers
86 - TOTAL NUMBER OF SHIPS SURVEYED

TABLE A-1 DETAIL FAMILY BEAM BRACKETS

LOCATION ON SHIP / SHIP TYPE		No. of Sound Details Observed	No. of Failed Details Observed	Total Number Details Observed	Percent Failures	Detail Family Number	Failure Mode	Failure Cause	
Naval	Fwd	30		30		1-A-1			
	⊠	140		140					
	Aft	40		40					
Naval	Fwd	20		20		1-A-2			
	⊠	110		110					
	Aft	30		30					
Naval	Fwd	240		240		1-A-3			
	⊠	1680		1680					
	Aft	490		490					
Naval	Fwd	120		120		1-A-4			
	⊠	510		510					
	Aft	200		200					
Miscella-neous	Fwd					1-A-5			
	⊠	40		40					
	Aft								
Tanker	Fwd					1-A-5	1	11	
	⊠	198	2	200	1.0				
	Aft								
Tanker	Fwd					1-A-6	1	8,11,14	
	⊠	45	15	60	25.0				
	Aft								
Naval	Fwd	50		50		1-A-7			
	⊠	270		270					
	Aft	90		90					
Naval	Fwd	40		40		1-A-8			
	⊠	240		240					
	Aft	70		70					
Tanker	Fwd	20		20		1-A-9	1	8,13	
	⊠	56	4	60	6.7				
	Aft	30		30					
General Cargo	Fwd					1-A-10	1	13	
	⊠								
	Aft	29	1	30	3.3				
Naval	Fwd	30		30		1-A-11			
	⊠	90		90					
	Aft	20		20					
Naval	Fwd					1-B-1			
	⊠	70		70					
	Aft								

NOTES:

(A) The above continued table gives information related to individual detail designs in the 86 ship survey.

(B) The rows labeled aft, ⊠ , and fwd refer to locations along the ship length. The mid-ship symbol row covers the mid-length throughout the entire cargo section.

(C) The numbers 1, 2, 3 & 4 in the column for failure mode refer to cracks, buckles, cracks and buckles, and twisted/distorted, respectively.

(D) Probable detail failure causes are estimated to be a combination of fatigue and the other factors indicated in the table by appropriate numbers as follows:

6. Shear
6. Tension
7. Combined Tension & Shear
8. Design
9. Fabrication/Workmanship
10. Welding
11. Neglect
12. Misuse/Abuse
13. Questionable
14. Heavy Seas
15. Collision
16. Other - See Discussion

TABLE A-1 DETAIL FAMILY: BEAM BRACKETS

LOCATION ON SHIP / SHIP TYPE		No. of Sound Details Observed	No. of Failed Details Observed	Total Number Details Observed	Percent Failures	Detail Family Number	Failure Mode	Failure Cause
Tanker	Fwd Aft	26	4	30	13.33	1-B-1	1	13
Miscella-neous	Fwd Aft	110 50		110 50		1-B-2		
Tanker	Fwd Aft	30		30		1-B-2		
Tanker	Fwd Aft	39 20	1	40 20	2.5	1-B-3	1	8
Tanker	Fwd Aft	266 40	14	280 40	5.0	1-B-4	1	8
Tanker	Fwd Aft	394	6	400	1.5	1-B-5	1	8,9,10
Miscella-neous	Fwd Aft	160		160		1-B-6		
Tanker	Fwd Aft	1494 40	6	1500 40	.4	1-B-6	1	8,9
Bulk Carrier	Fwd Aft	204		204		1-B-7		
Bulk Carrier	Fwd Aft	43		43		1-B-8		
Tanker	Fwd Aft	515	45	560	8.0	1-B-8	1	8
Tanker	Fwd Aft	150		150		1-B-9		
Tanker	Fwd Aft	288 40	12	300 40	4.0	1-B-10	1	8
Bulk Carrier	Fwd Aft	46	3	49	6.1	1-B-11	1	13
Container-Ship	Fwd Aft	40		40		1-B-11		
Miscella-neous	Fwd Aft	46	4	50	8.0	1-B-11	2	12

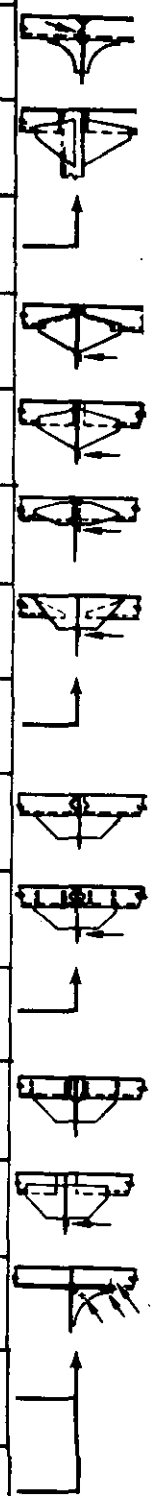


TABLE A-1 DETAIL FAMILY: BEAM BRACKETS

LOCATION ON SHIP / SHIP TYPE		No. of Sound Details Observed	No. of Failed Details Observed	Total Number Details Observed	Percent Failures	Detail Family Number	Failure Mode	Failure Cause
Tanker	Fwd Aft	28	12	40	30.0	1-B-11	1	13
Tanker	Fwd Aft	58	2	60	3.3	1-B-12	1	8
Bulk Carrier	Fwd Aft	49	1	50	2.0	1-B-13	1	14
Tanker	Fwd Aft	40		40		1-B-13		
Bulk Carrier	Fwd Aft	12		12		1-C-1		
Combination Carrier	Fwd Aft	60 2999 150	1	600 3000 150	.0	1-C-1	1	15
Container-ship	Fwd Aft	100 1885 110	560	100 2445 110	22.9	1-C-1	2	(8,12,14 15)
General Cargo	Fwd Aft	140 1926 230	128	140 2054 230	6.2	1-C-1	2	12,14,15
Tanker	Fwd Aft	198 400	2	200 400	1.0	1-C-1	2	14
Container-ship	Fwd Aft	488 2816 542	12 84 58	500 2900 600	2.4 2.9 9.7	1-C-2	2 1,2 2	11,12 10,14,15 11,14
General Cargo	Fwd Aft	1190	130	1320	9.8	1-C-2	2	12,14,15
Tanker	Fwd Aft	114 60	6	120 60	5.0	1-C-2	2	14
Bulk Carrier	Fwd Aft	20		20		1-C-3		

NOTES:

(A) The above continued table gives information related to individual detail designs in the 86 ship survey.

(B) The rows labeled aft, ⊠, and fwd refer to locations along the ship length. The mid-ship symbol row covers the mid-length throughout the entire cargo section.

(C) The numbers 1, 2, 3 & 4 in the column for failure mode refer to cracks, buckles, cracks and buckles, and twisted/distorted, respectively.

(D) Probable detail failure causes are estimated to be a combination of fatigue and the other factors indicated in the table by appropriate numbers as follows:

5. Shear
6. Tension
7. Combined Tension & Shear
8. Design
9. Fabrication/Workmanship
10. Welding
11. Neglect
12. Misuse/Abuse
13. Questionable
14. Heavy Seas
15. Collision
16. Other - See Discussion

TABLE A-1 DETAIL FAMILY: BEAM BRACKETS

LOCATION ON SHIP / SHIP TYPE		No. of Sound Details Observed	No. of Failed Details Observed	Total Number Details Observed	Percent Failures	Detail Family Number	Failure Mode	Failure Cause
Combination Carrier	Fwd	20		20		1-C-3		
		260		260				
	Aft	30		30				
Container-ship	Fwd	48	2	50	4.0	1-C-3	2	14
	Aft							
Container-ship	Fwd	70		70		1-C-4		
		450		450				
	Aft	130		130				
General Cargo	Fwd	90		90		1-C-4		
	Aft	90		90				
Tanker	Fwd	108	2	110	1.8	1-C-5	2	14
	Aft	240		240				
Container-ship	Fwd	116	4	120	3.3	1-C-6	2	14
	Aft	200		200				
Tanker	Fwd	59	1	60	1.7	1-C-6	1	15
	Aft	100		100				
Miscella-neous	Fwd	80		80		1-C-7		
	Aft	40		40				
Container-ship	Fwd	497	3	500	.6	1-C-8	2	14
		4131	16	4147	.4		2	14,15
	Aft	900		900				
General Cargo	Fwd	200	30	230	13.0	1-C-8	2	12,14
	Aft							
Bulk Carrier	Fwd	30		30		1-C-9		
		140		140				
	Aft	38	2	40	5.0		2	15
General Cargo	Fwd	20		20		1-C-9		
		100		100				
	Aft	40		40				
Tanker	Fwd					1-C-9		
	Aft	50		50				
Container-ship	Fwd	150		150		1-C-10		
	Aft							
General Cargo	Fwd	39	1	40	2.5	1-C-10	2	9,14
	Aft							
Container-ship	Fwd	236	4	240	1.7	1-C-11	2	8
	Aft							

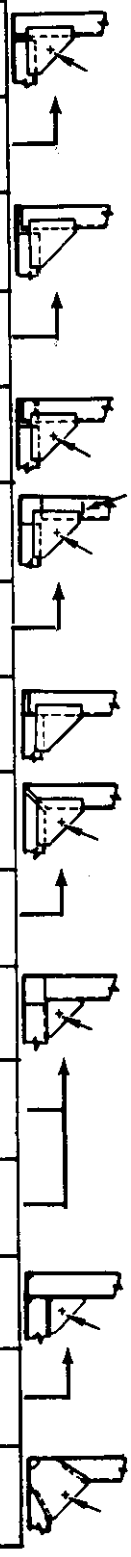


TABLE A-1 DETAIL FAMILY: BEAM BRACKETS

LOCATION ON SHIP / SHIP TYPE		No. of Sound Details Observed	No. of Failed Details Observed	Total Number Details Observed	Percent Failures	Detail Family Number	Failure Mode	Failure Cause
Bulk Carrier	Fwd Aft	45		45		1-C-12		
Tanker	Fwd Aft	45		45		1-C-12		
Container-ship	Fwd Aft	20 30		20 30		1-C-13		
Container-ship	Fwd Aft	20 158 20	2	20 160 20	1.2	1-C-14	2	9,14
Container-ship	Fwd Aft	136 100	14	150 100	9.3	1-C-15	2	11,14
Container-ship	Fwd Aft	96 190	4	100 190	4.0	1-C-16	2	15
Bulk Carrier	Fwd Aft	100 300		100 300		1-C-17		
Container-ship	Fwd Aft	85 340 90	5	90 340 90	5.6	1-C-17	2	15
Tanker	Fwd Aft	9	1	10	10.0	1-C-17	2	8,14
Container-ship	Fwd Aft	50 300 90		50 300 90		1-C-18		
Naval	Fwd Aft	20 100 20		20 100 20		1-C-19		
Combination Carrier	Fwd Aft	120		120		1-C-20		
Combination Carrier	Fwd Aft	50 170		50 170		1-C-21		

NOTES:

(A) The above continued table gives information related to individual detail designs in the 86 ship survey.

(B) The rows labeled aft, ⊠, and fwd refer to locations along the ship length. The mid-ship symbol row covers the mid-length throughout the entire cargo section.

(C) The numbers 1, 2, 3 & 4 in the column for failure mode refer to cracks, buckles, cracks and buckles, and twisted/distorted, respectively.

(D) Probable detail failure causes are estimated to be a combination of fatigue and the other factors indicated in the table by appropriate numbers as follows:

5. Shear
6. Tension
7. Combined Tension & Shear
8. Design
9. Fabrication/Workmanship
10. Welding
11. Neglect
12. Misuse/Abuse
13. Questionable
14. Heavy Seas
15. Collision
16. Other - See Discussion

TABLE A-1 DETAIL FAMILY: BEAM BRACKETS

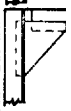
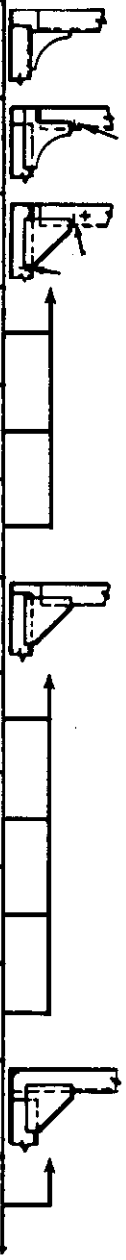
LOCATION ON SHIP / SHIP TYPE		No. of Sound Details Observed	No. of Failed Details Observed	Total Number Details Observed	Percent Failures	Detail Family Number	Failure Mode	Failure Cause	
Container-ship	Fwd	76	4	80	5.0		2	14	
	Aft	530	122	652	18.7	1-C-22	2	(11,12, 14,15)	
General Cargo	Fwd								
	Aft	60		60		1-C-23			
Tanker	Fwd								
	Aft	111	9	120	7.5	1-C-24	2	11	
Container-ship	Fwd								
	Aft	424	161	585	27.5	1-C-25	2	8,14,15	
General Cargo	Fwd								
	Aft	508	198	706	28.0	1-C-25	2	8,14,15	
Bulk Carrier	Fwd								
	Aft	12		12		1-C-26			
General Cargo	Fwd								
	Aft	22		22		1-C-27			
Bulk Carrier	Fwd	140		140					
		790		790		1-D-1			
	Aft	180		180					
General Cargo	Fwd	40		40					
		310		310		1-D-1			
	Aft	90		90					
Miscella-neous	Fwd	20		20					
		60		60		1-D-1			
	Aft	30		30					
Bulk Carrier	Fwd	50		50					
		1000		1000		1-D-2			
	Aft	50		50					
Miscella-neous	Fwd								
		300		300		1-D-2			
	Aft	80		80					
Miscella-neous	Fwd	20		20					
		120		120		1-D-3			
	Aft	30		30					
General Cargo	Fwd								
		70		70		1-D-4			
	Aft	20		20					
Bulk Carrier	Fwd	30		30		1-D-5			
	Aft								
General Cargo	Fwd								
		38	2	40	5.0	1-D-6	2	9	
	Aft								

TABLE A-1 DETAIL FAMILY: BEAM BRACKETS

LOCATION ON SHIP / SHIP TYPE		No. of Sound Details Observed	No. of Failed Details Observed	Total Number Details Observed	Percent Failures	Detail Family Number	Failure Mode	Failure Cause
Miscella-neous	Fwd	40		40				
	⊠	280		280		1-D-7		
	Aft	80		80				
Bulk Carrier	Fwd							
	⊠	50		50		1-D-8		
	Aft	49	1	50	2.0		1	10
Combination Carrier	Fwd							
	⊠							
	Aft	60		60		1-E-1		
Container-ship	Fwd	40		40				
	⊠	1328	89	1417	6.3	1-E-1	3,4	14,15
	Aft							
General Cargo	Fwd							
	⊠	1640	36	1676	2.1	1-E-1	4	15
	Aft							
Tanker	Fwd	20		20				
	⊠					1-E-1		
	Aft	30		30				
Bulk Carrier	Fwd	10		10				
	⊠	60		60		1-E-2		
	Aft	30		30				
Combination Carrier	Fwd							
	⊠	60		60		1-E-2		
	Aft							
Container-ship	Fwd	20		20		1-E-2		
	⊠							
	Aft							
General Cargo	Fwd							
	⊠	296		296		1-E-2		
	Aft							
Tanker	Fwd	30		30				
	⊠					1-E-2		
	Aft	40		40				
General Cargo	Fwd	20		20		1-E-3		
	⊠							
	Aft							
Tanker	Fwd	20		20				
	⊠					1-E-3		
	Aft	50		50				



NOTES:

(A) The above continued table gives information related to individual detail designs in the 86 ship survey.

(B) The rows labeled aft, ⊠, and fwd refer to locations along the ship length. The mid-ship symbol row covers the mid-length throughout the entire cargo section.

(C) The numbers 1, 2, 3 & 4 in the column for failure mode refer to cracks, buckles, cracks and buckles, and twisted/distorted, respectively.

(D) Probable detail failure causes are estimated to be a combination of fatigue and the other factors indicated in the table by appropriate numbers as follows:

5. Shear
6. Tension
7. Combined Tension & Shear
8. Design
9. Fabrication/Workmanship
10. Welding
11. Neglect
12. Misuse/Abuse
13. Questionable
14. Heavy Seas
15. Collision
16. Other - See Discussion

TABLE A-1 DETAIL FAMILY: BEAM BRACKETS

LOCATION ON SHIP / SHIP TYPE		No. of Sound Details Observed	No. of Failed Details Observed	Total Number Details Observed	Percent Failures	Detail Family Number	Failure Mode	Failure Cause
General Cargo	Fwd	90		90				
		820		820		1-E-4		
	Aft	130		130				
Combination Carrier	Fwd							
	Aft	50		50		1-E-5		
Miscella-neous	Fwd	20		20				
						1-E-5		
	Aft	80		80				
Tanker	Fwd	20		20				
						1-E-5		
	Aft	80		80				
Bulk Carrier	Fwd							
		20		20		1-E-6		
	Aft	20		20				
Tanker	Fwd							
	Aft	9	1	10	10.0	1-E-6	1	11
General Cargo	Fwd	253		253		1-E-7		
	Aft							
Tanker	Fwd	40		40		1-E-7		
	Aft	30		30				
Container-ship	Fwd	98	2	100	2.0	1-E-8	1,2	5,9
	Aft							
Bulk Carrier	Fwd	20		20		1-F-1		
	Aft							
Container-ship	Fwd	10		10				
		200		200		1-F-1		
	Aft	31	9	40	22.5		2	13
Tanker	Fwd							
		442	8	450	1.8	1-F-1	1	10
	Aft							
Container-ship	Fwd							
		176	2	178	1.1	1-F-2	2	13
	Aft							
Tanker	Fwd							
		175	5	180	2.8	1-F-2	1	9,10
	Aft							
Tanker	Fwd	30		30		1-F-3		
	Aft							
Bulk Carrier	Fwd	47	3	50	6.0	1-F-4	1	14
	Aft							

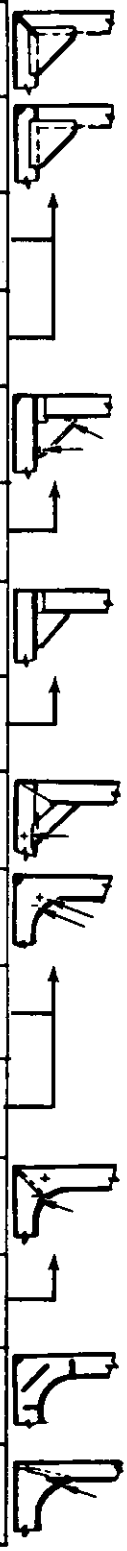
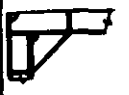
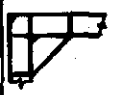
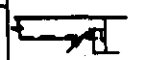
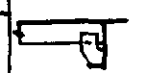


TABLE A-1 DETAIL FAMILY: BEAM BRACKETS

LOCATION ON SHIP / SHIP TYPE		No. of Sound Details Observed	No. of Failed Details Observed	Total Number Details Observed	Percent Failures	Detail Family Number	Failure Mode	Failure Cause	
Miscella-neous	Fwd Aft	20		20		1-F-4			
Tanker	Fwd Aft	47	3	50	6.0	1-F-5	1	14	
Naval	Fwd Aft	480 3400 960		480 3400 960		1-G-1			
Naval	Fwd Aft	10 50 30		10 50 30		1-G-2			
Tanker	Fwd Aft	30		30		1-G-3			
Container-ship	Fwd Aft	74		74		1-G-4			
General Cargo	Fwd Aft	20		20		1-G-4			
Naval	Fwd Aft	40		40		1-G-4			
Combination Carrier	Fwd Aft	20		20		1-G-5			
Container-ship	Fwd Aft	232		232		1-H-1			
General Cargo	Fwd Aft	84 466	6	90 466	6.7	1-H-1	1	14	
Bulk Carrier	Fwd Aft	56		56		1-H-2			
Combination Carrier	Fwd Aft	50		50		1-H-2			

NOTES:

(A) The above continued table gives information related to individual detail designs in the 86 ship survey.

(B) The rows labeled aft, ⊠ , and fwd refer to locations along the ship length. The mid-ship symbol row covers the mid-length throughout the entire cargo section.

(C) The numbers 1, 2, 3 & 4 in the column for *failure mode* refer to cracks, buckles, cracks and buckles, and twisted/distorted, respectively.

(D) Probable detail failure causes are estimated to be a combination of fatigue and the other factors indicated in the table by appropriate numbers as follows:

5. Shear
6. Tension
7. Combined Tension & Shear
8. Design
9. Fabrication/Workmanship
10. Welding
11. Neglect
12. Misuse/Abuse
13. Questionable
14. Heavy Seas
15. Collision
16. Other - See Discussion

TABLE A-1 DETAIL FAMILY: BEAM BRACKETS

SHIP TYPE / LOCATION ON SHIP		No. of Sound Details Observed	No. of Failed Details Observed	Total Number Details Observed	Percent Failures	Detail Family Number	Failure Mode	Failure Cause
Combination Carrier	Fwd	20		20				
		80		80		1-H-3		
	Aft	20		20				
Container-ship	Fwd	29	1	30	3.3	1-H-4	2	14
	Aft							
Bulk Carrier	Fwd							
	Aft	90		90		1-H-5		
Container-ship	Fwd							
		473		473		1-H-6		
	Aft							
Tanker	Fwd							
	Aft	30		30		1-H-6		
Bulk Carrier	Fwd	193	7	200	3.5		1	14
		236	4	240	1.7	1-H-7	2	12
	Aft							
Bulk Carrier	Fwd	85	5	90	5.5		1	14
		116		116		1-H-8		
	Aft	40		40				
Tanker	Fwd	30		30				
						1-H-9		
	Aft	40		40				
Bulk Carrier	Fwd							
		25		25		1-H-10		
	Aft							
General Cargo	Fwd							
	Aft	29	1	30	3.3	1-H-10	1	8
Combination Carrier	Fwd	20		20				
						1-H-11		
	Aft	20		20				
Tanker	Fwd	20		20				
						1-H-11		
	Aft	20		20				
Container-ship	Fwd							
		260		260		1-H-12		
	Aft							
General Cargo	Fwd							
		935		935		1-H-12		
	Aft							
Bulk Carrier	Fwd							
		144		144		1-H-13		
	Aft							
General Cargo	Fwd							
		1172	19	1191	1.6	1-H-13	2	8,12
	Aft							

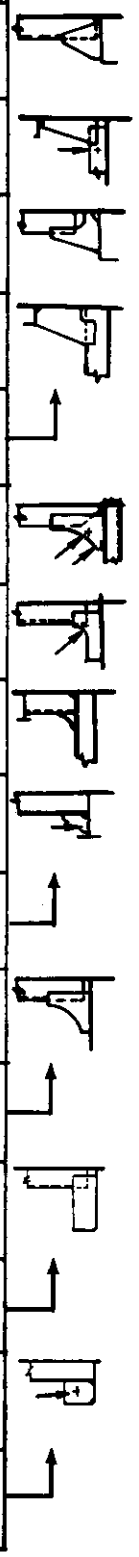
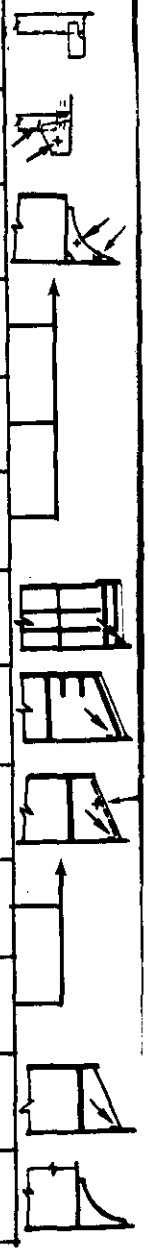


TABLE A-1 DETAIL FAMILY: BEAM BRACKETS

LOCATION ON SHIP / SHIP TYPE	↓	No. of Sound Details Observed	No. of Failed Details Observed	Total Number Details Observed	Percent Failures	Detail Family Number	Failure Mode	Failure Cause
General Cargo	Fwd ⊠ Aft	332		332		1-H-14		
General Cargo	Fwd ⊠ Aft	139	27	166	16.3	1-H-15	1,2	8,12
Bulk Carrier	Fwd ⊠ Aft	16		16		1-J-1		
Container-ship	Fwd ⊠ Aft	36	4	40	10.0	1-J-1	1	8,14
General Cargo	Fwd ⊠ Aft	36		36		1-J-1		
Naval	Fwd ⊠ Aft	8	2	10	20.0	1-J-1	2	13
Combination Carrier	Fwd ⊠ Aft	16	4	20	20.0	1-J-2	1	8
Combination Carrier	Fwd ⊠ Aft	22	8	30	26.7	1-J-3	1	8,11
Bulk Carrier	Fwd ⊠ Aft	18	12	30	40.0	1-J-4	1	8,14
Container-ship	Fwd ⊠ Aft	16	4	20	20.0	1-J-4	1	8,10
General Cargo	Fwd ⊠ Aft	89	1	90	1.1	1-J-4	2	15
Container-ship	Fwd ⊠ Aft	35	15	50	30.0	1-J-5	1	8
Bulk Carrier	Fwd ⊠ Aft	88		88		1-J-6		



NOTES:

(A) The above continued table gives information related to individual detail designs in the 86 ship survey.

(B) The rows labeled aft, ⊠, and fwd refer to locations along the ship length. The mid-ship symbol row covers the mid-length throughout the entire cargo section.

(C) The numbers 1, 2, 3 & 4 in the column for failure mode refer to cracks, buckles, cracks and buckles, and twisted/distorted, respectively.

(D) Probable detail failure causes are estimated to be a combination of fatigue and the other factors indicated in the table by appropriate numbers as follows:

5. Shear
6. Tension
7. Combined Tension & Shear
8. Design
9. Fabrication/Workmanship
10. Welding
11. Neglect
12. Misuse/Abuse
13. Questionable
14. Heavy Seas
15. Collision
16. Other - See Discussi

TABLE A-1 DETAIL FAMILY: BEAM BRACKETS

LOCATION ON SHIP / SHIP TYPE	↓	No. of Sound Details Observed	No. of Failed Details Observed	Total Number Details Observed	Percent Failures	Detail Family Number	Failure Mode	Failure Cause
Container-ship	Fwd Aft	20		20		1-J-6		
General Cargo	Fwd Aft	24		24		1-J-7		
Container-ship	Fwd Aft	26 90		26 90		1-K-1		
Container-ship	Fwd Aft	88	2	90	2.2	1-K-2	2	8
Tanker	Fwd Aft	8	2	10	20.0	1-K-3	1,2	14
Tanker	Fwd Aft	24	16	40	40.0	1-K-4	1	11,13
Container-ship	Fwd Aft	168	2	170	1.2	1-K-5	1	13
Tanker	Fwd Aft	87	3	90	3.3	1-K-6	2	11
Container-ship	Fwd Aft	9	1	10	10.0	1-K-7	1	10
Container-ship	Fwd Aft	120		120		1-K-8		
General Cargo	Fwd Aft	112 232	8	120 232	6.7	1-K-8	1	14
Container-ship	Fwd Aft	76		76		1-K-9		
Bulk Carrier	Fwd Aft	604	2	606	0.3	1-K-10	4	15
General Cargo	Fwd Aft	147		147		1-K-11		
Container-ship	Fwd Aft	76		76		1-K-12		
Bulk Carrier	Fwd Aft	32		32		1-K-13		

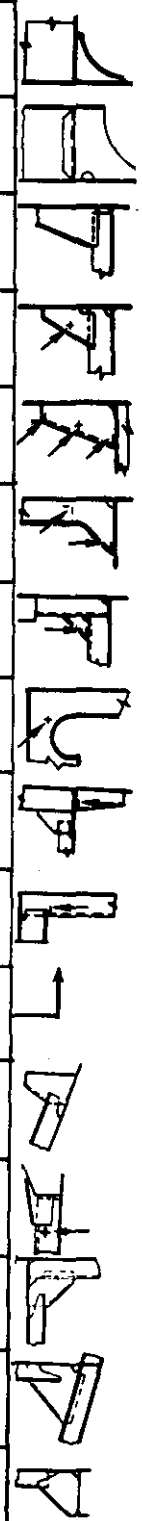


TABLE A-1 DETAIL FAMILY: BEAM BRACKETS

LOCATION ON SHIP / SHIP TYPE		No. of Sound Details Observed	No. of Failed Details Observed	Total Number Details Observed	Percent Failures	Detail Family Number	Failure Mode	Failure Cause
Bulk Carrier	Fwd ⊠ Aft	19		19		1-K-14		
Container-ship	Fwd ⊠ Aft	46		46		1-L-1		
Tanker	Fwd ⊠ Aft	82	8	90	8.9	1-L-1	2	14,15
Container-ship	Fwd ⊠ Aft	279 266	41 4	320 270	12.8 1.5	1-L-2	1,3 2	7,14,15 8,13
General Cargo	Fwd ⊠ Aft	56	4	60	6.7	1-L-2	1	7
Miscella-neous	Fwd ⊠ Aft	33 20	7	40 20	17.5	1-L-2	2	15
Container-ship	Fwd ⊠ Aft	237	1	238	0.4	1-L-3	2	13
Tanker	Fwd ⊠ Aft	50		50		1-L-3		
Bulk Carrier	Fwd ⊠ Aft	46	4	50	8.0	1-L-4	1	13
Container-ship	Fwd ⊠ Aft	50		50		1-L-5		
Container-ship	Fwd ⊠ Aft	30		30		1-L-6		
Bulk Carrier	Fwd ⊠ Aft	22		22		1-L-7		
Container-ship	Fwd ⊠ Aft	80		80		1-L-7		

NOTES:

(A) The above continued table gives information related to individual detail designs in the 86 ship survey.

(B) The rows labeled aft, ⊠, and fwd refer to locations along the ship length. The mid-ship symbol row covers the mid-length throughout the entire cargo section.

(C) The numbers 1, 2, 3 & 4 in the column for failure mode refer to cracks, buckles, cracks and buckles, and twisted/distorted, respectively.

(D) Probable detail failure causes are estimated to be a combination of fatigue and the other factors indicated in the table by appropriate numbers as follows:

5. Shear
6. Tension
7. Combined Tension & Shear
8. Design
9. Fabrication/Workmanship
10. Welding
11. Neglect
12. Misuse/Abuse
13. Questionable
14. Heavy Seas
15. Collision
16. Other - See Discussion

TABLE A-1 DETAIL FAMILY: BEAM BRACKETS

LOCATION ON SHIP / SHIP TYPE		No. of Sound Details Observed	No. of Failed Details Observed	Total Number Details Observed	Percent Failures	Detail Family Number	Failure Mode	Failure Cause	
Container-ship	Fwd	260		260					
		200		200		1-M-1			
	Aft	320		320					
Container-ship	Fwd	90		90					
		180		180		1-M-2			
	Aft	120		120					
General Cargo	Fwd								
	Aft	60		60		1-M-2			
Tanker	Fwd								
	Aft	39	1	40	2.5	1-M-2	1	11	
Combination Carrier	Fwd	200		200		1-M-3			
	Aft								
General Cargo	Fwd								
	Aft	10		10		1-M-4			
Tanker	Fwd								
	Aft	30		30		1-M-4			
General Cargo	Fwd	50		50		1-M-5			
	Aft	110		110					
Bulk Carrier	Fwd	243		243		1-M-6			
	Aft								
Container-ship	Fwd	354	16	370	4.3	1-M-6	2	14	
	Aft	109	1	110	0.9		1	7	
General Cargo	Fwd	480	20	500	4.0	1-M-6	1	11	
	Aft								
General Cargo	Fwd								
	Aft	220		220		1-M-7			
Tanker	Fwd	90		90					
						1-M-7			
	Aft	160		160					
Bulk Carrier	Fwd	24		24		1-M-8			
	Aft								
Combination Carrier	Fwd	148	2	150	1.3	1-M-8	2	13	
	Aft								
Tanker	Fwd								
	Aft	9	1	10	10.0	1-M-8	1	11	

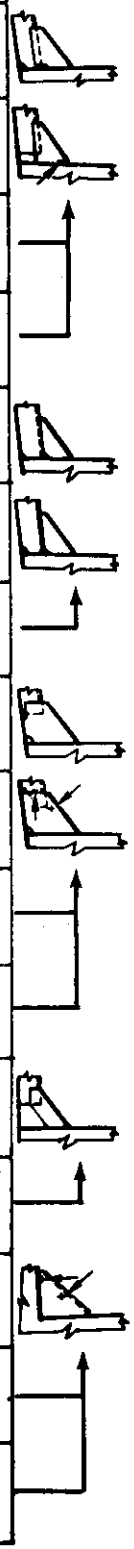
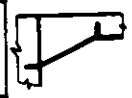
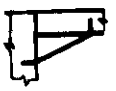


TABLE A-1 DETAIL FAMILY: BEAM BRACKETS

LOCATION ON SHIP / SHIP TYPE		No. of Sound Details Observed	No. of Failed Details Observed	Total Number Details Observed	Percent Failures	Detail Family Number	Failure Mode	Failure Cause	
Bulk Carrier	Fwd Aft	62	24	86	27.9	1-M-9	1	7	
Bulk Carrier	Fwd Aft	15	15	30	50.0	1-N-1	1	8	
Combination Carrier	Fwd Aft	90		90		1-N-1			
Container-ship	Fwd Aft	30		30		1-N-2			
Naval	Fwd Aft	10 30 10		10 30 10		1-N-3			
Naval	Fwd Aft	20 180 30		20 180 30		1-N-4			
Bulk Carrier	Fwd Aft	109	21	130	16.2	1-N-5	3,4	15	
Naval	Fwd Aft	50		50		1-N-6			
Naval	Fwd Aft	19	1	20	5.0	1-N-7	2	8,12	
Bulk Carrier	Fwd Aft	40		40		1-P-1			
Miscella-neous	Fwd Aft	10		10		1-P-1			
Tanker	Fwd Aft	181	39	220	17.7	1-P-1	1	6,8,14	
Combination Carrier	Fwd Aft	310		310		1-P-2			

NOTES:

(A) The above continued table gives information related to individual detail designs in the 86 ship survey.

(B) The rows labeled aft, ⊠ , and fwd refer to locations along the ship length. The mid-ship symbol row covers the mid-length throughout the entire cargo section.

(C) The numbers 1, 2, 3 & 4 in the column for failure mode refer to cracks, buckles, cracks and buckles, and twisted/distorted, respectively.

(D) Probable detail failure causes are estimated to be a combination of fatigue and the other factors indicated in the table by appropriate numbers as follows:

5. Shear
6. Tension
7. Combined Tension & Shear
8. Design
9. Fabrication/Workmanship
10. Welding
11. Neglect
12. Misuse/Abuse
13. Questionable
14. Heavy Seas
15. Collision
16. Other - See Discussion

TABLE A-1 DETAIL FAMILY: BEAM BRACKETS

LOCATION ON SHIP / SHIP TYPE		No. of Sound Details Observed	No. of Failed Details Observed	Total Number Details Observed	Percent Failures	Detail Family Number	Failure Mode	Failure Cause
Miscella-neous	Fwd Aft	50		50		1-P-3		
Bulk Carrier	Fwd Aft	24	6	30	20.0	1-P-4	3	15
Bulk Carrier	Fwd Aft	19		19		1-P-5		
Bulk Carrier	Fwd Aft	57	13	70	18.6	1-P-6	1,4	7,15
Bulk Carrier	Fwd Aft	155		155		1-P-7		
Bulk Carrier	Fwd Aft	4	8	12	66.7	1-P-8	1	8,11,14
Bulk Carrier	Fwd Aft	62		62		1-P-9		

TABLE A-2 DETAIL FAMILY: TRIPPING BRACKETS

LOCATION ON SHIP / SHIP TYPE		No. of Sound Details Observed	No. of Failed Details Observed	Total Number Details Observed	Percent Failures	Detail Family Number	Failure Mode	Failure Cause
Naval	Fwd Aft	10 20 20		10 20 20		2-A-1		
Container-ship	Fwd Aft	20 348 40		20 348 40		2-A-2		
General Cargo	Fwd Aft	10 100 40		10 100 40		2-A-2		
Tanker	Fwd Aft	20 160 30		20 160 30		2-A-2		
General Cargo	Fwd Aft	8	2	10	20.0	2-A-3	1	8,12

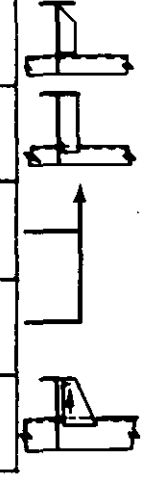
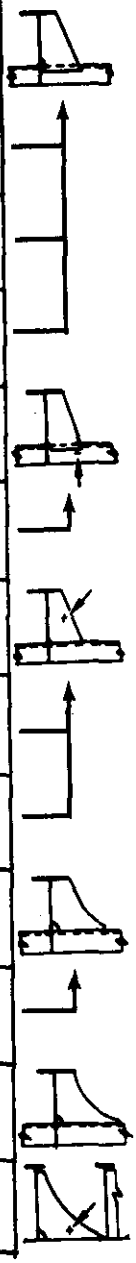


TABLE A-2 *DETAIL FAMILY: TRIPPING BRACKETS*

LOCATION ON SHIP / SHIP TYPE		No. of Sound Details Observed	No. of Failed Details Observed	Total Number Details Observed	Percent Failures	Detail Family Number	Failure Mode	Failure Cause
Combination Carrier	Fwd Aft	20 310 100		20 310 100		2-A-4		
Container-ship	Fwd Aft	30		30		2-A-4		
General Cargo	Fwd Aft	16		16		2-A-4		
Tanker	Fwd Aft	30		30		2-A-4		
Container-ship	Fwd Aft	28		28		2-A-5		
Tanker	Fwd Aft	145	5	150	3.3	2-A-5	1	8
Bulk Carrier	Fwd Aft	40 957 70	5	40 962 70	0.5	2-A-6	2	14
Combination Carrier	Fwd Aft	50		50		2-A-6		
Tanker	Fwd Aft	110 632 140	8	110 640 140	1.2	2-A-6	2	11
Bulk Carrier	Fwd Aft	198		198		2-A-7		
Tanker	Fwd Aft	80		80		2-A-7		
Container-ship	Fwd Aft	40 230 50		40 230 50		2-A-8		
Bulk Carrier	Fwd Aft	35	15	50	30.0	2-A-9	2	15



NOTES:

(A) The above continued table gives information related to individual detail designs in the 86 ship survey.

(B) The rows labeled aft, ⊠, and fwd refer to locations along the ship length. The mid-ship symbol row covers the mid-length throughout the entire cargo section.

(C) The numbers 1, 2, 3 & 4 in the column for failure mode refer to cracks, buckles, cracks and buckles, and twisted/distorted, respectively.

(D) Probable detail failure causes are estimated to be a combination of fatigue and the other factors indicated in the table by appropriate numbers as follows:

5. Shear
6. Tension
7. Combined Tension & Shear
8. Design
9. Fabrication/Workmanship
10. Welding
11. Neglect
12. Misuse/Abuse
13. Questionable
14. Heavy Seas
15. Collision
16. Other - See Discussio

TABLE A-2 DETAIL FAMILY: TRIPPING BRACKETS

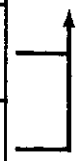
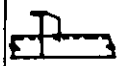
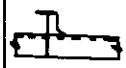
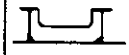
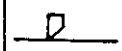
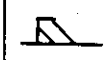
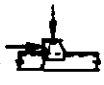
SHIP TYPE / LOCATION ON SHIP		No. of Sound Details Observed	No. of Failed Details Observed	Total Number Details Observed	Percent Failures	Detail Family Number	Failure Mode	Failure Cause	
Bulk Carrier	Fwd Aft	50	1	51	2.0	2-A-10	1	7,11	
Container-ship	Fwd Aft	10 200 40		10 200 40		2-A-10			
Tanker	Fwd Aft	10 260 20	10	10 270 20	3.7	2-A-10	1	6,10	
Container-ship	Fwd Aft	20 100 40		20 100 40		2-A-11			
Container-ship	Fwd Aft	40 370 80		40 370 80		2-A-12			
Naval	Fwd Aft	60 160 70		60 160 70		2-A-13			
Tanker	Fwd Aft	20 70 30		20 70 30		2-A-14			
Tanker	Fwd Aft	20 30		20 30		2-A-15			
Combination Carrier	Fwd Aft	30		30		2-A-16			
Bulk Carrier	Fwd Aft	140		140		2-A-17			
Combination Carrier	Fwd Aft	110		110		2-A-17			
General Cargo	Fwd Aft	20		20		2-A-17			
Tanker	Fwd Aft	40 80		40 80		2-A-17			
Combination Carrier	Fwd Aft	40		40		2-A-18			
Container-ship	Fwd Aft	12		12		2-A-19			
Tanker	Fwd Aft	110 1200 40		110 1200 40		2-A-19			

TABLE A-2 DETAIL FAMILY: TRIPPING BRACKETS

SHIP TYPE / LOCATION ON SHIP		No. of Sound Details Observed	No. of Failed Details Observed	Total Number Details Observed	Percent Failures	Detail Family Number	Failure Mode	Failure Cause	
Container-ship	Fwd	56	54	110	49.1	2-A-20	1,2,4	(8,11,14, 15)	
Tanker	Fwd	9	1	10	10.0	2-A-20	2	15	
Combination Carrier	Fwd	56	4	60	6.7	2-A-21	2	15	
Container-ship	Fwd Aft	80 150 40		80 150 40		2-A-22			
General Cargo	Fwd Aft	10 40 20		10 40 20		2-A-22			
Tanker	Fwd Aft	40 60		40 60		2-A-22			
Container-ship	Fwd Aft	30 20		30 20		2-A-23			
Miscella-neous	Fwd Aft	20		20		2-A-23			
Bulk Carrier	Fwd Aft	130		130		2-A-24			
Container-ship	Fwd Aft	140 1037 190	51	140 1088 190	4.7	2-A-24	1,2,4	8,14,15	
Tanker	Fwd Aft	30 30		30 30		2-A-24			
Tanker	Fwd Aft	10 50		10 50		2-A-25			
General Cargo	Fwd Aft	10 180 30		10 180 30		2-A-26			

NOTES:

(A) The above continued table gives information related to individual detail designs in the 86 ship survey.

(B) The rows labeled aft, ⊠, and fwd refer to locations along the ship length. The mid-ship symbol row covers the mid-length throughout the entire cargo section.

(C) The numbers 1, 2, 3 & 4 in the column for failure mode refer to cracks, buckles, cracks and buckles, and twisted/distorted, respectively.

(D) Probable detail failure causes are estimated to be a combination of fatigue and the other factors indicated in the table by appropriate numbers as follows:

5. Shear
6. Tension
7. Combined Tension & Shear
8. Design
9. Fabrication/Workmanship
10. Welding
11. Neglect
12. Misuse/Abuse
13. Questionable
14. Heavy Seas
15. Collision
16. Other - See Discussion

TABLE A-2 DETAIL FAMILY: TRIPPING BRACKETS

LOCATION ON SHIP / SHIP TYPE		No. of Sound Details Observed	No. of Failed Details Observed	Total Number Details Observed	Percent Failures	Detail Family Number	Failure Mode	Failure Cause
Tanker	Fwd Aft	106	4	110	3.6	2-A-26	1	6,10
Naval	Fwd Aft	10 30 20		10 30 20		2-A-27		
Tanker	Fwd Aft	49	1	50	2.0	2-A-27	1	13
Bulk Carrier	Fwd Aft	24		24		2-A-28		
General Cargo	Fwd Aft	10 70 20		10 70 20		2-A-28		
Naval	Fwd Aft	110 640 240		110 640 240		2-A-29		
Bulk Carrier	Fwd Aft	180	20	200	10.0	2-A-30	2	15
Bulk Carrier	Fwd Aft	12		12		2-A-31		
Bulk Carrier	Fwd Aft	51		51		2-A-32		
Bulk Carrier	Fwd Aft	24	1	25	4.0	2-A-33	2	8,14
Container-ship	Fwd Aft	378	4	382	1.0	2-A-33	2	14
Bulk Carrier	Fwd Aft	31	5	36	13.9	2-A-34	1	7,10
Bulk Carrier	Fwd Aft	10 40 10		10 40 10		2-B-1		
Combination Carrier	Fwd Aft	30 420 30		30 420 30		2-B-1		
Tanker	Fwd Aft	20 600 40		20 600 40		2-B-2		
Bulk Carrier	Fwd Aft	10 260 30		10 260 30		2-B-3		

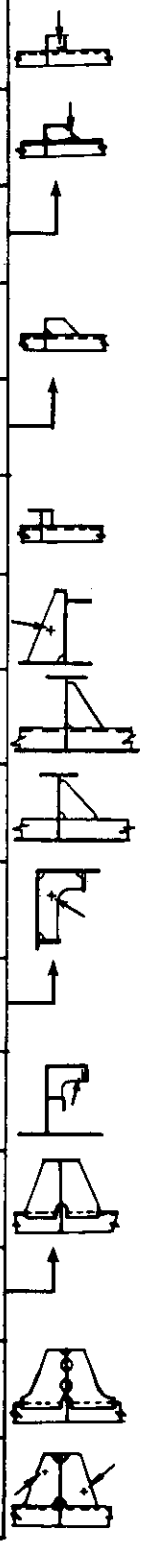


TABLE A-2 DETAIL FAMILY: TRIPPING BRACKETS

LOCATION ON SHIP / SHIP TYPE		No. of Sound Details Observed	No. of Failed Details Observed	Total Number Details Observed	Percent Failures	Detail Family Number	Failure Mode	Failure Cause
Combination Carrier	Fwd	40		40				
		476	4	480	.8	2-B-3	2	13,14
	Aft	70		70				
Tanker	Fwd	20		20				
		433	17	450	3.8	2-B-3	2	11,15
	Aft	40		40				
Container-ship	Fwd	20		20				
		200		200		2-B-4		
	Aft	50		50				
Miscella-neous	Fwd	10		10				
		70		70		2-B-4		
	Aft	10		10				
Tanker	Fwd	20		20				
						2-B-4		
	Aft	30		30				
Naval	Fwd	60		60				
		310		310		2-B-5		
	Aft	149	1	150	.7		2	13
Naval	Fwd							
		120		120		2-B-6		
	Aft							
Container-ship	Fwd							
		40		40		2-B-7		
	Aft							
Combination Carrier	Fwd	30		30				
		100		100		2-B-8		
	Aft	90		90				
Miscella-neous	Fwd							
		20		20		2-B-8		
	Aft							
Combination Carrier	Fwd	20		20				
		390		390		2-B-9		
	Aft	110		110				
Combination Carrier	Fwd	20		20				
		180		180		2-B-10		
	Aft	60		60				
Naval	Fwd	40		40				
		230		230		2-B-10		
	Aft	90		90				

NOTES:

(A) The above continued table gives information related to individual detail designs in the 86 ship survey.

(B) The rows labeled aft, ⊠, and fwd refer to locations along the ship length. The mid-ship symbol row covers the mid-length throughout the entire cargo section.

(C) The numbers 1, 2, 3 & 4 in the column for failure mode refer to cracks, buckles, cracks and buckles, and twisted/distorted, respectively.

(D) Probable detail failure causes are estimated to be a combination of fatigue and the other factors indicated in the table by appropriate numbers as follows:

5. Shear
6. Tension
7. Combined Tension & Shear
8. Design
9. Fabrication/Workmanship
10. Welding
11. Neglect
12. Misuse/Abuse
13. Questionable
14. Heavy Seas
15. Collision
16. Other - See Discussion

TABLE A-2 DETAIL FAMILY: TRIPPING BRACKETS

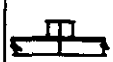
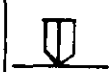
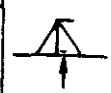
LOCATION ON SHIP / SHIP TYPE		No. of Sound Details Observed	No. of Failed Details Observed	Total Number Details Observed	Percent Failures	Detail Family Number	Failure Mode	Failure Cause	
Tanker	Fwd Aft	10 170 20		10 170 20		2-B-11			
Bulk Carrier	Fwd Aft	30 30		30 30		2-B-12			
Naval	Fwd Aft	10 30 20		10 30 20		2-B-12			
Tanker	Fwd Aft	821 50	29	850 50	3.4	2-B-12	1	8,13	
Tanker	Fwd Aft	50		50		2-B-13			
Container-ship	Fwd Aft	20		20		2-B-14			
Tanker	Fwd Aft	99 20 40	1	100 20 40	1.0	2-B-15	1	15	
Naval	Fwd Aft	20 140 50		20 140 50		2-B-16			
Container-ship	Fwd Aft	114 10		114 10		2-B-17			
Container-ship	Fwd Aft	60	2	62	3.2	2-B-18	1	8,14	
Container-ship	Fwd Aft	10 99 20	1	10 100 20	1.7	2-B-19	1	13	
Container-ship	Fwd Aft	30		30		2-C-1			
Tanker	Fwd Aft	360		360		2-C-1			
Tanker	Fwd Aft	30	10	40	25.0	2-C-2	1	8	
Container-ship	Fwd Aft	20		20		2-C-3			
Bulk Carrier	Fwd Aft	65		65		2-C-4			

TABLE A-2 DETAIL FAMILY: TRIPPING BRACKETS

LOCATION ON SHIP / SHIP TYPE		No. of Sound Details Observed	No. of Failed Details Observed	Total Number Details Observed	Percent Failures	Detail Family Number	Failure Mode	Failure Cause
Combination Carrier	Fwd ⊠ Aft	69	1	70	1.4	2-C-4	1	14
Container-ship	Fwd ⊠ Aft	1005	72	1077	6.7	2-C-4	1	(7,10,11, 14)
General Cargo	Fwd ⊠ Aft	448	12	460	2.6	2-C-4	1,4	(10,11, 14,15)
Container-ship	Fwd ⊠ Aft	329	3	332	0.9	2-C-5	1	14,15
Bulk Carrier	Fwd ⊠ Aft	164	6	170	3.5	2-C-6	1,4	7,15
Container-ship	Fwd ⊠ Aft	148	14	162	8.6	2-C-6	1	8,10
Tanker	Fwd ⊠ Aft	18	2	20	10.0	2-C-6	2	12
Bulk Carrier	Fwd ⊠ Aft	1606	83	1689	4.9	2-C-7	1	(7,8,10, 14)
Container-ship	Fwd ⊠ Aft	1045	146	1191	12.3	2-C-7	1,4	(7,10, 11,14)
Bulk Carrier	Fwd ⊠ Aft	75	1	76	1.3	2-C-8	1	7,14
Container-ship	Fwd ⊠ Aft	956	92	1048	8.8	2-C-8	1,4	(8,10, 14,15)
General Cargo	Fwd ⊠ Aft	63	1	64	1.6	2-C-8	4	15
Bulk Carrier	Fwd ⊠ Aft	74		74		2-C-9		

NOTES:

(A) The above continued table gives information related to individual detail designs in the 86 ship survey.

(B) The rows labeled aft, ⊠, and fwd refer to locations along the ship length. The mid-ship symbol row covers the mid-length throughout the entire cargo section.

(C) The numbers 1, 2, 3 & 4 in the column for failure mode refer to cracks, buckles, cracks and buckles, and twisted/distorted, respectively.

(D) Probable detail failure causes are estimated to be a combination of fatigue and the other factors indicated in the table by appropriate numbers as follows:

5. Shear
6. Tension
7. Combined Tension & Shear
8. Design
9. Fabrication/Workmanship
10. Welding
11. Neglect
12. Misuse/Abuse
13. Questionable
14. Heavy Seas
15. Collision
16. Other - See Discussion

TABLE A-2 DETAIL FAMILY: TRIPPING BRACKETS

LOCATION ON SHIP / SHIP TYPE		No. of Sound Details Observed	No. of Failed Details Observed	Total Number Details Observed	Percent Failures	Detail Family Number	Failure Mode	Failure Cause
Container-ship	Fwd Aft	169	1	170	0.6	2-C-9	1	14
General Cargo	Fwd Aft	4		4		2-C-9		
Bulk Carrier	Fwd Aft	60		60		2-C-10		
General Cargo	Fwd Aft	1116	196	1312	14.9	2-C-11	1,4	(9,11, 15,16)
Container-ship	Fwd Aft	103	5	108	4.6	2-C-12	1	14
General Cargo	Fwd Aft	37	3	40	7.5	2-C-12	1	11
General Cargo	Fwd Aft	40	60	100	60.0	2-C-13	1	12
Bulk Carrier	Fwd Aft	16		16		2-C-14		
General Cargo	Fwd Aft	61	9	70	12.9	2-C-14	1	11
Naval	Fwd Aft	10 30 10		10 30 10		2-C-15		
Naval	Fwd Aft	160 800 310		160 800 310		2-C-16		
Naval	Fwd Aft	10 10 10		10 10 10		2-C-17		
Naval	Fwd Aft	10 20 10		10 20 10		2-C-18		
Container-ship	Fwd Aft	175	12	187	6.4	2-C-19	1	(7,10, 11,16)
General Cargo	Fwd Aft	1249	318	1567	20.3	2-C-19	1,4	(7,12, 15,16)
Container-ship	Fwd Aft	118	60	178	33.7	2-C-20	1,2,4	10,11,15

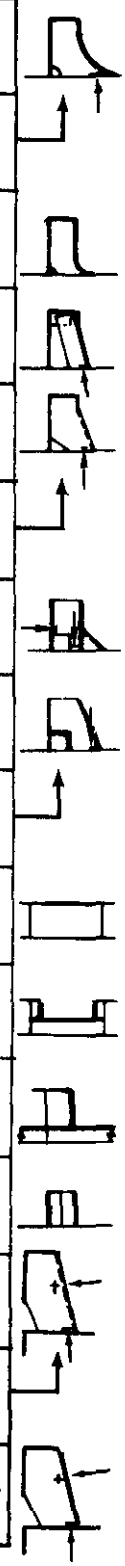
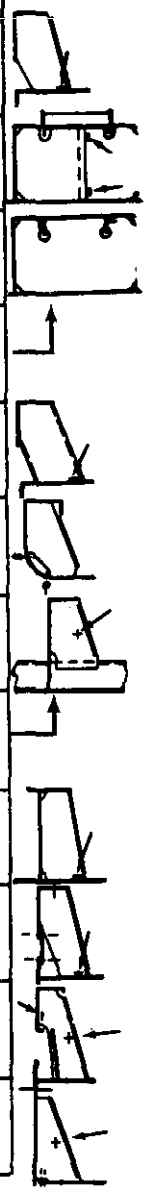


TABLE A-2 DETAIL FAMILY: TRIPPING BRACKETS

LOCATION ON SHIP / SHIP TYPE		No. of Sound Details Observed	No. of Failed Details Observed	Total Number Details Observed	Percent Failures	Detail Family Number	Failure Mode	Failure Cause
General Cargo	Fwd Aft	562	38	600	6.3	2-C-20	1,4	(11,12, 15,16)
Container-ship	Fwd Aft	78	11	89	12.4	2-C-21	1	11,15
Bulk Carrier	Fwd Aft	75	1	76	1.3	2-C-22	1	7,11
Container-ship	Fwd Aft	100	5	105	4.8	2-C-22	1	7,11
General Cargo	Fwd Aft	43	9	52	17.3	2-C-23	1	7,8,16
Bulk Carrier	Fwd Aft	228		228		2-C-24		
Container-ship	Fwd Aft	627	69	696	9.9	2-C-25	2,4	14,15
General Cargo	Fwd Aft	50		50		2-C-25		
General Cargo	Fwd Aft	99	30	129	23.2	2-C-26	1,4	(10,11, 14,15)
General Cargo	Fwd Aft	68	50	118	42.4	2-C-27	1	7,8,14
Container-ship	Fwd Aft	222	18	240	7.5	2-C-28	3,4	12,15
General Cargo	Fwd Aft	107	3	110	2.7	2-C-29	4	15



NOTES:

(A) The above continued table gives information related to individual detail designs in the 86 ship survey.

(B) The rows labeled aft, ⊠ , and fwd refer to locations along the ship length. The mid-ship symbol row covers the mid-length throughout the entire cargo section.

(C) The numbers 1, 2, 3 & 4 in the column for failure mode refer to cracks, buckles, cracks and buckles, and twisted/distorted, respectively.

(D) Probable detail failure causes are estimated to be a combination of fatigue and the other factors indicated in the table by appropriate numbers as follows:

5. Shear
6. Tension
7. Combined Tension & Shear
8. Design
9. Fabrication/Workmanship
10. Welding
11. Neglect
12. Misuse/Abuse
13. Questionable
14. Heavy Seas
15. Collision
16. Other - See Discussion

TABLE A-3 DETAIL FAMILY: NON-TIGHT COLLARS

LOCATION ON SHIP / SHIP TYPE		No. of Sound Details Observed	No. of Failed Details Observed	Total Number Details Observed	Percent Failures	Detail Family Number	Failure Mode	Failure Cause
Combination Carrier	Fwd	130		130		3-A-1		
		1200		1200				
	Aft	180		180				
Bulk Carrier	Fwd	50		50		3-A-2		
		260		260				
	Aft	70		70				
Container-ship	Fwd	10		10		3-A-2		
		100		100				
	Aft	50		50				
General Cargo	Fwd					3-A-2		
		68		68				
	Aft							
Tanker	Fwd	20		20		3-A-2		
		90		90				
	Aft	40		40				
Container-ship	Fwd					3-A-3		
		212		212				
	Aft	30		30				
General Cargo	Fwd					3-A-3		
		204		204				
	Aft							
Tanker	Fwd	25	5	30	16.7	3-A-3	2	15
		110		110				
	Aft							
Container-ship	Fwd	20		20		3-A-4		
		200		200				
	Aft	50		50				
Bulk Carrier	Fwd					3-A-5		
		207		207				
	Aft							
Container-ship	Fwd	90		90		3-A-5		
		1700		1700				
	Aft	120		120				
Bulk Carrier	Fwd	10		10		3-A-6		
	Aft	10		10				
Container-ship	Fwd	10		10		3-A-6		
		110		110				
	Aft	30		30				
Container-ship	Fwd	30		30		3-A-7		
		488		488				
	Aft	50		50				
Bulk Carrier	Fwd					3-A-8		
		41		41				
	Aft							
Tanker	Fwd					3-A-8		
	Aft	40		40				

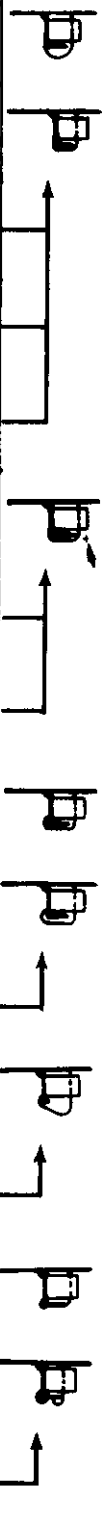


TABLE A-3 DETAIL FAMILY: NON-TIGHT COLLARS

LOCATION ON SHIP / SHIP TYPE		No. of Sound Details Observed	No. of Failed Details Observed	Total Number Details Observed	Percent Failures	Detail Family Number	Failure Mode	Failure Cause
Bulk Carrier	Fwd Aft	60		60		3-A-9		
Container-ship	Fwd Aft	40		40		3-A-10		
General Cargo	Fwd Aft	10 10		10 10		3-A-11		
Naval	Fwd Aft	160 1200 320		160 1200 320		3-A-11		
Tanker	Fwd Aft	10 30		10 30		3-A-11		
Container-ship	Fwd Aft	40 200 50		40 200 50		3-A-12		
Naval	Fwd Aft	20 100 40		20 100 40		3-A-12		
Naval	Fwd Aft	20 100 40		20 100 40		3-A-13		
Container-ship	Fwd Aft	70		70		3-A-14		
General Cargo	Fwd Aft	58	2	60	3.3	3-A-15	1	9
Bulk Carrier	Fwd Aft	66	2	68	2.9	3-A-16	1	10
Container-ship	Fwd Aft	30		30		3-A-16		
Container-ship	Fwd Aft	58	2	60	3.3	3-A-17	1	9

NOTES:

(A) The above continued table gives information related to individual detail designs in the 86 ship survey.

(B) The rows labeled aft, ⊠, and fwd refer to locations along the ship length. The mid-ship symbol row covers the mid-length throughout the entire cargo section.

(C) The numbers 1, 2, 3 & 4 in the column for failure mode refer to cracks, buckles, cracks and buckles, and twisted/distorted, respectively.

(D) Probable detail failure causes are estimated to be a combination of fatigue and the other factors indicated in the table by appropriate numbers as follows:

5. Shear
6. Tension
7. Combined Tension & Shear
8. Design
9. Fabrication/Workmanship
10. Welding
11. Neglect
12. Misuse/Abuse
13. Questionable
14. Heavy Seas
15. Collision
16. Other - See Discussion

TABLE A-3 DETAIL FAMILY: NON-TIGHT COLLARS

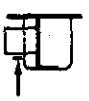
LOCATION ON SHIP / SHIP TYPE		No. of Sound Details Observed	No. of Failed Details Observed	Total Number Details Observed	Percent Failures	Detail Family Number	Failure Mode	Failure Cause	
General Cargo	Fwd Aft	68	2	70	2.9	3-A-17	1	9	
Bulk Carrier	Fwd Aft	228		228		3-A-18			
Container-ship	Fwd Aft	34		34		3-A-18			
Bulk Carrier	Fwd Aft	103		103		3-A-19			
Container-ship	Fwd Aft	84		84		3-A-20			
Bulk Carrier	Fwd Aft	47		47		3-A-21			
Bulk Carrier	Fwd Aft	120		120		3-A-22			
Container-ship	Fwd Aft	104		104		3-A-23			
Container-ship	Fwd Aft	104		104		3-A-24			
Container-ship	Fwd Aft	261	3	264	1.1	3-A-25	1	9,10	
Bulk Carrier	Fwd Aft	90 1340 300		90 1340 300		3-B-1			
Combination Carrier	Fwd Aft	140 1200 380		140 1200 380		3-B-1			
General Cargo	Fwd Aft	40		40		3-B-2			
Tanker	Fwd Aft	110		110		3-B-3			
Tanker	Fwd Aft	20 40		20 40		3-B-4			
Tanker	Fwd Aft	160 1200 400		160 1200 400		3-B-5			

TABLE A-3 DETAIL FAMILY: NON-TIGHT COLLARS

LOCATION ON SHIP / SHIP TYPE		No. of Sound Details Observed	No. of Failed Details Observed	Total Number Details Observed	Percent Failures	Detail Family Number	Failure Mode	Failure Cause
Bulk Carrier	Fwd	30		30		3-B-6		
	⊠	260		260				
	Aft	90		90				
Bulk Carrier	Fwd ⊠ Aft	200		200		3-B-7		
Container-ship	Fwd ⊠ Aft	103		103		3-B-7		
Bulk Carrier	Fwd ⊠ Aft	500		500		3-B-8		
Tanker	Fwd ⊠ Aft	80		80		3-C-1		
Bulk Carrier	Fwd ⊠ Aft	96		96		3-C-2		
Combination Carrier	Fwd ⊠ Aft	110		110		3-C-2		
Container-ship	Fwd ⊠ Aft	28		28		3-C-2		
Bulk Carrier	Fwd	180		180				
	⊠	990		990		3-C-3		
	Aft	302	8	310	2.6		1	13
Miscella-neous	Fwd ⊠ Aft	20 / 20		20 / 20		3-C-4		
Naval	Fwd	80		80				
	⊠ Aft	300		300		3-C-5		
Naval	Fwd	160		160				
	⊠	700		700		3-C-6		
	Aft	320		320				
Container-ship	Fwd ⊠ Aft	50		50		3-C-7		

NOTES:

(A) The above continued table gives information related to individual detail designs in the 86 ship survey.

(B) The rows labeled aft, ⊠, and fwd refer to locations along the ship length. The mid-ship symbol row covers the mid-length throughout the entire cargo section.

(C) The numbers 1, 2, 3 & 4 in the column for failure mode refer to cracks, buckles, cracks and buckles, and twisted/distorted, respectively.

(D) Probable detail failure causes are estimated to be a combination of fatigue and the other factors indicated in the table by appropriate numbers as follows:

5. Shear
6. Tension
7. Combined Tension & Shear
8. Design
9. Fabrication/Workmanship
10. Welding
11. Neglect
12. Misuse/Abuse
13. Questionable
14. Heavy Seas
15. Collision
16. Other - See Discussion

TABLE A-3 DETAIL FAMILY: NON-TIGHT COLLARS

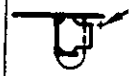
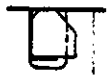
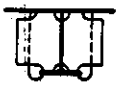
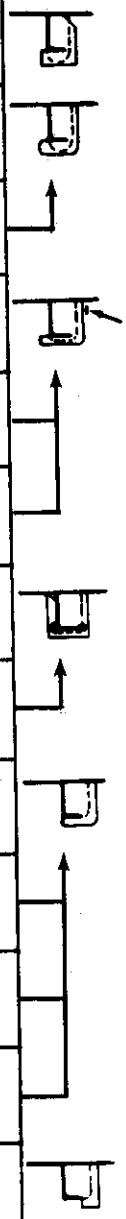
LOCATION ON SHIP / SHIP TYPE		No. of Sound Details Observed	No. of Failed Details Observed	Total Number Details Observed	Percent Failures	Detail Family Number	Failure Mode	Failure Cause	
General Cargo	Fwd Aft	30		30		3-C-7			
Naval	Fwd Aft	30 150 60		30 150 60		3-C-8			
Naval	Fwd Aft	20 70 20		20 70 20		3-C-9			
Bulk Carrier	Fwd Aft	80		80		3-C-10			
General Cargo	Fwd Aft	56	4	60	6.7	3-C-10	1	9	
Container-ship	Fwd Aft	18	2	20	10.0	3-C-11	1	9	
Miscella-neous	Fwd Aft	57 140 50	3	60 140 50	5.0	3-C-12	2	15	
Bulk Carrier	Fwd Aft	21		21		3-C-13			
General Cargo	Fwd Aft	76		76		3-C-14			
Bulk Carrier	Fwd Aft	24		24		3-C-15			
Container-ship	Fwd Aft	60		60		3-C-16			

TABLE A-4 DETAIL FAMILY: TIGHT COLLARS

LOCATION ON SHIP / SHIP TYPE		No. of Sound Details Observed	No. of Failed Details Observed	Total Number Details Observed	Percent Failures	Detail Family Number	Failure Mode	Failure Cause	
Bulk Carrier	Fwd Aft	30 304 90		30 304 90		4-A-1			

TABLE A-4 DETAIL FAMILY: TIGHT COLLARS

SHIP TYPE	LOCATION ON SHIP	No. of Sound Details Observed	No. of Failed Details Observed	Total Number Details Observed	Percent Failures	Detail Family Number	Failure Mode	Failure Cause
Combination Carrier	Fwd	210		210		4-A-1		
	⊠	1100		1100				
	Aft	290		290				
Bulk Carrier	Fwd					4-A-2		
	⊠	19		19				
	Aft							
Combination Carrier	Fwd	30		30		4-A-2		
	⊠	220		220				
	Aft	70		70				
Bulk Carrier	Fwd					4-A-3		
	⊠	56		56				
	Aft							
Combination Carrier	Fwd	40		40		4-A-3		
	⊠	300		300				
	Aft	90		90				
General Cargo	Fwd					4-A-3		
	⊠	50	5	55	9.1		1	11
	Aft							
General Cargo	Fwd					4-A-4		
	⊠	24		24				
	Aft							
Tanker	Fwd	80		80		4-A-4		
	⊠							
	Aft							
Bulk Carrier	Fwd					4-A-5		
	⊠	21		21				
	Aft							
Container-ship	Fwd	10		10		4-A-5		
	⊠							
	Aft	120		120				
General Cargo	Fwd					4-A-5		
	⊠	24		24				
	Aft							
Tanker	Fwd	20		20		4-A-5		
	⊠	200		200				
	Aft	50		50				
Bulk Carrier	Fwd	60		60		4-A-6		
	⊠	445		445				
	Aft	90		90				



NOTES:

(A) The above continued table gives information related to individual detail designs in the 86 ship survey.

(B) The rows labeled aft, ⊠, and fwd refer to locations along the ship length. The mid-ship symbol row covers the mid-length throughout the entire cargo section.

(C) The numbers 1, 2, 3 & 4 in the column for failure mode refer to cracks, buckles, cracks and buckles, and twisted/distorted, respectively.

(D) Probable detail failure causes are estimated to be a combination of fatigue and the other factors indicated in the table by appropriate numbers as follows:

5. Shear
6. Tension
7. Combined Tension & Shear
8. Design
9. Fabrication/Workmanship
10. Welding
11. Neglect
12. Misuse/Abuse
13. Questionable
14. Heavy Seas
15. Collision
16. Other - See Discussion

TABLE A-4 DETAIL FAMILY: TIGHT COLLARS

LOCATION ON SHIP / SHIP TYPE		No. of Sound Details Observed	No. of Failed Details Observed	Total Number Details Observed	Percent Failures	Detail Family Number	Failure Mode	Failure Cause
Combination Carrier	Fwd Aft	50 210 120		50 210 120		4-A-6		
Container-ship	Fwd Aft	20 80		20 80		4-A-6		
General Cargo	Fwd Aft	20 594 50	40	20 634 50	6.3	4-A-6	3,4	11,15
Miscella-neous	Fwd Aft	40 180 80		40 180 80		4-A-6		
Tanker	Fwd Aft	90 100		90 100		4-A-6		
Bulk Carrier	Fwd Aft	100		100		4-A-7		
Container-ship	Fwd Aft	90		90		4-A-7		
Combination Carrier	Fwd Aft	40 210 60		40 210 60		4-A-8		
Bulk Carrier	Fwd Aft	64		64		4-A-9		
Combination Carrier	Fwd Aft	130		130		4-A-9		
General Cargo	Fwd Aft	30 34		30 34		4-A-9		
Tanker	Fwd Aft	30		30		4-A-10		
Bulk Carrier	Fwd Aft	28		28		4-A-11		
Container-ship	Fwd Aft	90 841 170		90 841 170		4-A-11		
General Cargo	Fwd Aft	313		313		4-A-11		
Bulk Carrier	Fwd Aft	11		11		4-A-12		

TABLE A-4 DETAIL FAMILY: TIGHT COLLARS

LOCATION ON SHIP / SHIP TYPE		No. of Sound Details Observed	No. of Failed Details Observed	Total Number Details Observed	Percent Failures	Detail Family Number	Failure Mode	Failure Cause
Container-ship	Fwd Aft	128		128		4-A-12		
General Cargo	Fwd Aft	30 396 80		30 396 80		4-A-12		
Container-ship	Fwd Aft	30 250 60		30 250 60		4-A-13		
General Cargo	Fwd Aft	34		34		4-A-13		
Tanker	Fwd Aft	20 30		20 30		4-A-13		
Tanker	Fwd Aft	20 30		20 30		4-A-14		
Combination Carrier	Fwd Aft	10 40		10 40		4-B-1		
Container-ship	Fwd Aft	20		20		4-B-1		
Bulk Carrier	Fwd Aft	50		50		4-B-2		
Container-ship	Fwd Aft	20 373 10		20 373 10		4-B-2		
Container-ship	Fwd Aft	50 200 80		50 200 80		4-B-3		
General Cargo	Fwd Aft	115		115		4-B-3		
Naval	Fwd Aft	300 1200 600		300 1200 600		4-B-3		

NOTES:

(A) The above continued table gives information related to individual detail designs in the 86 ship survey.

(B) The rows labeled aft, ⊠, and fwd refer to locations along the ship length. The mid-ship symbol row covers the mid-length throughout the entire cargo section.

(C) The numbers 1, 2, 3 & 4 in the column for failure mode refer to cracks, buckles, cracks and buckles, and twisted/distorted, respectively.

(D) Probable detail failure causes are estimated to be a combination of fatigue and the other factors indicated in the table by appropriate numbers as follows:

5. Shear
6. Tension
7. Combined Tension & Shear
8. Design
9. Fabrication/Workmanship
10. Welding
11. Neglect
12. Misuse/Abuse
13. Questionable
14. Heavy Seas
15. Collision
16. Other - See Discussi

TABLE A-4 DETAIL FAMILY: TIGHT COLLARS

LOCATION ON SHIP / SHIP TYPE		No. of Sound Details Observed	No. of Failed Details Observed	Total Number Details Observed	Percent Failures	Detail Family Number	Failure Mode	Failure Cause
Naval	Fwd Aft	20 100 30		20 100 30		4-B-4		
Naval	Fwd Aft	60 300 100		60 300 100		4-B-5		
Naval	Fwd Aft	30		30		4-B-6		
Naval	Fwd Aft	60 300 100		60 300 100		4-B-7		
Naval	Fwd Aft	20		20		4-B-8		
Bulk Carrier	Fwd Aft	18		18		4-C-1		
Container-ship	Fwd Aft	112	1	113	0.9	4-C-1	2	13,16
General Cargo	Fwd Aft	10 40 30		10 40 30		4-C-1		
Container-ship	Fwd Aft	100		100		4-C-2		
Container-ship	Fwd Aft	120		120		4-C-3		
Tanker	Fwd Aft	40		40		4-C-4		
Tanker	Fwd Aft	40		40		4-C-5		
Bulk Carrier	Fwd Aft	10 300 50		10 300 50		4-C-6		
Bulk Carrier	Fwd Aft	62		62		4-C-7		
Bulk Carrier	Fwd Aft	192		192		4-D-1		
Tanker	Fwd Aft	50 1000 180		50 1000 180		4-D-1		

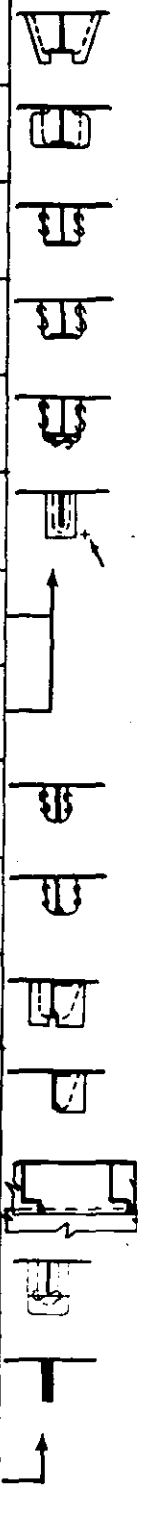
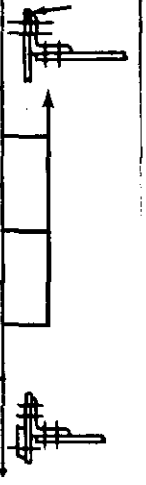


TABLE A-4 DETAIL FAMILY: TIGHT COLLARS

LOCATION ON SHIP / SHIP TYPE		No. of Sound Details Observed	No. of Failed Details Observed	Total Number Details Observed	Percent Failures	Detail Family Number	Failure Mode	Failure Cause
Miscella-neous	Fwd Aft	200		200		4-D-2		
Tanker	Fwd Aft	20 2900 240		20 2900 240		4-D-2		
Container-ship	Fwd Aft	500		500		4-D-3		
Tanker	Fwd Aft	1100 80		1100 80		4-D-4		

TABLE A-5 DETAIL FAMILY: GUNWALE CONNECTIONS

LOCATION ON SHIP / SHIP TYPE		No. of Sound Details Observed	No. of Failed Details Observed	Total Number Details Observed	Percent Failures	Detail Family Number	Failure Mode	Failure Cause
Bulk Carrier	Fwd Aft	6		6		5-A-1		
Container-ship	Fwd Aft	5	1	6	16.7	5-A-1	2	15,16
General Cargo	Fwd Aft	14		14		5-A-1		
Tanker	Fwd Aft	10		10		5-A-1		
Container-ship	Fwd Aft	2		2		5-A-2		



NOTES:

(A) The above continued table gives information related to individual detail designs in the 86 ship survey.

(B) The rows labeled aft, ⊠, and fwd refer to locations along the ship length. The mid-ship symbol row covers the mid-length throughout the entire cargo section.

(C) The numbers 1, 2, 3 & 4 in the column for failure mode refer to cracks, buckles, cracks and buckles, and twisted/distorted, respectively.

(D) Probable detail failure causes are estimated to be a combination of fatigue and the other factors indicated in the table by appropriate numbers as follows:

5. Shear
6. Tension
7. Combined Tension & Shear
8. Design
9. Fabrication/Workmanship
10. Welding
11. Neglect
12. Misuse/Abuse
13. Questionable
14. Heavy Seas
15. Collision
16. Other - See Discussion

TABLE A-5 DETAIL FAMILY: GUNWALE CONNECTIONS

LOCATION ON SHIP / SHIP TYPE		No. of Sound Details Observed	No. of Failed Details Observed	Total Number Details Observed	Percent Failures	Detail Family Number	Failure Mode	Failure Cause
Container-ship	Fwd Aft	4		4		5-A-3		
General Cargo	Fwd Aft	2		2		5-A-3		
Container-ship	Fwd Aft	2		2		5-A-4		
Naval	Fwd Aft	6		6		5-A-5		
General Cargo	Fwd Aft	4		4		5-A-6		
Bulk Carrier	Fwd Aft	4		4		5-A-7		
Combination Carrier	Fwd Aft	4		4		5-A-7		
General Cargo	Fwd Aft	6		6		5-A-7		
Miscella-neous	Fwd Aft	2		2		5-A-7		
Tanker	Fwd Aft	6	2	8	25.0	5-A-7	2	12,15
Bulk Carrier	Fwd Aft	4		4		5-A-8		
Combination Carrier	Fwd Aft	2		2		5-A-9		
General Cargo	Fwd Aft	4		4		5-A-9		
Tanker	Fwd Aft	2		2		5-A-9		
General Cargo	Fwd Aft	2		2		5-A-10		
Naval	Fwd Aft	2		2		5-A-11		

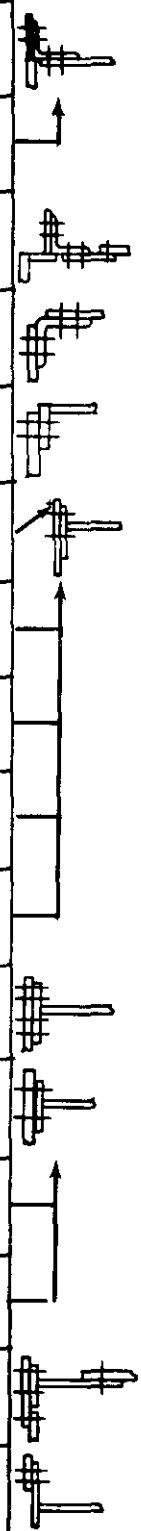
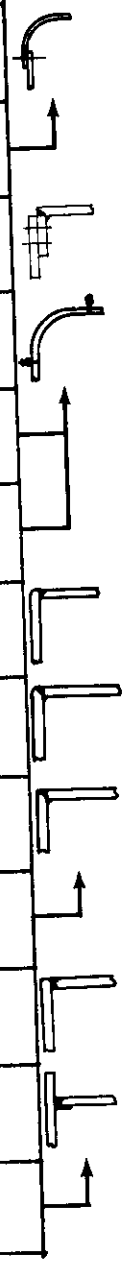


TABLE A-5 DETAIL FAMILY: GUNWALE CONNECTIONS

LOCATION ON SHIP / SHIP TYPE		No. of Sound Details Observed	No. of Failed Details Observed	Total Number Details Observed	Percent Failures	Detail Family Number	Failure Mode	Failure Cause
Bulk Carrier	Fwd Aft	2		2		5-A-12		
Naval	Fwd Aft	2		2		5-A-12		
Bulk Carrier	Fwd Aft	2		2		5-A-13		
Bulk Carrier	Fwd Aft	10		10		5-B-1		
Combination Carrier	Fwd Aft	4		4		5-B-1		
Tanker	Fwd Aft	4		4		5-B-1		
Naval	Fwd Aft	4		4		5-B-2		
General Cargo	Fwd Aft	2		2		5-B-3		
Container-ship	Fwd Aft	4		4		5-B-4		
Naval	Fwd Aft	2		2		5-B-4		
Container-ship	Fwd Aft	10		10		5-B-5		
Container-ship	Fwd Aft	2		2		5-B-6		
Naval	Fwd Aft	2		2		5-B-6		



NOTES:

(A) The above continued table gives information related to individual detail designs in the 86 ship survey.

(B) The rows labeled aft, ⊠, and fwd refer to locations along the ship length. The mid-ship symbol row covers the mid-length throughout the entire cargo section.

(C) The numbers 1, 2, 3 & 4 in the column for failure mode refer to cracks, buckles, cracks and buckles, and twisted/distorted, respectively.

(D) Probable detail failure causes are estimated to be a combination of fatigue and the other factors indicated in the table by appropriate numbers as follows:

5. Shear
6. Tension
7. Combined Tension & Shear
8. Design
9. Fabrication/Workmanship
10. Welding
11. Neglect
12. Misuse/Abuse
13. Questionable
14. Heavy Seas
15. Collision
16. Other - See Discussion

TABLE A-5 DETAIL FAMILY: GUNWALE CONNECTIONS

LOCATION ON SHIP / SHIP TYPE		No. of Sound Details Observed	No. of Failed Details Observed	Total Number Details Observed	Percent Failures	Detail Family Number	Failure Mode	Failure Cause
Container-ship	Fwd Aft	2		2		5-B-7		
Bulk Carrier	Fwd Aft	4		4		5-B-8		
Container-ship	Fwd Aft	16		16		5-B-8		
Miscella-neous	Fwd Aft	0	2	2	100.0	5-B-8	2	12,15
Tanker	Fwd Aft	2		2		5-B-8		

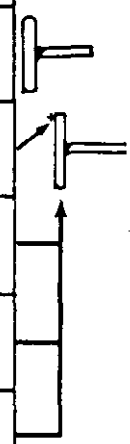
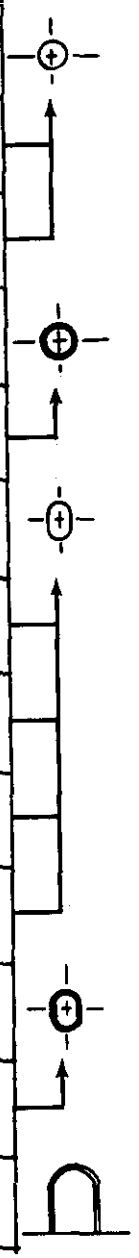


TABLE A-6 DETAIL FAMILY: KNIFE EDGES

LOCATION ON SHIP / SHIP TYPE		No. of Sound Details Observed	No. of Failed Details Observed	Total Number Details Observed	Percent Failures	Detail Family Number	Failure Mode	Failure Cause
Bulk Carrier	Fwd Aft							
Combination Carrier	Fwd Aft							
Container-ship	Fwd Aft		NO KNIFE EDGE CROSSINGS OBSERVED IN THE SURVEY					
General Cargo	Fwd Aft							
Miscella-neous	Fwd Aft							
Naval	Fwd Aft							
Tanker	Fwd Aft							

TABLE A-7 DETAIL FAMILY: MISCELLANEOUS CUTOUTS

LOCATION ON SHIP / SHIP TYPE		No. of Sound Details Observed	No. of Failed Details Observed	Total Number Details Observed	Percent Failures	Detail Family Number	Failure Mode	Failure Cause
Bulk Carrier	Fwd	10		10		7-A-1		
	⊗	95		95				
	Aft	10		10				
Container-ship	Fwd	50		50		7-A-1		
	⊗	60		60				
	Aft	20		20				
Tanker	Fwd	10		10		7-A-1		
	⊗	40		40				
	Aft	10		10				
Bulk Carrier	Fwd					7-A-2		
	⊗	18		18				
	Aft							
Naval	Fwd	30		30		7-A-2		
	⊗	90		90				
	Aft	60		60				
Bulk Carrier	Fwd	20		20		7-A-3		
	⊗	143		143				
	Aft	30		30				
Container-ship	Fwd	90		90		7-A-3		
	⊗	933		933				
	Aft	90		90				
General Cargo	Fwd					7-A-3		
	⊗	45		45				
	Aft							
Naval	Fwd	60		60		7-A-3		
	⊗	450		450				
	Aft	100		100				
Tanker	Fwd	10		10		7-A-3		
	⊗	120		120				
	Aft	20		20				
Combination Carrier	Fwd	20		20		7-A-4		
	⊗	70		70				
	Aft	30		30				
Container-ship	Fwd	10		10		7-A-4		
	⊗	65		65				
	Aft	10		10				
Bulk Carrier	Fwd	10		10		7-A-5		
	⊗							
	Aft	10		10				



NOTES:

(A) The above continued table gives information related to individual detail designs in the 86 ship survey.

(B) The rows labeled aft, ⊗, and fwd refer to locations along the ship length. The mid-ship symbol row covers the mid-length throughout the entire cargo section.

(C) The numbers 1, 2, 3 & 4 in the column for failure mode refer to cracks, buckles, cracks and buckles, and twisted/distorted, respectively.

(D) Probable detail failure causes are estimated to be a combination of fatigue and the other factors indicated in the table by appropriate numbers as follows:

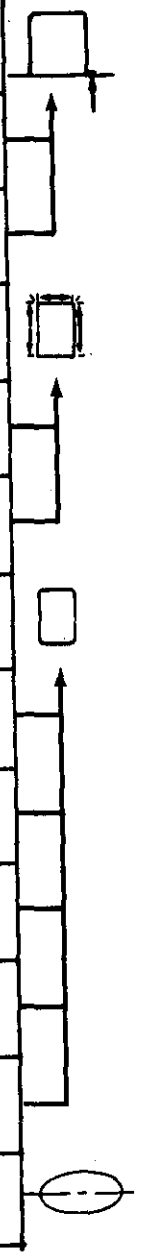
5. Shear
6. Tension
7. Combined Tension & Shear
8. Design
9. Fabrication/Workmanship
10. Welding
11. Neglect
12. Misuse/Abuse
13. Questionable
14. Heavy Seas
15. Collision
16. Other - See Discussion

TABLE A-7 DETAIL FAMILY: MISCELLANEOUS CUTOUTS

LOCATION ON SHIP / SHIP TYPE		No. of Sound Details Observed	No. of Failed Details Observed	Total Number Details Observed	Percent Failures	Detail Family Number	Failure Mode	Failure Cause
Container-ship	Fwd	10		10		7-A-5		
		197		197				
	Aft	10		10				
Naval	Fwd	10		10		7-A-5		
		10		10				
	Aft	10		10				
Bulk Carrier	Fwd	10		10		7-A-6		
		34		34				
	Aft	10		10				
Container-ship	Fwd	40		40		7-A-6	1	7,14
		97	2	99	2.0			
	Aft	40		40				
General Cargo	Fwd					7-A-6		
	Aft	3		3				
Tanker	Fwd	10		10		7-A-6		
	Aft	20		20				
Bulk Carrier	Fwd	10		10		7-A-7		
	Aft	10		10				
Container-ship	Fwd	20		20		7-A-7		
	Aft	30		30				
Bulk Carrier	Fwd	30		30		7-A-8		
		10		10				
	Aft	30		30				
Combination Carrier	Fwd	20		20		7-A-8		
		20		20				
	Aft	30		30				
Container-ship	Fwd	20		20		7-A-8	1	7,14
		64	6	70	8.6			
	Aft	40		40				
General Cargo	Fwd	10		10		7-A-8		
		17		17				
	Aft	20		20				
Miscella-neous	Fwd	10		10		7-A-8		
		10		10				
	Aft	20		20				
Naval	Fwd	30		30		7-A-8	4	14,16
		175	5	180	2.8			
	Aft	40		40				
Tanker	Fwd	30		30		7-A-8		
		150		150				
	Aft	60		60				
General Cargo	Fwd					7-A-9	1	7,8,14
		32	8	40	20.0			
	Aft	10		10				

TABLE A-7 DETAIL FAMILY: MISCELLANEOUS CUTOUTS

SHIP TYPE / LOCATION ON SHIP		No. of Sound Details Observed	No. of Failed Details Observed	Total Number Details Observed	Percent Failures	Detail Family Number	Failure Mode	Failure Cause
Container-ship	Fwd	10		10		7-A-10		
	Aft	10		10				
General Cargo	Fwd	23	1	24	4.2	7-A-10	1	5,11
	Aft							
Tanker	Fwd	20		20		7-A-10		
	Aft	20		20				
Combination Carrier	Fwd	30		30		7-A-11		
	Aft							
Naval	Fwd	6	4	10	40.0	7-A-11	1	7,8
	Aft							
Tanker	Fwd	17	3	20	15.0	7-A-11	1	7,8,9
	Aft							
Bulk Carrier	Fwd	4		4		7-A-12		
	Aft							
Combination Carrier	Fwd	10		10		7-A-12		
		60		60				
	Aft	30		30				
Container-ship	Fwd	30		30		7-A-12		
		70		70				
	Aft	50		50				
General Cargo	Fwd	38		38		7-A-12		
	Aft							
Naval	Fwd	10		10		7-A-12		
	Aft	10		10				
Tanker	Fwd	10		10		7-A-12		
	Aft	10		10				
Container-ship	Fwd	14		14		7-A-13		
	Aft							



NOTES:

(A) The above continued table gives information related to individual detail designs in the 86 ship survey.

(B) The rows labeled aft, ⊠, and fwd refer to locations along the ship length. The mid-ship symbol row covers the mid-length throughout the entire cargo section.

(C) The numbers 1, 2, 3 & 4 in the column for failure mode refer to cracks, buckles, cracks and buckles, and twisted/distorted, respectively.

(D) Probable detail failure causes are estimated to be a combination of fatigue and the other factors indicated in the table by appropriate numbers as follows:

5. Shear
6. Tension
7. Combined Tension & Shear
8. Design
9. Fabrication/Workmanship
10. Welding
11. Neglect
12. Misuse/Abuse
13. Questionable
14. Heavy Seas
15. Collision
16. Other - See Discussion

TABLE A-7 DETAIL FAMILY: MISCELLANEOUS CUTOUTS

LOCATION ON SHIP / SHIP TYPE		No. of Sound Details Observed	No. of Failed Details Observed	Total Number, Details Observed	Percent Failures	Detail Family Number	Failure Mode	Failure Cause
Container-ship	Fwd	50	8	50	8.0	7-B-1	1	9,14
	Aft	92		100				
		100		100				
General Cargo	Fwd	40		40		7-B-1		
	Aft	100		100				
		90		90				
Tanker	Fwd	30		30		7-B-1		
	Aft	600		600				
		120		120				
Bulk Carrier	Fwd	70		70		7-B-2		
	Aft	1170		1170				
		200		200				
Combination Carrier	Fwd	100		100		7-B-2		
	Aft	900		900				
		200		200				
Container-ship	Fwd	150		150		7-B-2		
	Aft	1000		1000				
		300		300				
General Cargo	Fwd	60		60		7-B-2		
	Aft	920		920				
		100		100				
Naval	Fwd	70	20	70	1.6	7-B-2	1,2	11,16
	Aft	1200		1220				
		80		80				
Tanker	Fwd	70		70		7-B-2		
	Aft	500		500				
		50		50				
Bulk Carrier	Fwd	30		30		7-B-3		
	Aft	1000		1000				
		150		150				
Container-ship	Fwd	40		40		7-B-3		
	Aft	340		340				
		70		70				
Miscella-neous	Fwd	120		120		7-B-3		
	Aft	1300		1300				
		300		300				
Naval	Fwd	120		120		7-B-3		
	Aft	600		600				
		220		220				
Tanker	Fwd	80		80		7-B-3		
	Aft	5400		5400				
		400		400				
Container-ship	Fwd	300		300		7-B-4		
	Aft							
General Cargo	Fwd	80		80		7-B-5		
	Aft							

TABLE A-7 DETAIL FAMILY: MISCELLANEOUS CUTOUTS

LOCATION ON SHIP / SHIP TYPE		No. of Sound Details Observed	No. of Failed Details Observed	Total Number Details Observed	Percent Failures	Detail Family Number	Failure Mode	Failure Cause
Bulk Carrier	Fwd	40		40		7-C-1		
	⊠	572		572				
	Aft	70		70				
Combination Carrier	Fwd	80		80		7-C-1		
	⊠	60		60				
	Aft	90		90				
Container-ship	Fwd	90		90		7-C-1	1	(7,9 14,15)
	⊠	781	31	812	3.8			
	Aft	110		110				
General Cargo	Fwd	70		70		7-C-1	1	9
	⊠	980		980				
	Aft	74	16	90	17.8			
Miscella-neous	Fwd	60		60		7-C-1		
	⊠	80		80				
	Aft	60		60				
Naval	Fwd	80		80		7-C-1		
	⊠	200		200				
	Aft	60		60				
Tanker	Fwd	90		90		7-C-1	1	8
	⊠	2586	14	2600	.5			
	Aft	200		200				
Container-ship	Fwd	20		20		7-C-2		
	⊠	100		100				
	Aft	20		20				
Miscella-neous	Fwd	20		20		7-C-2		
	⊠							
	Aft	20		20				
Bulk Carrier	Fwd					7-C-3		
	⊠	36		36				
	Aft							
Combination Carrier	Fwd	210		210		7-C-3		
	⊠	900		900				
	Aft	180		180				
Container-ship	Fwd	70		70		7-C-3	1	11
	⊠	502	10	512	2.0			
	Aft	68	2	70	2.9		1	11
General Cargo	Fwd					7-C-3		
	⊠	38		38				
	Aft	80		80				

NOTES:

(A) The above continued table gives information related to individual detail designs in the 86 ship survey.

(B) The rows labeled aft, ⊠, and fwd refer to locations along the ship length. The mid-ship symbol row covers the mid-length throughout the entire cargo section.

(C) The numbers 1, 2, 3 & 4 in the column for failure mode refer to cracks, buckles, cracks and buckles, and twisted/distorted, respectively.

(D) Probable detail failure causes are estimated to be a combination of fatigue and the other factors indicated in the table by appropriate numbers as follows:

5. Shear
6. Tension
7. Combined Tension & Shear
8. Design
9. Fabrication/Workmanship
10. Welding
11. Neglect
12. Misuse/Abuse
13. Questionable
14. Heavy Seas
15. Collision
16. Other - See Discussion

TABLE A-7 DETAIL FAMILY: MISCELLANEOUS CUTOUTS

LOCATION ON SHIP / SHIP TYPE		No. of Sound Details Observed	No. of Failed Details Observed	Total Number Details Observed	Percent Failures	Detail Family Number	Failure Mode	Failure Cause
Tanker	Fwd Aft	90 1600 90		90 1600 90		7-C-3		
Bulk Carrier	Fwd Aft	4		4		7-C-4		
Container-ship	Fwd Aft	199	1	200	.5	7-C-4	1	11,14
Naval	Fwd Aft	200 2000 400		200 2000 400		7-C-4		
Container-ship	Fwd Aft	150		150		7-C-5		
General Cargo	Fwd Aft	40 20		40 20		7-C-6		
Bulk Carrier	Fwd Aft	1228		1228		7-C-7		
Combination Carrier	Fwd Aft	70 110 60		70 110 60		7-C-7		
General Cargo	Fwd Aft	30		30		7-C-7		
Miscella-neous	Fwd Aft	20 50		20 50		7-C-7		
Container-ship	Fwd Aft	30 150		30 150		7-C-8		
General Cargo	Fwd Aft	20 20		20 20		7-C-8		
Bulk Carrier	Fwd Aft	70 3526 120		70 3526 120		7-C-9		
Container-ship	Fwd Aft	80		80		7-C-9		
Naval	Fwd Aft	96 1491 196	4 9 4	100 1500 200	4.0 .7 2.0	7-C-9	1 1 1	11 11 15
Tanker	Fwd Aft	400 16000 1000		400 16000 1000		7-C-9		

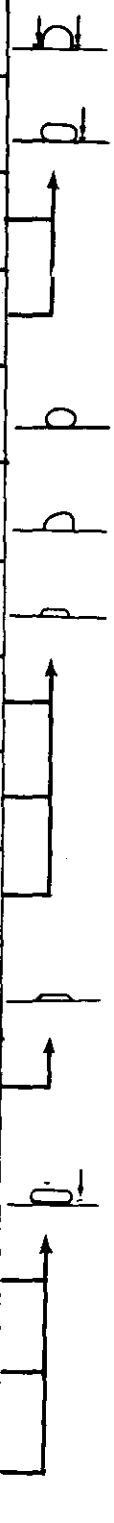


TABLE A-7 DETAIL FAMILY: MISCELLANEOUS CUTOUTS

LOCATION ON SHIP / SHIP TYPE		No. of Sound Details Observed	No. of Failed Details Observed	Total Number Details Observed	Percent Failures	Detail Family Number	Failure Mode	Failure Cause
Container-ship	Fwd Aft	8	2	10	20.0	7-C-10	1	8,9
Combination Carrier	Fwd Aft	10		10		7-C-11		
Container-ship	Fwd Aft	20		20		7-C-11		
General Cargo	Fwd Aft	10		10		7-C-11		
Combination Carrier	Fwd Aft	8	2	10	20.0	7-C-12	1	8
Bulk Carrier	Fwd Aft	356		356		7-C-13		
Container-ship	Fwd Aft	70		70		7-C-13		
Naval	Fwd Aft	800 2000 1100		800 2000 1100		7-C-13		
Naval	Fwd Aft	40 30		40 30		7-C-14		
Bulk Carrier	Fwd Aft	126 40		126 40		7-C-15		
Combination Carrier	Fwd Aft	60		60		7-C-15		
Container-ship	Fwd Aft	20 759 180	19	20 778 180	2.4	7-C-15	1	7,11
General Cargo	Fwd Aft	10 477 40	1	10 478 40	0.2	7-C-15	1	9,11

NOTES:

(A) The above continued table gives information related to individual detail designs in the 86 ship survey.

(B) The rows labeled aft, ⊠, and fwd refer to locations along the ship length. The mid-ship symbol row covers the mid-length throughout the entire cargo section.

(C) The numbers 1, 2, 3 & 4 in the column for failure mode refer to cracks, buckles, cracks and buckles, and twisted/distorted, respectively.

(D) Probable detail failure causes are estimated to be a combination of fatigue and the other factors indicated in the table by appropriate numbers as follows:

5. Shear
6. Tension
7. Combined Tension & Shear
8. Design
9. Fabrication/Workmanship
10. Welding
11. Neglect
12. Misuse/Abuse
13. Questionable
14. Heavy Seas
15. Collision
16. Other - See Discussion

TABLE A-7 DETAIL FAMILY: MISCELLANEOUS CUTOUTS

LOCATION ON SHIP / SHIP TYPE		No. of Sound Details Observed	No. of Failed Details Observed	Total Number Details Observed	Percent Failures	Detail Family Number	Failure Mode	Failure Cause
Container-ship	Fwd	40		40		7-D-3		
	⊠							
	Aft	60		60				
Bulk Carrier	Fwd	10		10		7-D-4		
	⊠	20		20				
	Aft	10		10				
Container-ship	Fwd	20		20		7-D-4		
	⊠	30		30				
	Aft	30		30				
General Cargo	Fwd	50		50		7-D-4		
	⊠							
	Aft	80		80				
Container-ship	Fwd					7-D-5		
	⊠	24		24				
	Aft							
Tanker	Fwd	40		40		7-D-5		
	⊠	1200		1200				
	Aft	80		80				
Bulk Carrier	Fwd	50		50		7-E-1		
	⊠	812		812				
	Aft	180		180				
Combination Carrier	Fwd	40		40		7-E-1		
	⊠	1200		1200				
	Aft	120		120				
Container-ship	Fwd	80		80		7-E-1	1	7,14
	⊠	804	4	808	0.5			
	Aft	300		300				
General Cargo	Fwd					7-E-1		
	⊠	446		446				
	Aft							
Miscella-neous	Fwd	70		70		7-E-1		
	⊠	200		200				
	Aft	170		170				
Naval	Fwd	800		800		7-E-1		
	⊠	5000		5000				
	Aft	1200		1200				
Tanker	Fwd	140		140		7-E-1	1	8,16
	⊠	5410	90	5500	1.6			
	Aft	700		700				

NOTES:

(A) The above continued table gives information related to individual detail designs in the 86 ship survey.

(B) The rows labeled aft, ⊠, and fwd refer to locations along the ship length. The mid-ship symbol row covers the mid-length throughout the entire cargo section.

(C) The numbers 1, 2, 3 & 4 in the column for failure mode refer to cracks, buckles, cracks and buckles, and twisted/distorted, respectively.

(D) Probable detail failure causes are estimated to be a combination of fatigue and the other factors indicated in the table by appropriate numbers as follows:

5. Shear
6. Tension
7. Combined Tension & Shear
8. Design
9. Fabrication/Workmanship
10. Welding
11. Neglect
12. Misuse/Abuse
13. Questionable
14. Heavy Seas
15. Collision
16. Other - See Discussion

TABLE A-7 DETAIL FAMILY: MISCELLANEOUS CUTOUTS

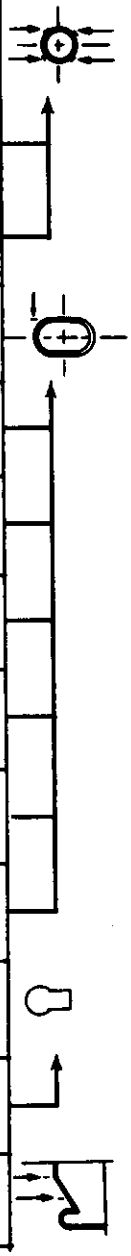
LOCATION ON SHIP / SHIP TYPE		No. of Sound Details Observed	No. of Failed Details Observed	Total Number Details Observed	Percent Failures	Detail Family Number	Failure Mode	Failure Cause
Miscella-neous	Fwd	10		10				
	Aft	30		30		7-C-15		
		20		20				
Naval	Fwd	10		10				
	Aft	20		20		7-C-15		
		10		10				
Tanker	Fwd	300		300				
	Aft	8000		8000		7-C-15		
		800		800				
Bulk Carrier	Fwd							
	Aft	673		673		7-C-16		
Container-ship	Fwd	40		40				
	Aft	2172	3	2175	0.1	7-C-16	1	11
		80		80				
General Cargo	Fwd							
	Aft	1417	17	1434	1.2	7-C-16	1	11
Container-ship	Fwd							
	Aft	300		300		7-C-17		
		80		80				
Naval	Fwd							
	Aft	70		70		7-C-17		
Container-ship	Fwd							
	Aft	84		84		7-C-18		
Naval	Fwd							
	Aft	78	2	80	2.5	7-C-18	1	10
Naval	Fwd							
	Aft	60		60		7-C-19		
		10		10				
Container-ship	Fwd							
	Aft	269		269		7-C-20		
Bulk Carrier	Fwd							
	Aft	116		116		7-D-1		
Container-ship	Fwd	20		20				
	Aft	279	1	280	0.4	7-D-1	1	14
		50		50				
Tanker	Fwd	10		10				
	Aft	118	2	120	1.7	7-D-1	1	14
		40		40				
Bulk Carrier	Fwd	20		20				
	Aft	80		80		7-D-2		
		104	16	120	13.3		1	9,10,13

TABLE A-7 DETAIL FAMILY: MISCELLANEOUS CUTOUTS

LOCATION ON SHIP / SHIP TYPE		No. of Sound Details Observed	No. of Failed Details Observed	Total Number Details Observed	Percent Failures	Detail Family Number	Failure Mode	Failure Cause
Bulk Carrier	Fwd	20		20				
		173		173		7-E-2		
	Aft	40		40				
Combination Carrier	Fwd	20		20				
		435	65	500	13.0	7-E-2	2,3	8,14
	Aft	30		30				
Container-ship	Fwd	20		20				
		496		496		7-E-2		
	Aft	30		30				
General Cargo	Fwd							
		46		46		7-E-2		
	Aft							
Tanker	Fwd	20		20				
		300		300		7-E-2		
	Aft	40		40				
Bulk Carrier	Fwd	20		20				
		196	7	203	3.4	7-F-1	1	9,10,11
	Aft	50		50				
Combination Carrier	Fwd	20		20				
		60		60		7-F-1		
	Aft	40		40				
Container-ship	Fwd	30		30				
		1294	11	1305	0.8	7-F-1	1	(8,9
	Aft	120		120				11,14)
General Cargo	Fwd	20		20				
		593	2	595	0.3	7-F-1	1	6,11
	Aft	60		60				
Miscella-neous	Fwd	10		10				
		60		60		7-F-1		
	Aft	40		40				
Naval	Fwd	10		10				
		80		80		7-F-1		
	Aft	60		60				
Tanker	Fwd	10		10				
		220		220		7-F-1		
	Aft	159	1	160	0.6		1	8,9
Bulk Carrier	Fwd	10		10				
		150		150		7-F-2		
	Aft	50		50				
Combination Carrier	Fwd	20		20				
		150		150		7-F-2		
	Aft	60		60				
Container-ship	Fwd	20		20				
		145		145		7-F-2		
	Aft	115	5	120	4.2		1	10
General Cargo	Fwd	10		10				
		121		121		7-F-2		
	Aft	80		80				

TABLE A-7 DETAIL FAMILY: MISCELLANEOUS CUTOUTS

LOCATION ON SHIP / SHIP TYPE		No. of Sound Details Observed	No. of Failed Details Observed	Total Number Details Observed	Percent Failures	Detail Family Number	Failure Mode	Failure Cause
Miscella-neous	Fwd	10		10				
	⊠	90		90		7-F-2		
	Aft	40		40				
Naval	Fwd	20		20				
	⊠	600		600		7-F-2		
	Aft	90		90				
Tanker	Fwd	20		20				
	⊠	120		120		7-F-2		
	Aft	140		140				
Bulk Carrier	Fwd	10		10				
	⊠	51	1	52	1.9	7-F-3	1	7,8,14
	Aft	20		20				
Combination Carrier	Fwd	10		10				
	⊠	30		30		7-F-3		
	Aft	40		40				
Container-ship	Fwd	20		20				
	⊠	102	1	103	1.0	7-F-3	1	10
	Aft	50		50				
General Cargo	Fwd							
	⊠	30		30		7-F-3		
	Aft	20		20				
Miscella-neous	Fwd							
	⊠	10		10		7-F-3		
	Aft	10		10				
Naval	Fwd	20		20				
	⊠	200		200		7-F-3		
	Aft	50		50				
Tanker	Fwd	10		10				
	⊠	50		50		7-F-3		
	Aft	38	2	40	5.0		1	10
Container-ship	Fwd							
	⊠	101		101		7-F-4		
	Aft							
General Cargo	Fwd							
	⊠							
	Aft	10		10		7-F-4		
Tanker	Fwd							
	⊠							
	Aft	8	2	10	20.0	7-F-5	1	8,9



NOTES:

(A) The above continued table gives information related to individual detail designs in the 86 ship survey.

(B) The rows labeled aft, ⊠ , and fwd refer to locations along the ship length. The mid-ship symbol row covers the mid-length throughout the entire cargo section.

(C) The numbers 1, 2, 3 & 4 in the column for failure mode refer to cracks, buckles, cracks and buckles, and twisted/distorted, respectively.

(D) Probable detail failure causes are estimated to be a combination of fatigue and the other factors indicated in the table by appropriate numbers as follows:

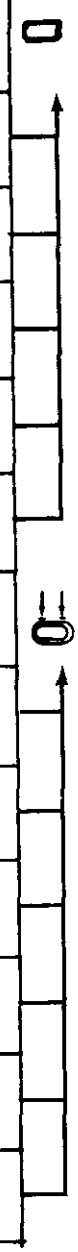
5. Shear
6. Tension
7. Combined Tension & Shear
8. Design
9. Fabrication/Workmanship
10. Welding
11. Neglect
12. Misuse/Abuse
13. Questionable
14. Heavy Seas
15. Collision
16. Other - See Discussion

TABLE A-7 DETAIL FAMILY: MISCELLANEOUS CUTOUTS

LOCATION ON SHIP / SHIP TYPE		No. of Sound Details Observed	No. of Failed Details Observed	Total Number Details Observed	Percent Failures	Detail Family Number	Failure Mode	Failure Cause
Container-ship	Fwd Aft	30		30		7-F-6		
General Cargo	Fwd Aft	10		10		7-F-6		
Miscella-neous	Fwd Aft	10		10		7-F-6		
Naval	Fwd Aft	50 50		50 50		7-F-6		
Tanker	Fwd Aft	30		30		7-F-6		
Bulk Carrier	Fwd Aft	95	1	96	1.0	7-F-7	1	10
Container-ship	Fwd Aft	124		124		7-F-8		
General Cargo	Fwd Aft	40		40		7-F-8		
Bulk Carrier	Fwd Aft	97 40		97 40		7-G-1		
Combination Carrier	Fwd Aft	10 40		10 40		7-G-1		
Container-ship	Fwd Aft	28 60	2	30 60	6.7	7-G-1	1	10
General Cargo	Fwd Aft	10 20		10 20		7-G-1		
Miscella-neous	Fwd Aft	10 20		10 20		7-G-1		
Naval	Fwd Aft	100 200 200		100 200 200		7-G-1		
Tanker	Fwd Aft	150 200		150 200		7-G-1		
Bulk Carrier	Fwd Aft	10 50		10 50		7-G-2		

TABLE A-7 DETAIL FAMILY: MISCELLANEOUS CUTOUTS

LOCATION ON SHIP / SHIP TYPE		No. of Sound Details Observed	No. of Failed Details Observed	Total Number Details Observed	Percent Failures	Detail Family Number	Failure Mode	Failure Cause
Combination Carrier	Fwd					7-G-2		
	⊠	150		150				
	Aft	250		250				
Container-ship	Fwd					7-G-2		
	⊠	50		50				
	Aft	90		90				
General Cargo	Fwd					7-G-2		
	⊠	10		10				
	Aft	30		30				
Miscella-neous	Fwd					7-G-2		
	⊠	40		40				
	Aft	40		40				
Naval	Fwd	60		60		7-G-2		
	⊠	200		200				
	Aft	220		220				
Tanker	Fwd					7-G-2		
	⊠	10		10				
	Aft	60		60				
Bulk Carrier	Fwd	20		20		7-G-3	1	9,10
	⊠	300	5	305	1.6			
	Aft	300		300				
Combination Carrier	Fwd	30		30		7-G-3		
	⊠	200		200				
	Aft	600		600				
Container-ship	Fwd	40		40		7-G-3	1	7,14
	⊠	332	1	333	0.3			
	Aft	500		500				
General Cargo	Fwd	20		20		7-G-3		
	⊠	95		95				
	Aft	80		80				
Miscella-neous	Fwd	10		10		7-G-3		
	⊠	30		30				
	Aft	70		70				
Naval	Fwd	500		500		7-G-3		
	⊠	1800		1800				
	Aft	2197	3	2200	.1		1	7,8
Tanker	Fwd	50		50		7-G-3		
	⊠	200		200				
	Aft	299	1	300	.3		1	10



NOTES:

(A) The above continued table gives information related to individual detail designs in the 86 ship survey.

(B) The rows labeled aft, ⊠, and fwd refer to locations along the ship length. The mid-ship symbol row covers the mid-length throughout the entire cargo section.

(C) The numbers 1, 2, 3 & 4 in the column for failure mode refer to cracks, buckles, cracks and buckles, and twisted/distorted, respectively.

(D) Probable detail failure causes are estimated to be a combination of fatigue and the other factors indicated in the table by appropriate numbers as follows:

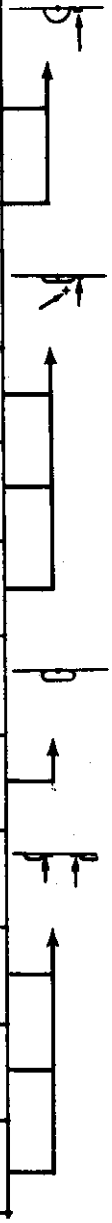
5. Shear
6. Tension
7. Combined Tension & Shear
8. Design
9. Fabrication/Workmanship
10. Welding
11. Neglect
12. Misuse/Abuse
13. Questionable
14. Heavy Seas
15. Collision
16. Other - See Discussion

TABLE A-7 DETAIL FAMILY: MISCELLANEOUS CUTOUTS

LOCATION ON SHIP / SHIP TYPE		No. of Sound Details Observed	No. of Failed Details Observed	Total Number Details Observed	Percent Failures	Detail Family Number	Failure Mode	Failure Cause
Container-ship	Fwd Aft	20		20		7-G-4		
Bulk Carrier	Fwd Aft	10 20 30		10 20 30		7-G-5		
Combination Carrier	Fwd Aft	20		20		7-G-5		
Container-ship	Fwd Aft	80		80		7-G-5		
General Cargo	Fwd Aft	100 20		100 20		7-G-5		
Miscella-neous	Fwd Aft	20		20		7-G-5		
Tanker	Fwd Aft	60		60		7-G-5		
Bulk Carrier	Fwd Aft	300 3915 600	4	300 3919 600	0.1	7-H-1	1	9,14
Combination Carrier	Fwd Aft	366 1878 894	34 22 6	400 1900 900	8.5 1.1 0.7	7-H-1	1 1 1	8,10,15 10,13,15 10,11
Container-ship	Fwd Aft	271 9032 884	29 54 16	300 9086 900	9.7 0.6 1.8	7-H-1	1 1 1	14,15 9,12,14 9,10,14
General Cargo	Fwd Aft	900 8721 1300	59	900 8780 1300	0.7	7-H-1	1	(9,10,11, 12,14 15)
Miscella-neous	Fwd Aft	300 1500 400		300 1500 400		7-H-1		
Naval	Fwd Aft	60 797 200	3	60 800 200	0.4	7-H-1	1	15
Tanker	Fwd Aft	597 6468 1700	3 32	600 6500 1700	0.5 0.5	7-H-1	1 1	5,15 5,7,8,9
Bulk Carrier	Fwd Aft	845		845		7-H-2		
Combination Carrier	Fwd Aft	120 700 200		120 700 200		7-H-2		

TABLE A-7 DETAIL FAMILY: MISCELLANEOUS CUTOUTS

LOCATION ON SHIP / SHIP TYPE		No. of Sound Details Observed	No. of Failed Details Observed	Total Number Details Observed	Percent Failures	Detail Family Number	Failure Mode	Failure Cause
Container-ship	Fwd							
	⋈	86		86		7-H-2		
	Aft							
General Cargo	Fwd							
	⋈	885	1	856	0.1	7-H-2	1	10
	Aft							
Naval	Fwd	100		100				
	⋈	900		900		7-H-2		
	Aft	300		300				
Container-ship	Fwd	100		100				
	⋈	889	8	897	0.9	7-H-3	1	14
	Aft	200		200				
General Cargo	Fwd							
	⋈	19	1	20	5.0	7-H-3	1	9,10
	Aft							
Naval	Fwd	200		200				
	⋈	1200		1200		7-H-3		
	Aft	198	2	200	1.0		1,2	15
Tanker	Fwd	20		20				
	⋈	30		30		7-H-3		
	Aft	20		20				
Bulk Carrier	Fwd							
	⋈	18		18		7-H-4		
	Aft							
Tanker	Fwd							
	⋈	1200		1200		7-H-4		
	Aft							
Bulk Carrier	Fwd	260	40	300	13.3		1	5,14,15
	⋈	4800		4800		7-H-5		
	Aft	784	16	800	2.0		1	14
Container-ship	Fwd	600		600				
	⋈	2600		2600		7-H-5		
	Aft	1200		1200				
Miscella-neous	Fwd	600		600				
	⋈	2600		2600		7-H-5		
	Aft	1200		1200				
Tanker	Fwd	60		60				
	⋈	1400		1400		7-H-5		
	Aft	140		140				



NOTES:

(A) The above continued table gives information related to individual detail designs in the 86 ship survey.

(B) The rows labeled aft, ⋈ , and fwd refer to locations along the ship length. The mid-ship symbol row covers the mid-length throughout the entire cargo section.

(C) The numbers 1, 2, 3 & 4 in the column for failure mode refer to cracks, buckles, cracks and buckles, and twisted/distorted, respectively.

(D) Probable detail failure causes are estimated to be a combination of fatigue and the other factors indicated in the table by appropriate numbers as follows:

5. Shear
6. Tension
7. Combined Tension & Shear
8. Design
9. Fabrication/Workmanship
10. Welding
11. Neglect
12. Misuse/Abuse
13. Questionable
14. Heavy Seas
15. Collision
16. Other - See Discussion

TABLE A-7 DETAIL FAMILY: MISCELLANEOUS CUTOUTS

LOCATION ON SHIP / SHIP TYPE		No. of Sound Details Observed	No. of Failed Details Observed	Total Number Details Observed	Percent Failures	Detail Family Number	Failure Mode	Failure Cause
Tanker	Fwd Aft	500 10000 800		500 10000 800		7-H-6		
Bulk Carrier	Fwd Aft	170		170		7-H-7		
Container-ship	Fwd Aft	20		20		7-H-7		
General Cargo	Fwd Aft	1323 79	1	1323 80	1.2	7-H-7	1	8,12
Tanker	Fwd Aft	600 50		600 50		7-H-7		
Bulk Carrier	Fwd Aft	40		40		7-H-8		
General Cargo	Fwd Aft	104		104		7-H-8		
Tanker	Fwd Aft	30 400 60		30 400 60		7-H-8		
Bulk Carrier	Fwd Aft	200 1466 400		200 1466 400		7-H-9		
Combination Carrier	Fwd Aft	200 700 300		200 700 300		7-H-9		
Container-ship	Fwd Aft	1800 12804 3000	35	1800 12839 3000	0.3	7-H-9	1	(7,9 10,11)
General Cargo	Fwd Aft	500 6802 1000	21	500 6823 1000	0.3	7-H-9	1	5,8,10
Miscella-neous	Fwd Aft	300 1500 700		300 1500 700		7-H-9		
Naval	Fwd Aft	1000 7000 2000		1000 7000 2000		7-H-9		
Tanker	Fwd Aft	2000 25000 4000		2000 25000 4000		7-H-9		
Bulk Carrier	Fwd Aft	200 2345 500		200 2345 500		7-H-10		

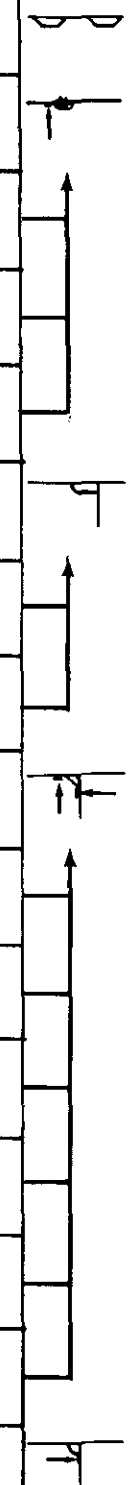


TABLE A-7 DETAIL FAMILY: MISCELLANEOUS CUTOUTS

LOCATION ON SHIP / SHIP TYPE		No. of Sound Details Observed	No. of Failed Details Observed	Total Number Details Observed	Percent Failures	Detail Family Number	Failure Mode	Failure Cause
Combination Carrier	Fwd	400		400		7-H-10		
	⊠	3000		3000				
	Aft	800		800				
Container-ship	Fwd	400		400				
	⊠	3268	4	3272	0.1	7-H-10	1	9,10
	Aft	900		900				
General Cargo	Fwd	200		200				
	⊠	1458	26	1484	1.8	7-H-10	1	10,12
	Aft	400		400				
Miscella-neous	Fwd	100		100				
	⊠	300		300		7-H-10		
	Aft	100		100				
Naval	Fwd	400		400				
	⊠	2800		2800		7-H-10		
	Aft	800		800				
Tanker	Fwd	200		200				
	⊠	2500		2500		7-H-10		
	Aft	500		500				
Container-ship	Fwd							
	⊠	11	3	14	21.4	7-H-11	1	10
	Aft							
Tanker	Fwd	9	1	10	10.0	7-H-11	1	8,14
	⊠							
	Aft							
Combination Carrier	Fwd							
	⊠							
	Aft	47	3	50	6.0	7-H-12	1	13
Container-ship	Fwd							
	⊠	10		10		7-H-12		
	Aft	100		100				
Tanker	Fwd							
	⊠							
	Aft	50		50		7-H-12		
Bulk Carrier	Fwd							
	⊠	12	12	24	50.0	7-H-13	1	7
	Aft							
Bulk Carrier	Fwd							
	⊠	32		32		7-H-14		
	Aft							

NOTES:

(A) The above continued table gives information related to individual detail designs in the 86 ship survey.

(B) The rows labeled aft, ⊠, and fwd refer to locations along the ship length. The mid-ship symbol row covers the mid-length throughout the entire cargo section.

(C) The numbers 1, 2, 3 & 4 in the column for failure mode refer to cracks, buckles, cracks and buckles, and twisted/distorted, respectively.

(D) Probable detail failure causes are estimated to be a combination of fatigue and the other factors indicated in the table by appropriate numbers as follows:

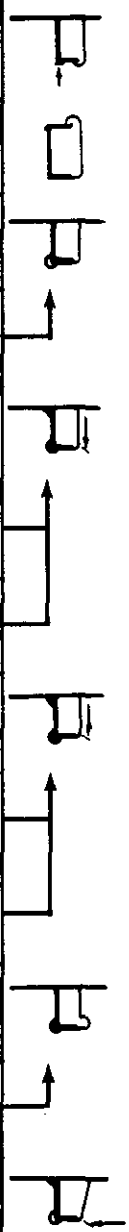
5. Shear
6. Tension
7. Combined Tension & Shear
8. Design
9. Fabrication/Workmanship
10. Welding
11. Neglect
12. Misuse/Abuse
13. Questionable
14. Heavy Seas
15. Collision
16. Other - See Discussion

TABLE A-8 DETAIL FAMILY: CLEARANCE CUTOUTS

LOCATION ON SHIP / SHIP TYPE		No. of Sound Details Observed	No. of Failed Details Observed	Total Number Details Observed	Percent Failures	Detail Family Number	Failure Mode	Failure Cause
General Cargo	Fwd Aft	234	36	270	13.3	8-A-1	1	8
Container-ship	Fwd Aft	150		150		8-A-2		
Bulk Carrier	Fwd Aft	75		75		8-A-3		
Container-ship	Fwd Aft	177		177		8-A-3		
Bulk Carrier	Fwd Aft	150 345		150 345		8-B-1		
Container-ship	Fwd Aft	100		100		8-B-1		
General Cargo	Fwd Aft	6		6		8-B-1		
Combination Carrier	Fwd Aft	19	1	20	5.0	8-B-2	1	8,9
Container-ship	Fwd Aft	166 39	1 1	167 40	0.6 2.5	8-B-2	1 1	9 9
General Cargo	Fwd Aft	73 100		73 100		8-B-2		
Tanker	Fwd Aft	150 1958 496	22 4	150 1980 500	1.0 0.8	8-B-2	1,2 1	8,11,12 8
Container-ship	Fwd Aft	12		12		8-B-3		
General Cargo	Fwd Aft	224 50		224 50		8-B-3		
Tanker	Fwd Aft	2400 100		2400 100		8-B-3		
Bulk Carrier	Fwd Aft	40		40		8-B-4		
Naval	Fwd Aft	70		70		8-B-5		

TABLE A-8 DETAIL FAMILY: CLEARANCE CUTOUTS

LOCATION ON SHIP / SHIP TYPE		No. of Sound Details Observed	No. of Failed Details Observed	Total Number Details Observed	Percent Failures	Detail Family Number	Failure Mode	Failure Cause
Container-ship	Fwd Aft	188	2	190	1.1	8-B-6	1	5,10
Bulk Carrier	Fwd Aft	40		40		8-B-7		
Container-ship	Fwd Aft	15		15		8-C-1		
Tanker	Fwd Aft	80		80		8-C-1		
Container-ship	Fwd Aft	15		15		8-C-2		
General Cargo	Fwd Aft	56		56		8-C-2		
Tanker	Fwd Aft	300 628 70	72	300 700 70	10.3	8-C-2	1	14
Bulk Carrier	Fwd Aft	12	2	14	14.3	8-C-3	1	7
Container-ship	Fwd Aft	300 1100 59	1	300 1100 60	1.7	8-C-3	1	9
General Cargo	Fwd Aft	39		39		8-C-3		
Container-ship	Fwd Aft	100		100		8-C-4		
General Cargo	Fwd Aft	73		73		8-C-4		
Container-ship	Fwd Aft	68 414 650	2 3	70 417 650	2.9 0.7	8-C-5	1 1	14 9,10



NOTES:

(A) The above continued table gives information related to individual detail designs in the 86 ship survey.

(B) The rows labeled aft, ⊠, and fwd refer to locations along the ship length. The mid-ship symbol row covers the mid-length throughout the entire cargo section.

(C) The numbers 1, 2, 3 & 4 in the column for failure mode refer to cracks, buckles, cracks and buckles, and twisted/distorted, respectively.

(D) Probable detail failure causes are estimated to be a combination of fatigue and the other factors indicated in the table by appropriate numbers as follows:

5. Shear
6. Tension
7. Combined Tension & Shear
8. Design
9. Fabrication/Workmanship
10. Welding
11. Neglect
12. Misuse/Abuse
13. Questionable
14. Heavy Seas
15. Collision
16. Other - See Discussion

TABLE A-8 DETAIL FAMILY: CLEARANCE CUTOUTS

LOCATION ON SHIP / SHIP TYPE		No. of Sound Details Observed	No. of Failed Details Observed	Total Number Details Observed	Percent Failures	Detail Family Number	Failure Mode	Failure Cause
Bulk Carrier	Fwd	40		40				
		400		400		8-C-6		
	Aft	40		40				
Miscella-neous	Fwd	80		80		8-C-6		
	Aft							
Tanker	Fwd							
	Aft	200		200		8-C-6		
Bulk Carrier	Fwd	400		400				
		3332		3332		8-C-7		
	Aft	1100		1100				
Container-ship	Fwd							
		162		162		8-C-7		
	Aft							
Container-ship	Fwd							
		278	4	282	1.4	8-D-1	1	9
	Aft	50		50				
General Cargo	Fwd							
		125		125		8-D-1		
	Aft							
Tanker	Fwd							
	Aft	150		150		8-D-1		
Container-ship	Fwd							
		210		210		8-D-2		
	Aft							
General Cargo	Fwd							
		42		42		8-D-2		
	Aft							
Tanker	Fwd	100		100				
		755	45	800	5.6	8-D-2	1	8,9
	Aft	150		150				
Bulk Carrier	Fwd							
	Aft	80		80		8-D-3		
Container-ship	Fwd							
	Aft	60		60		8-D-3		
General Cargo	Fwd							
	Aft	60		60		8-D-4		
Miscella-neous	Fwd	50		50				
		240		240		8-D-4		
	Aft	100		100				
Container-ship	Fwd							
		215	4	219	1.8	8-D-5	1	5,8
	Aft							

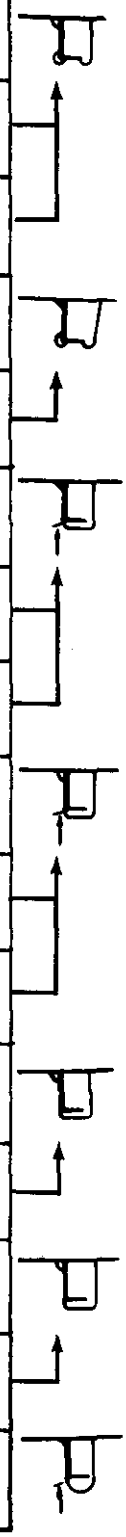
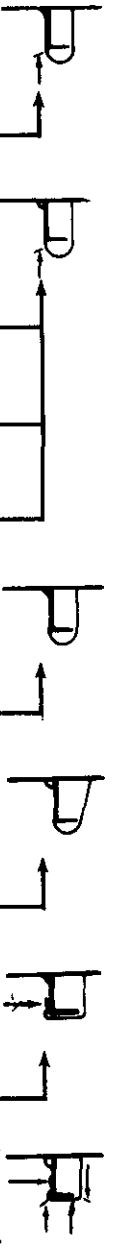


TABLE A-8 DETAIL FAMILY: CLEARANCE CUTOUTS

LOCATION ON SHIP / SHIP TYPE		No. of Sound Details Observed	No. of Failed Details Observed	Total Number Details Observed	Percent Failures	Detail Family Number	Failure Mode	Failure Cause
General Cargo	Fwd							
	⊠	28		28		8-D-5		
	Aft							
Tanker	Fwd	170		170				
	⊠	1880	120	2000	6.0	8-D-5	1	5,8
	Aft	400		400				
Bulk Carrier	Fwd							
	⊠	350		350		8-D-6		
	Aft							
Combination Carrier	Fwd	500		500				
	⊠	3850	350	4200	8.3	8-D-6	1	(5,8,11, 14)
	Aft	900		900				
Miscella-neous	Fwd	60		60				
	⊠	2100		2100		8-D-6		
	Aft	300		300				
Tanker	Fwd	60		60				
	⊠	530	70	600	11.7	8-D-6	1	8,14
	Aft	100		100				
General Cargo	Fwd							
	⊠	70		70		8-D-7		
	Aft							
Tanker	Fwd	30		30				
	⊠	90		90		8-D-7		
	Aft	60		60				
Miscella-neous	Fwd							
	⊠							
	Aft	70		70		8-D-8		
Tanker	Fwd							
	⊠	300		300		8-D-8		
	Aft							
Container-ship	Fwd							
	⊠	643	1	644	0.2	8-E-1	1	10
	Aft							
General Cargo	Fwd	90		90				
	⊠	422		422		8-E-1		
	Aft	30		30				
Bulk Carrier	Fwd	126	14	140	10.0		1	8,14
	⊠	2271	12	2283	0.5	8-E-2	1,2	(9,11, 14,16)
	Aft	200		200				



NOTES:

(A) The above continued table gives information related to individual detail designs in the 86 ship survey.

(B) The rows labeled aft, ⊠ , and fwd refer to locations along the ship length. The mid-ship symbol row covers the mid-length throughout the entire cargo section.

(C) The numbers 1, 2, 3 & 4 in the column for failure mode refer to cracks, buckles, cracks and buckles, and twisted/distorted, respectively.

(D) Probable detail failure causes are estimated to be a combination of fatigue and the other factors indicated in the table by appropriate numbers as follows:

5. Shear
6. Tension
7. Combined Tension & Shear
8. Design
9. Fabrication/Workmanship
10. Welding
11. Neglect
12. Misuse/Abuse
13. Questionable
14. Heavy Seas
15. Collision
16. Other - See Discussion

TABLE A-8 DETAIL FAMILY: CLEARANCE CUTOUTS

LOCATION ON SHIP / SHIP TYPE		No. of Sound Details Observed	No. of Failed Details Observed	Total Number Details Observed	Percent Failures	Detail Family Number	Failure Mode	Failure Cause
Container-ship	Fwd	210		210				
	Aft	2415	1	2416	0.0	8-E-2	1	5,10
		400		400				
General Cargo	Fwd	148	2	150	1.3		1	14
	Aft	918		918		8-E-2		
		300		300				
Tanker	Fwd	110		110				
	Aft	409	11	420	2.6	8-E-2	1	8,14
		90		90				
Bulk Carrier	Fwd							
	Aft	32		32		8-E-3		
Container-ship	Fwd	100		100				
	Aft	132		132		8-E-3		
Tanker	Fwd	60		60		8-E-3		
	Aft							
Bulk Carrier	Fwd							
	Aft	132		132		8-E-4		
Tanker	Fwd	146	4	150	2.7		1,2	15
	Aft	2376	24	2400	1.0	8-E-5	1,2	5,14
		100		100				
Bulk Carrier	Fwd							
	Aft	98	2	100	2.0	8-E-6	2	15
Tanker	Fwd	229	1	230	0.4		1	15
	Aft	2484	16	2500	0.6	8-E-6	2	14,15
		160		160				
Combination Carrier	Fwd	108	12	120	10.0		1,2	8,14
	Aft	110		110		8-E-7		
Container-ship	Fwd	120		120				
	Aft	1500		1500		8-E-8		
		200		200				
Bulk Carrier	Fwd							
	Aft	43		43		8-E-9		
Container-ship	Fwd	140		140				
	Aft	3924	3	3927	0.1	8-E-9	1	10,14
		260		260				
Bulk Carrier	Fwd							
	Aft	80		80		8-E-10		
Container-ship	Fwd							
	Aft	296		296		8-E-10		

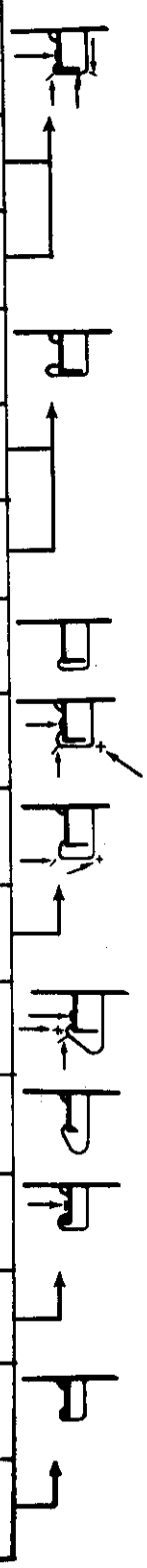
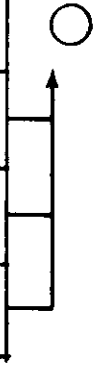


TABLE A-8 DETAIL FAMILY: CLEARANCE CUTOUTS

LOCATION ON SHIP / SHIP TYPE		No. of Sound Details Observed	No. of Failed Details Observed	Total Number Details Observed	Percent Failures	Detail Family Number	Failure Mode	Failure Cause
Tanker	Fwd ⊠ Aft	920		920		8-E-10		
Tanker	Fwd ⊠ Aft	800		800		8-E-11		
Tanker	Fwd ⊠ Aft	1200		1200		8-E-12		
Bulk Carrier	Fwd ⊠ Aft	84		84		8-E-13		
Bulk Carrier	Fwd ⊠ Aft	240		240		8-E-14		

TABLE A-9 DETAIL FAMILY. STRUCTURAL DECK CUTS

LOCATION ON SHIP / SHIP TYPE		No. of Sound Details Observed	No. of Failed Details Observed	Total Number Details Observed	Percent Failures	Detail Family Number	Failure Mode	Failure Cause
Bulk Carrier	Fwd ⊠ Aft	45		45		9-A-1		
Combination Carrier	Fwd ⊠ Aft	10		10		9-A-1		
Container-ship	Fwd ⊠ Aft	10 10		10 10		9-A-1		
General Cargo	Fwd ⊠ Aft	10		10		9-A-1		



NOTES:

(A) The above continued table gives information related to individual detail designs in the 86 ship survey.

(B) The rows labeled aft, ⊠, and fwd refer to locations along the ship length. The mid-ship symbol row covers the mid-length throughout the entire cargo section.

(C) The numbers 1, 2, 3 & 4 in the column for failure mode refer to cracks, buckles, cracks and buckles, and twisted/distorted, respectively.

(D) Probable detail failure causes are estimated to be a combination of fatigue and the other factors indicated in the table by appropriate numbers as follows:

5. Shear
6. Tension
7. Combined Tension & Shear
8. Design
9. Fabrication/Workmanship
10. Welding
11. Neglect
12. Misuse/Abuse
13. Questionable
14. Heavy Seas
15. Collision
16. Other - See Discussion

TABLE A-9 DETAIL FAMILY: STRUCTURAL DECK CUTS

LOCATION ON SHIP / SHIP TYPE		No. of Sound Details Observed	No. of Failed Details Observed	Total Number Details Observed	Percent Failures	Detail Family Number	Failure Mode	Failure Cause
Tanker	Fwd Aft	900 30		900 30		9-A-1		
Bulk Carrier	Fwd Aft	14		14		9-A-2		
Combination Carrier	Fwd Aft	20 10 10		20 10 10		9-A-2		
Container-ship	Fwd Aft	10 12		10 12		9-A-2		
General Cargo	Fwd Aft	50		50		9-A-2		
Miscella-neous	Fwd Aft	10 20 10		10 20 10		9-A-2		
Tanker	Fwd Aft	20 40		20 40		9-A-2		
Bulk Carrier	Fwd Aft	20 33 20		20 33 20		9-A-3		
Combination Carrier	Fwd Aft	20 40 20		20 40 20		9-A-3		
Container-ship	Fwd Aft	20 34 30		20 34 30		9-A-3		
General Cargo	Fwd Aft	45		45		9-A-3		
Tanker	Fwd Aft	20 59	1	20 60	1.7	9-A-3	1	8
Combination Carrier	Fwd Aft	10		10		9-A-4		
Naval	Fwd Aft	10		10		9-A-4		
Tanker	Fwd Aft	10		10		9-A-4		
Bulk Carrier	Fwd Aft	12		12		9-A-5		

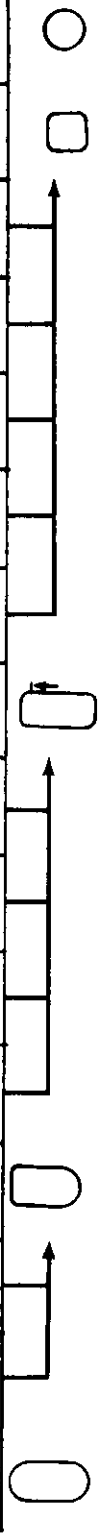
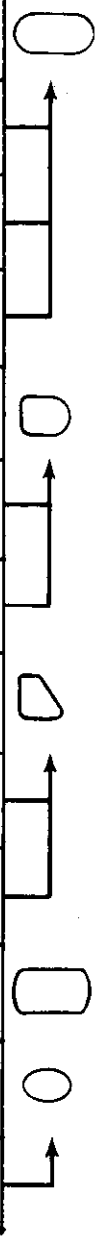


TABLE A-9 DETAIL FAMILY: STRUCTURAL DECK CUTS

LOCATION ON SHIP / SHIP TYPE		No. of Sound Details Observed	No. of Failed Details Observed	Total Number Details Observed	Percent Failures	Detail Family Number	Failure Mode	Failure Cause
Combination Carrier	Fwd	20		20		9-A-5		
	⊠	90		90				
	Aft	30		30				
Container-ship	Fwd	30		30		9-A-5		
	⊠	197		197				
	Aft	30		30				
General Cargo	Fwd	20		20		9-A-5		
	⊠	49		49				
	Aft	30		30				
Miscella-neous	Fwd	80		80		9-A-5		
	⊠	60		60				
	Aft	150		150				
Combination Carrier	Fwd ⊠ Aft	10		10		9-A-6		
Miscella-neous	Fwd ⊠ Aft	10		10		9-A-6		
Tanker	Fwd ⊠ Aft	10		10		9-A-6		
Bulk Carrier	Fwd	30		30		9-A-7		
	⊠	30		30				
	Aft							
Container-ship	Fwd ⊠ Aft	10		10		9-A-7		
Tanker	Fwd ⊠ Aft	10		10		9-A-7		
Tanker	Fwd ⊠ Aft	250		250		9-A-8		
General Cargo	Fwd	20		20		9-A-9		
	⊠	40		40				
	Aft	40		40				
Tanker	Fwd ⊠ Aft	60		60		9-A-9		



NOTES:

(A) The above continued table gives information related to individual detail designs in the 86 ship survey.

(B) The rows labeled aft, ⊠, and fwd refer to locations along the ship length. The mid-ship symbol row covers the mid-length throughout the entire cargo section.

(C) The numbers 1, 2, 3 & 4 in the column for failure mode refer to cracks, buckles, cracks and buckles, and twisted/distorted, respectively.

(D) Probable detail failure causes are estimated to be a combination of fatigue and the other factors indicated in the table by appropriate numbers as follows:

5. Shear
6. Tension
7. Combined Tension & Shear
8. Design
9. Fabrication/Workmanship
10. Welding
11. Neglect
12. Misuse/Abuse
13. Questionable
14. Heavy Seas
15. Collision
16. Other - See Discussion

TABLE A-9 DETAIL FAMILY: STRUCTURAL DECK CUTS

LOCATION ON SHIP / SHIP TYPE		No. of Sound Details Observed	No. of Failed Details Observed	Total Number Details Observed	Percent Failures	Detail Family Number	Failure Mode	Failure Cause
Bulk Carrier	Fwd Aft	10 61 10		10 61 10		9-B-1		
Container-ship	Fwd Aft	34	4	38	10.5	9-B-1	1	10
General Cargo	Fwd Aft	18		18		9-B-1		
Miscella-neous	Fwd Aft	10		10		9-B-1		
Naval	Fwd Aft	30 120 40		30 120 40		9-B-1		
Tanker	Fwd Aft	10 10		10 10		9-B-1		
Bulk Carrier	Fwd Aft	17	8	25	32.0	9-B-2	1	9,11,14
Combination Carrier	Fwd Aft	10		10		9-B-2		
Container-ship	Fwd Aft	40 22 10		40 22 10		9-B-2		
General Cargo	Fwd Aft	38		38		9-B-2		
Naval	Fwd Aft	20 120 10		20 120 10		9-B-2		
Tanker	Fwd Aft	10 10 10		10 10 10		9-B-2		
Combination Carrier	Fwd Aft	10 69 10	1	10 70 10	1.4	9-B-3	1	8
Container-ship	Fwd Aft	40 145 20		40 145 20		9-B-3		
Miscella-neous	Fwd Aft	20 10		20 10		9-B-3		
Naval	Fwd Aft	40 260 80		40 260 80		9-B-3		

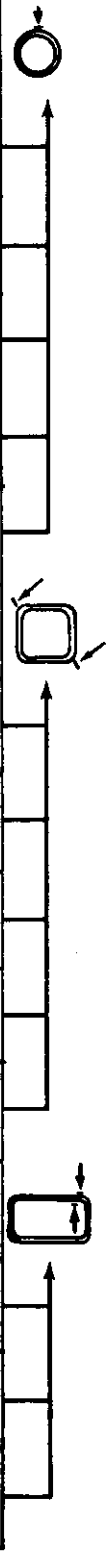
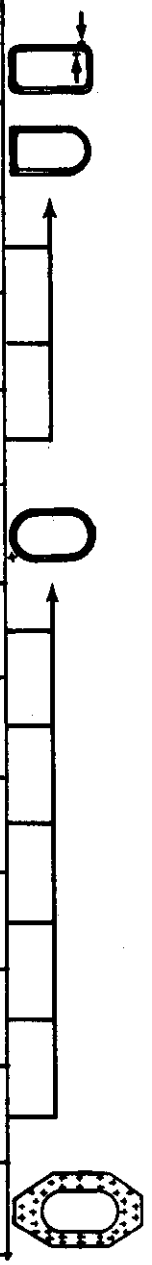


TABLE A-9 DETAIL FAMILY: STRUCTURAL DECK CUTS

LOCATION ON SHIP / SHIP TYPE		No. of Sound Details Observed	No. of Failed Details Observed	Total Number Details Observed	Percent Failures	Detail Family Number	Failure Mode	Failure Cause
Tanker	Fwd	20		20		9-B-3		
	Aft	40		40				
Bulk Carrier	Fwd	20		20		9-B-4		
	Aft							
Miscella-neous	Fwd	10		10		9-B-4		
	Aft	10		10				
Naval	Fwd	10		10		9-B-4		
	Aft	20		20				
Tanker	Fwd					9-B-4		
	Aft	10		10				
Bulk Carrier	Fwd	46		46		9-B-5		
	Aft	10		10				
Combination Carrier	Fwd	10		10		9-B-5		
		20		20				
	Aft	20		20				
Container-ship	Fwd	80		80		9-B-5		
		173		173				
	Aft	90		90				
General Cargo	Fwd	10		10		9-B-5		
		242	4	246	1.6		4	12,15
	Aft	10		10				
Miscella-neous	Fwd	10		10		9-B-5		
		10		10				
	Aft	10		10				
Naval	Fwd	60		60		9-B-5		
		300		300				
	Aft	110		110				
Tanker	Fwd	50		50		9-B-5		
		50		50				
	Aft	60		60				
Combination Carrier	Fwd					9-B-6		
	Aft	10		10				



NOTES:

(A) The above continued table gives information related to individual detail designs in the 86 ship survey.

(B) The rows labeled aft, ⊠, and fwd refer to locations along the ship length. The mid-ship symbol row covers the mid-length throughout the entire cargo section.

(C) The numbers 1, 2, 3 & 4 in the column for failure mode refer to cracks, buckles, cracks and buckles, and twisted/distorted, respectively.

(D) Probable detail failure causes are estimated to be a combination of fatigue and the other factors indicated in the table by appropriate numbers as follows:

5. Shear
6. Tension
7. Combined Tension & Shear
8. Design
9. Fabrication/Workmanship
10. Welding
11. Neglect
12. Misuse/Abuse
13. Questionable
14. Heavy Seas
15. Collision
16. Other - See Discussion

TABLE A-9 DETAIL FAMILY: STRUCTURAL DECK CUTS

SHIP TYPE / LOCATION ON SHIP		No. of Sound Details Observed	No. of Failed Details Observed	Total Number Details Observed	Percent Failures	Detail Family Number	Failure Mode	Failure Cause
Container-ship	Fwd Aft	10		10		9-B-6		
Tanker	Fwd Aft	20		20		9-B-6		
Naval	Fwd Aft	10		10		9-B-7		
Tanker	Fwd Aft	10		10		9-B-7		
Bulk Carrier	Fwd Aft	30		30		9-C-1		
Combination Carrier	Fwd Aft	30		30		9-C-1		
Combination Carrier	Fwd Aft	4	6	10	60.0	9-C-2	1	8
Container-ship	Fwd Aft	14		14		9-C-2		
Combination Carrier	Fwd Aft	20		20		9-C-3		
Container-ship	Fwd Aft	59		59		9-C-3		
General Cargo	Fwd Aft	16		16		9-C-3		
Bulk Carrier	Fwd Aft	112		112		9-C-4		
Combination Carrier	Fwd Aft	100		100		9-C-4		
Container-ship	Fwd Aft	533	1	534	0.2	9-C-4	1	10
General Cargo	Fwd Aft	472	4	476	0.8	9-C-4	1,3	10,11,15
Container-ship	Fwd Aft	10		10		9-C-5		

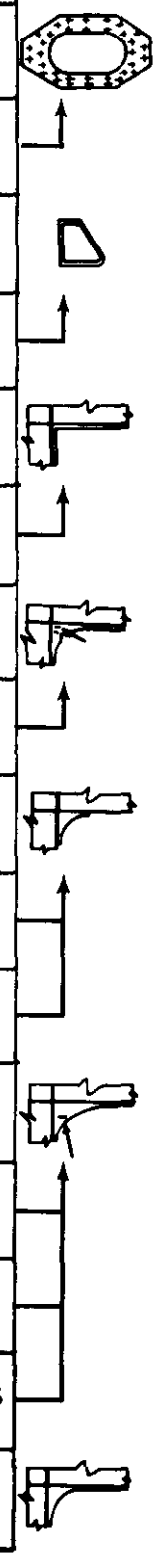


TABLE A-9 DETAIL FAMILY: STRUCTURAL DECK CUTS

SHIP TYPE / LOCATION ON SHIP		No. of Sound Details Observed	No. of Failed Details Observed	Total Number Details Observed	Percent Failures	Detail Family Number	Failure Mode	Failure Cause
Bulk Carrier	Fwd ⊠ Aft	50		50		9-C-6		
Container-ship	Fwd ⊠ Aft	30		30		9-C-6		
General Cargo	Fwd ⊠ Aft	90		90		9-C-6		
Naval	Fwd ⊠ Aft	40		40		9-C-7		

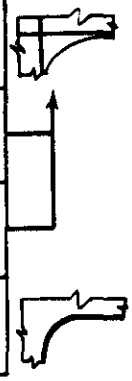


TABLE A-10 DETAIL FAMILY: STANCHION ENDS

SHIP TYPE / LOCATION ON SHIP		No. of Sound Details Observed	No. of Failed Details Observed	Total Number Details Observed	Percent Failures	Detail Family Number	Failure Mode	Failure Cause
Combination Carrier	Fwd ⊠ Aft	10		10		10-A-1		
Container-ship	Fwd ⊠ Aft	8 14	2 6	10 20	20.0 30.0	10-A-1	1 1	8,10 8,10
Container-ship	Fwd ⊠ Aft	99 20 20	1	100 20 20	1.0	10-A-2	1	6,10
General Cargo	Fwd ⊠ Aft	20 20		20 20		10-A-2		
Miscella-neous	Fwd ⊠ Aft	50 130 60		50 130 60		10-A-2		

NOTES:

(A) The above continued table gives information related to individual detail designs in the 86 ship survey.

(B) The rows labeled aft, ⊠, and fwd refer to locations along the ship length. The mid-ship symbol row covers the mid-length throughout the entire cargo section.

(C) The numbers 1, 2, 3 & 4 in the column for failure mode refer to cracks, buckles, cracks and buckles, and twisted/distorted, respectively.

(D) Probable detail failure causes are estimated to be a combination of fatigue and the other factors indicated in the table by appropriate numbers as follows:

5. Shear
6. Tension
7. Combined Tension & Shear
8. Design
9. Fabrication/Workmanship
10. Welding
11. Neglect
12. Misuse/Abuse
13. Questionable
14. Heavy Seas
15. Collision
16. Other - See Discussion

TABLE A-10 DETAIL FAMILY: STANCHION ENDS

LOCATION ON SHIP / SHIP TYPE		No. of Sound Details Observed	No. of Failed Details Observed	Total Number Details Observed	Percent Failures	Detail Family Number	Failure Mode	Failure Cause
Tanker	Fwd Aft	20 10 20		20 10 20		10-A-2		
Miscella-neous	Fwd Aft	10		10		10-A-3		
Naval	Fwd Aft	50 150 30		50 150 30		10-A-3		
Naval	Fwd Aft	20 70 20		20 70 20		10-A-4		
Container-ship	Fwd Aft	20		20		10-A-5		
Tanker	Fwd Aft	20 20		20 20		10-A-5		
Bulk Carrier	Fwd Aft	20		20		10-A-6		
Bulk Carrier	Fwd Aft	10		10		10-A-7		
Combination Carrier	Fwd Aft	20 20		20 20		10-A-7		
Tanker	Fwd Aft	20		20		10-A-8		
Bulk Carrier	Fwd Aft	10		10		10-A-9		
Naval	Fwd Aft	20 20		20 20		10-A-9		
Combination Carrier	Fwd Aft	10		10		10-A-10		
General Cargo	Fwd Aft	10		10		10-A-10		
Naval	Fwd Aft	10 20		10 20		10-A-10		
Combination Carrier	Fwd Aft	20 10		20 10		10-A-11		

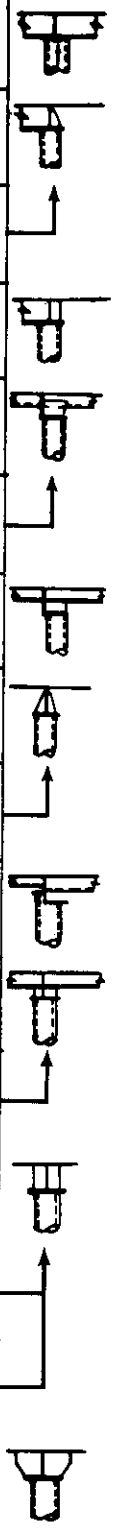


TABLE A-10 DETAIL FAMILY: STANCHION ENDS

SHIP TYPE	LOCATION ON SHIP	No. of Sound Details Observed	No. of Failed Details Observed	Total Number Details Observed	Percent Failures	Detail Family Number	Failure Mode	Failure Cause
Combination Carrier	Fwd	40		40		10-A-12		
	Aft	40		40				
Container-ship	Fwd	10		10		10-A-12		
	Aft							
General Cargo	Fwd	10		10				
		26	36	62	58.1	10-A-12	1,4	12
	Aft	10		10				
Miscella-neous	Fwd	30		30		10-A-12		
	Aft	10		10				
Tanker	Fwd	130		130		10-A-12		
	Aft	20		20				
Container-ship	Fwd							
	Aft	10		10		10-A-13		
Miscella-neous	Fwd	10		10		10-A-14		
	Aft							
Tanker	Fwd	10		10		10-A-14		
	Aft							
Container-ship	Fwd	10		10		10-A-15		
	Aft							
General Cargo	Fwd	83		83		10-A-15		
	Aft							
Tanker	Fwd	30		30		10-A-15		
	Aft							
Combination Carrier	Fwd	20		20		10-A-16		
	Aft							
Naval	Fwd							
	Aft	10		10		10-A-16		

NOTES:

(A) The above continued table gives information related to individual detail designs in the 86 ship survey.

(B) The rows labeled aft, ⊠ , and fwd refer to locations along the ship length. The mid-ship symbol row covers the mid-length throughout the entire cargo section.

(C) The numbers 1, 2, 3 & 4 in the column for failure mode refer to cracks, buckles, cracks and buckles, and twisted/distorted, respectively.

(D) Probable detail failure causes are estimated to be a combination of fatigue and the other factors indicated in the table by appropriate numbers as follows:

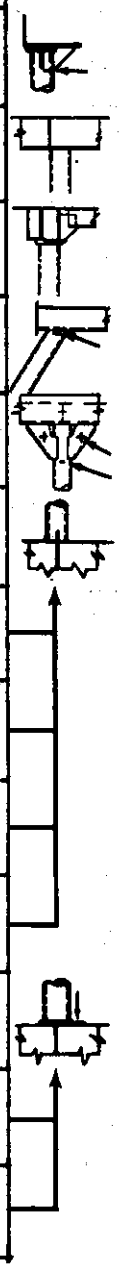
5. Shear
6. Tension
7. Combined Tension & Shear
8. Design
9. Fabrication/Workmanship
10. Welding
11. Neglect
12. Misuse/Abuse
13. Questionable
14. Heavy Seas
15. Collision
16. Other - See Discussion

TABLE A-10 DETAIL FAMILY: STANCHION ENDS

LOCATION ON SHIP / SHIP TYPE		No. of Sound Details Observed	No. of Failed Details Observed	Total Number Details Observed	Percent Failures	Detail Family Number	Failure Mode	Failure Cause
Combination Carrier	Fwd Aft	10		10		10-A-17		
Tanker	Fwd Aft	20		20		10-A-17		
Miscella-neous	Fwd Aft	10		10		10-A-18		
General Cargo	Fwd Aft	10		10		10-A-19		
Tanker	Fwd Aft	20		20		10-A-19		
Combination Carrier	Fwd Aft	10		10		10-A-20		
Naval	Fwd Aft	10 20 10		10 20 10		10-A-21		
Bulk Carrier	Fwd Aft	40 40		40 40		10-A-22		
Miscella-neous	Fwd Aft	20		20		10-A-22		
Tanker	Fwd Aft	10 40		10 40		10-A-22		
Bulk Carrier	Fwd Aft	20 20		20 20		10-A-23		
Container-ship	Fwd Aft	40		40		10-A-23		
Bulk Carrier	Fwd Aft	20		20		10-A-24		
General Cargo	Fwd Aft	40		40		10-A-24		
Tanker	Fwd Aft	20 10		20 10		10-A-24		
Container-ship	Fwd Aft	10		10		10-A-25		

TABLE A-10 DETAIL FAMILY: STANCHION ENDS

LOCATION ON SHIP / SHIP TYPE		No. of Sound Details Observed	No. of Failed Details Observed	Total Number Details Observed	Percent Failures	Detail Family Number	Failure Mode	Failure Cause
General Cargo	Fwd Aft	4	2	6	33.3	10-A-25	1	8
General Cargo	Fwd Aft	34		34		10-A-26		
General Cargo	Fwd Aft	58		58		10-A-27		
General Cargo	Fwd Aft	1	3	4	75.0	10-A-28	1	8,11
General Cargo	Fwd Aft	0	2	2	100.0	10-A-29	3	8
Combination Carrier	Fwd Aft	20 20		20 20		10-B-1		
Container-ship	Fwd Aft	20		20		10-B-1		
General Cargo	Fwd Aft	20 10 10		20 10 10		10-B-1		
Naval	Fwd Aft	10 20 20		10 20 20		10-B-1		
Tanker	Fwd Aft	20		20		10-B-1		
Bulk Carrier	Fwd Aft	70 70		70 70		10-B-2		
Combination Carrier	Fwd Aft	60 60		60 60		10-B-2		
Container-ship	Fwd Aft	120 131 50		120 131 50		10-B-2		



NOTES:

(A) The above continued table gives information related to individual detail designs in the 86 ship survey.

(B) The rows labeled aft, ⊠, and fwd refer to locations along the ship length. The mid-ship symbol row covers the mid-length throughout the entire cargo section.

(C) The numbers 1, 2, 3 & 4 in the column for failure mode refer to cracks, buckles, cracks and buckles, and twisted/distorted, respectively.

(D) Probable detail failure causes are estimated to be a combination of fatigue and the other factors indicated in the table by appropriate numbers as follows:

5. Shear
6. Tension
7. Combined Tension & Shear
8. Design
9. Fabrication/Workmanship
10. Welding
11. Neglect
12. Misuse/Abuse
13. Questionable
14. Heavy Seas
15. Collision
16. Other - See Discussion

TABLE A-10 DETAIL FAMILY: STANCHION ENDS

LOCATION ON SHIP / SHIP TYPE		No. of Sound Details Observed	No. of Failed Details Observed	Total Number Details Observed	Percent Failures	Detail Family Number	Failure Mode	Failure Cause
General Cargo	Fwd	20		20				
		90		90		10-B-2		
	Aft	30		30				
Miscella-neous	Fwd	40		40				
	Aft	10		10		10-B-2		
Naval	Fwd	60		60				
		210		210		10-B-2		
	Aft	90		90				
Tanker	Fwd	208	2	210	1.0		1	6,9,13
		10		10		10-B-2		
	Aft	130		130				
Miscella-neous	Fwd							
	Aft	10		10		10-B-3		
Combination Carrier	Fwd							
	Aft	10		10		10-B-4		
Container-ship	Fwd	6		6		10-B-4		
	Aft							
Bulk Carrier	Fwd							
	Aft	10		10		10-B-5		
General Cargo	Fwd	4		4		10-B-5		
	Aft							
Naval	Fwd	20		20		10-B-6		
	Aft							
Naval	Fwd	20		20		10-B-7		
	Aft	20		20				
Container-ship	Fwd	10		10		10-B-8		
	Aft							
Naval	Fwd	50		50				
		190		190		10-B-8		
	Aft	40		40				
Tanker	Fwd	10		10		10-B-8		
	Aft	10		10				
Combination Carrier	Fwd	0	20	20	100.0	10-B-9	1	8
	Aft							
Container-ship	Fwd	0	10	10	100.0	10-B-9	1	8
	Aft							

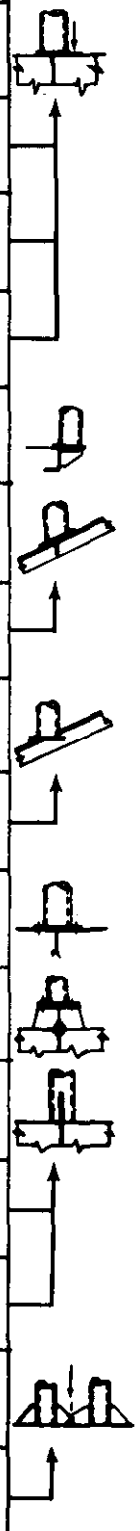
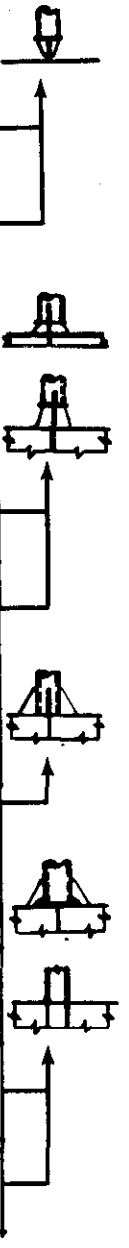


TABLE A-10 DETAIL FAMILY: STANCHION ENDS

LOCATION ON SHIP / SHIP TYPE		No. of Sound Details Observed	No. of Failed Details Observed	Total Number Details Observed	Percent Failures	Detail Family Number	Failure Mode	Failure Cause
Container-ship	Fwd Aft	32		32		10-B-10		
General Cargo	Fwd Aft	40		40		10-B-10		
Naval	Fwd Aft	20 10		20 10		10-B-10		
Naval	Fwd Aft	20 20		20 20		10-B-11		
Combination Carrier	Fwd Aft	20		20		10-B-12		
Naval	Fwd Aft	10		10		10-B-12		
Tanker	Fwd Aft	20		20		10-B-12		
Container-ship	Fwd Aft	40		40		10-B-13		
Naval	Fwd Aft	10 10		10 10		10-B-13		
Bulk Carrier	Fwd Aft	20		20		10-B-14		
Bulk Carrier	Fwd Aft	30		30		10-B-15		
Combination Carrier	Fwd Aft	10 10		10 10		10-B-15		
Container-ship	Fwd Aft	10 30		10 30		10-B-15		



NOTES:

(A) The above continued table gives information related to individual detail designs in the 86 ship survey.

(B) The rows labeled aft, ⊠, and fwd refer to locations along the ship length. The mid-ship symbol row covers the mid-length throughout the entire cargo section.

(C) The numbers 1, 2, 3 & 4 in the column for failure mode refer to cracks, buckles, cracks and buckles, and twisted/distorted, respectively.

(D) Probable detail failure causes are estimated to be a combination of fatigue and the other factors indicated in the table by appropriate numbers as follows:

5. Shear
6. Tension
7. Combined Tension & Shear
8. Design
9. Fabrication/Workmanship
10. Welding
11. Neglect
12. Misuse/Abuse
13. Questionable
14. Heavy Seas
15. Collision
16. Other - See Discussion

TABLE A-10 DETAIL FAMILY: STANCHION ENDS

LOCATION ON SHIP / SHIP TYPE		No. of Sound Details Observed	No. of Failed Details Observed	Total Number Details Observed	Percent Failures	Detail Family Number	Failure Mode	Failure Cause
General Cargo	Fwd	48	2	50	4.0	10-B-15	1,4	12,15
	Aft	10		10				
Naval	Fwd	40		40		10-B-15		
		60		60				
	Aft	50		50				
Tanker	Fwd	30		30		10-B-15		
	Aft	20		20				
Bulk Carrier	Fwd	10		10		10-B-16		
	Aft	10		10				
Combination Carrier	Fwd	30		30		10-B-16		
		30		30				
	Aft	10		10				
Container-ship	Fwd	30		30		10-B-16		
		28		28				
	Aft	20		20				
General Cargo	Fwd	62		62		10-B-16		
	Aft	10		10				
Miscella-neous	Fwd					10-B-16		
	Aft	10		10				
Naval	Fwd	30		30		10-B-16		
		80		80				
	Aft	50		50				
Tanker	Fwd	10		10		10-B-16		
	Aft	70		70				
General Cargo	Fwd					10-B-17		
	Aft	40		40				
Combination Carrier	Fwd					10-B-18		
	Aft	20		20				
Container-ship	Fwd	4		4		10-B-18		
	Aft							
General Cargo	Fwd	6		6		10-B-18		
	Aft	30		30				
Naval	Fwd	20		20		10-B-19		
	Aft							
Combination Carrier	Fwd					10-B-20		
	Aft	10		10				

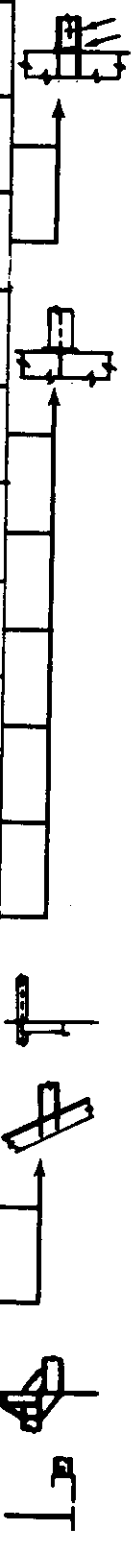
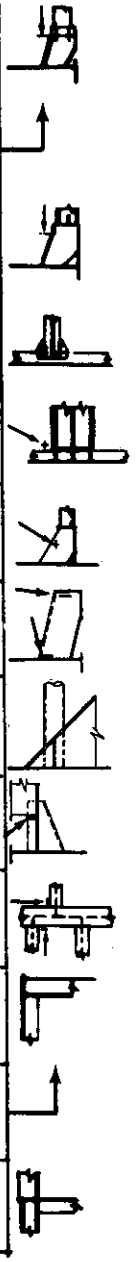


TABLE A-10 DETAIL FAMILY: STANCHION ENDS

LOCATION ON SHIP / SHIP TYPE		No. of Sound Details Observed	No. of Failed Details Observed	Total Number Details Observed	Percent Failures	Detail Family Number	Failure Mode	Failure Cause
Container-ship	Fwd Aft	28	2	30	6.7	10-B-21	1	8,10
Tanker	Fwd Aft	10		10		10-B-21		
Container-ship	Fwd Aft	8	2	10	20.0	10-B-22	1	8
Tanker	Fwd Aft	20		20		10-B-23		
Bulk Carrier	Fwd Aft	4	6	10	60.0	10-B-24	3	8
Tanker	Fwd Aft	9	1	10	10.0	10-B-25	2	12
Container-ship	Fwd Aft	8	6	14	42.9	10-B-26	1	6,8
General Cargo	Fwd Aft	4		4		10-B-27		
General Cargo	Fwd Aft	8	2	10	20.0	10-B-28	1	7
Container-ship	Fwd Aft	8	2	10	20.0	10-C-1	1	8
Container-ship	Fwd Aft	20		20		10-C-2		
Tanker	Fwd Aft	30		30		10-C-2		
Naval	Fwd Aft	20		20		10-C-3		



NOTES:

(A) The above continued table gives information related to individual detail designs in the 86 ship survey.

(B) The rows labeled aft, ⊠ , and fwd refer to locations along the ship length. The mid-ship symbol row covers the mid-length throughout the entire cargo section.

(C) The numbers 1, 2, 3 & 4 in the column for failure mode refer to cracks, buckles, cracks and buckles, and twisted/distorted, respectively.

(D) Probable detail failure causes are estimated to be a combination of fatigue and the other factors indicated in the table by appropriate numbers as follows:

5. Shear
6. Tension
7. Combined Tension & Shear
8. Design
9. Fabrication/Workmanship
10. Welding
11. Neglect
12. Misuse/Abuse
13. Questionable
14. Heavy Seas
15. Collision
16. Other - See Discussion

TABLE A-10 DETAIL FAMILY: STANCHION ENDS

LOCATION ON SHIP / SHIP TYPE	↓	No. of Sound Details Observed	No. of Failed Details Observed	Total Number Details Observed	Percent Failures	Detail Family Number	Failure Mode	Failure Cause
Tanker	Fwd Aft	10		10		10-C-3		
Container-ship	Fwd Aft	10		10		10-C-4		
Bulk Carrier	Fwd Aft	4	6	10	60.0	10-C-5	1	8
Combination Carrier	Fwd Aft	10		10		10-C-6		
General Cargo	Fwd Aft	8	2	10	20.0	10-C-6	1,2	12
Container-ship	Fwd Aft	10		10		10-C-7		
General Cargo	Fwd Aft	52	2	54	3.7	10-C-7	2	8
Tanker	Fwd Aft	20		20		10-C-7		
Tanker	Fwd Aft	20		20		10-C-8		
Combination Carrier	Fwd Aft	10		10		10-C-9		
General Cargo	Fwd Aft	26 20		26 20		10-C-9		
Bulk Carrier	Fwd Aft	20		20		10-C-10		
Combination Carrier	Fwd Aft	10		10		10-C-10		
Tanker	Fwd Aft	20		20		10-C-11		
General Cargo	Fwd Aft	20		20		10-C-12		
Naval	Fwd Aft	20 20		20 20		10-C-12		

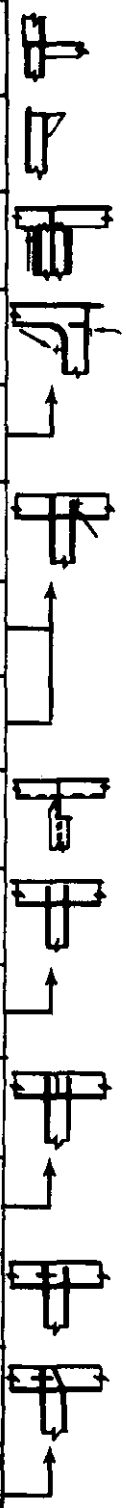
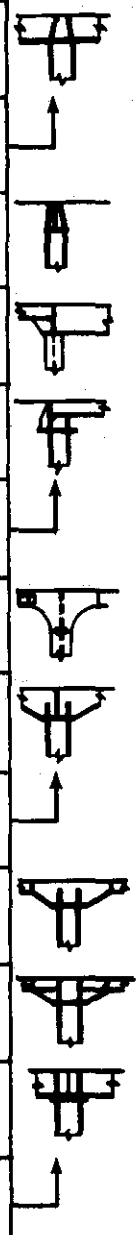


TABLE A-10 DETAIL FAMILY: STANCHION ENDS

SHIP TYPE	LOCATION ON SHIP	No. of Sound Details Observed	No. of Failed Details Observed	Total Number Details Observed	Percent Failures	Detail Family Number	Failure Mode	Failure Cause
General Cargo	Fwd Aft	40		40		10-C-13		
Naval	Fwd Aft	30 70 20		30 70 20		10-C-13		
Naval	Fwd Aft	50 30 20		50 30 20		10-C-14		
General Cargo	Fwd Aft	40		40		10-C-15		
Container-ship	Fwd Aft	10		10		10-C-16		
General Cargo	Fwd Aft	32		32		10-C-16		
Bulk Carrier	Fwd Aft	10		10		10-C-17		
Combination Carrier	Fwd Aft	20		20		10-C-18		
Naval	Fwd Aft	20		20		10-C-18		
Combination Carrier	Fwd Aft	10		10		10-C-19		
Naval	Fwd Aft	20 40 20		20 40 20		10-C-20		
Bulk Carrier	Fwd Aft	20		20		10-C-21		
Container-ship	Fwd Aft	10 10		10 10		10-C-21		



NOTES:

(A) The above continued table gives information related to individual detail designs in the 86 ship survey.

(B) The rows labeled aft, ⊠, and fwd refer to locations along the ship length. The mid-ship symbol row covers the mid-length throughout the entire cargo section.

(C) The numbers 1, 2, 3 & 4 in the column for failure mode refer to cracks, buckles, cracks and buckles, and twisted/distorted, respectively.

(D) Probable detail failure causes are estimated to be a combination of fatigue and the other factors indicated in the table by appropriate numbers as follows:

5. Shear
6. Tension
7. Combined Tension & Shear
8. Design
9. Fabrication/Workmanship
10. Welding
11. Neglect
12. Misuse/Abuse
13. Questionable
14. Heavy Seas
15. Collision
16. Other - See Discussion

TABLE A-10 DETAIL FAMILY: STANCHION ENDS

LOCATION ON SHIP / SHIP TYPE		No. of Sound Details Observed	No. of Failed Details Observed	Total Number Details Observed	Percent Failures	Detail Family Number	Failure Mode	Failure Cause
General Cargo	Fwd Aft	20 10		20 10		10-C-21		
Tanker	Fwd Aft	30		30		10-C-21		
Container-ship	Fwd Aft	10		10		10-C-22		
Tanker	Fwd Aft	10		10		10-C-22		
General Cargo	Fwd Aft	10		10		10-C-23		
Naval	Fwd Aft	20		20		10-C-24		
Container-ship	Fwd Aft	10		10		10-C-25		
Miscella-neous	Fwd Aft	10		10		10-C-25		
Naval	Fwd Aft	10 10 10		10 10 10		10-C-25		
Container-ship	Fwd Aft	20		20		10-C-26		
Tanker	Fwd Aft	10		10		10-C-26		
Container-ship	Fwd Aft	20		20		10-C-27		
Combination Carrier	Fwd Aft	10		10		10-C-28		
Bulk Carrier	Fwd Aft	20		20		10-C-29		
General Cargo	Fwd Aft	6		6		10-C-30		
General Cargo	Fwd Aft	108		108		10-C-31		

TABLE A-10 DETAIL FAMILY: STANCHION ENDS

LOCATION ON SHIP / SHIP TYPE	↓	No. of Sound Details Observed	No. of Failed Details Observed	Total Number Details Observed	Percent Failures	Detail Family Number	Failure Mode	Failure Cause
General Cargo	Fwd ⊠ Aft	70		70		10-C-32		
General Cargo	Fwd ⊠ Aft	0	4	4	100.0	10-C-33	1	6,8
General Cargo	Fwd ⊠ Aft	44		44		10-C-34		
General Cargo	Fwd ⊠ Aft	7	1	8	12.5	10-C-35	4	12,15
General Cargo	Fwd ⊠ Aft	12		12		10-C-36		
General Cargo	Fwd ⊠ Aft	6		6		10-C-37		

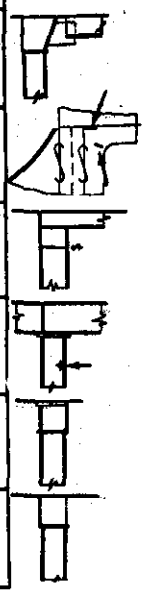
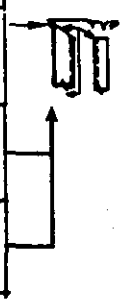


TABLE A-11 DETAIL FAMILY: STIFFENER ENDS

LOCATION ON SHIP / SHIP TYPE	↓	No. of Sound Details Observed	No. of Failed Details Observed	Total Number Details Observed	Percent Failures	Detail Family Number	Failure Mode	Failure Cause
Bulk Carrier	Fwd ⊠ Aft	200 190	 10	200 200	 5.0	11-A-1	 1	 5
Combination Carrier	Fwd ⊠ Aft	280 300 300		280 300 300		11-A-1		
Container-ship	Fwd ⊠ Aft	90 316 340	1	90 317 340	0.3	11-A-1	1	5



NOTES:

(A) The above continued table gives information related to individual detail designs in the 86 ship survey.

(B) The rows labeled aft, ⊠, and fwd refer to locations along the ship length. The mid-ship symbol row covers the mid-length throughout the entire cargo section.

(C) The numbers 1, 2, 3 & 4 in the column for *failure mode refer to cracks*, buckles, cracks and buckles, and twisted/distorted, respectively.

(D) Probable detail failure causes are estimated to be a combination of fatigue and the other factors indicated in the table by appropriate numbers as follows:

5. Shear
6. Tension
7. Combined Tension & Shear
8. Design
9. Fabrication/Workmanship
10. Welding
11. Neglect
12. Misuse/Abuse
13. Questionable
14. Heavy Seas
15. Collision
16. Other - See Discussion

TABLE A-11 DETAIL FAMILY: STIFFENER ENDS

LOCATION ON SHIP / SHIP TYPE		No. of Sound Details Observed	No. of Failed Details Observed	Total Number Details Observed	Percent Failures	Detail Family Number	Failure Mode	Failure Cause
General Cargo	Fwd	70		70				
	⊗	395	8	403	2.0	11-A-1	1	5
	Aft	118	2	120	1.7		1	5
Miscella-neous	Fwd	50		50				
	⊗	60		60		11-A-1		
	Aft	80		80				
Tanker	Fwd	700		700				
	⊗	1523	77	1600	4.8	11-A-1	1	5
	Aft	650		650				
Container-ship	Fwd	80		80				
	⊗	118	2	120	1.7	11-A-2	1	5
	Aft	80		80				
General Cargo	Fwd							
	⊗	85		85		11-A-2		
	Aft	10		10				
Tanker	Fwd	20		20		11-A-2		
	⊗							
	Aft							
Bulk Carrier	Fwd	20		20		11-A-3		
	⊗							
	Aft							
Container-ship	Fwd	290		290				
	⊗	262	5	267	1.9	11-A-3	1	5,10
	Aft	110		110				
General Cargo	Fwd							
	⊗	674		674		11-A-3		
	Aft	50		50				
Naval	Fwd	19	1	20	5.0		1	6,8,14
	⊗					11-A-3		
	Aft	20		20				
Tanker	Fwd	30		30				
	⊗					11-A-3		
	Aft	60		60				
Naval	Fwd	50		50				
	⊗	120		120		11-A-4		
	Aft	70		70				
Container-ship	Fwd	19	1	20	5.0	11-A-5	1	5
	⊗							
	Aft							
Tanker	Fwd	20		20		11-A-5		
	⊗							
	Aft							
Container-ship	Fwd							
	⊗	252	5	257	1.9	11-A-6	1,4	5,7,15
	Aft	18	2	20	10.0		2	8
Naval	Fwd							
	⊗	63	7	70	10.0	11-A-6	1	7
	Aft							

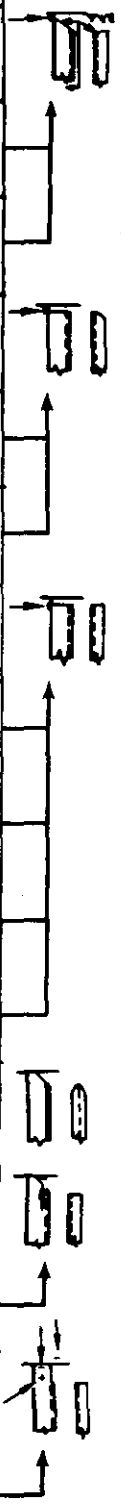


TABLE A-11 DETAIL FAMILY: STIFFENER ENDS

LOCATION ON SHIP / SHIP TYPE		No. of Sound Details Observed	No. of Failed Details Observed	Total Number Details Observed	Percent Failures	Detail Family Number	Failure Mode	Failure Cause
Bulk Carrier	Fwd	170		170				
	⊠	1003		1003		11-A-7		
	Aft	210		210				
Combination Carrier	Fwd	375	5	380	1.3		1	14
	⊠	360		360		11-A-7		
	Aft	250		250				
Container-ship	Fwd	547	3	550	0.5		1	14,15
	⊠	2868	6	2874	0.2	11-A-7	1	8
	Aft	660		660				
General Cargo	Fwd	210		210				
	⊠	3032	6	3038	0.2	11-A-7	1	11
	Aft	500		500				
Miscella-neous	Fwd	110		110				
	⊠	30		30		11-A-7		
	Aft	100		100				
Tanker	Fwd	604	6	610	1.0		1	7,11,14
	⊠	820		820		11-A-7		
	Aft	540		540				
Combination Carrier	Fwd							
	⊠	200		200		11-A-8		
	Aft							
Naval	Fwd	80		80				
	⊠	420		420		11-A-8		
	Aft	166	4	170	2.4		1	8,14
Bulk Carrier	Fwd	80		80				
	⊠	293		293		11-A-9		
	Aft	170		170				
Combination Carrier	Fwd	40		40				
	⊠					11-A-9		
	Aft	90		90				
Container-ship	Fwd	50		50				
	⊠	504		504		11-A-9		
	Aft	150		150				
General Cargo	Fwd	60		60				
	⊠	429	45	474	9.5	11-A-9	1	5,8,11
	Aft	110		110				
Naval	Fwd	240		240				
	⊠	1600		1600		11-A-9		
	Aft	300		300				

NOTES:

(A) The above continued table gives information related to individual detail designs in the 86 ship survey.

(B) The rows labeled aft, ⊠, and fwd refer to locations along the ship length. The mid-ship symbol row covers the mid-length throughout the entire cargo section.

(C) The numbers 1, 2, 3 & 4 in the column for failure mode refer to cracks, buckles, cracks and buckles, and twisted/distorted, respectively.

(D) Probable detail failure causes are estimated to be a combination of fatigue and the other factors indicated in the table by appropriate numbers as follows:

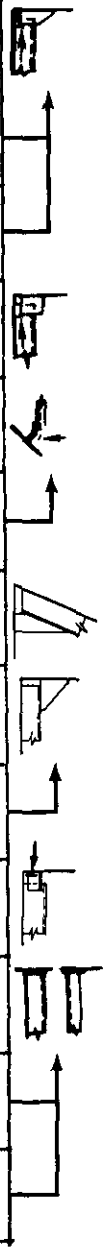
5. Shear
6. Tension
7. Combined Tension & Shear
8. Design
9. Fabrication/Workmanship
10. Welding
11. Neglect
12. Misuse/Abuse
13. Questionable
14. Heavy Seas
15. Collision
16. Other - See Discussion

TABLE A-11 DETAIL FAMILY: STIFFENER ENDS

SHIP TYPE / LOCATION ON SHIP		No. of Sound Details Observed	No. of Failed Details Observed	Total Number Details Observed	Percent Failures	Detail Family Number	Failure Mode	Failure Cause
Tanker	Fwd	87	3	90	3.3	11-A-9	1	11
	Aft	130		130				
Naval	Fwd	230		230		11-A-10		
		1500		1500				
	Aft	400		400				
Container-ship	Fwd							
	Aft	20		20		11-A-11		
Naval	Fwd	60		60		11-A-11		
	Aft							
Tanker	Fwd	50		50		11-A-11		
	Aft	60		60				
Bulk Carrier	Fwd							
	Aft	20		20		11-A-12		
Naval	Fwd	30		30		11-A-12		
		110		110				
	Aft	50		50				
Tanker	Fwd							
	Aft	40		40		11-A-12		
Combination Carrier	Fwd	30		30		11-B-1		
	Aft	30		30				
Container-ship	Fwd	491	2	493	0.4	11-B-1	1	5
	Aft	80		80				
General Cargo	Fwd	786	4	790	0.5	11-B-1	1	10,11
	Aft							
Tanker	Fwd	20		20		11-B-1		
		195	5	200	2.5		1	7
	Aft	16	4	20			1	5
Container-ship	Fwd	60		60		11-B-2		
	Aft							
Container-ship	Fwd	50		50		11-B-3		
		832	8	840	1.0		1	7
	Aft	247	3	250	1.2		2	14
General Cargo	Fwd	60		60		11-B-3		
	Aft							
Bulk Carrier	Fwd	111		111		11-B-4		
	Aft							

TABLE A-11 DETAIL FAMILY: STIFFENER ENDS

LOCATION ON SHIP / SHIP TYPE		No. of Sound Details Observed	No. of Failed Details Observed	Total Number Details Observed	Percent Failures	Detail Family Number	Failure Mode	Failure Cause
Container-ship	Fwd Aft	201		201		11-B-4		
General Cargo	Fwd Aft	20 159 50	2	20 161 50	1.2	11-B-4	2	12,15
Tanker	Fwd Aft	1908	12	1920	0.6	11-B-4	1	7
Container-ship	Fwd Aft	140 59	1	140 60	1.7	11-B-5	1	7
Container-ship	Fwd Aft	37	1	38	2.6	11-B-6	1	8
General Cargo	Fwd Aft	74	4	78	5.1	11-B-6	1	11
Bulk Carrier	Fwd Aft	412		412		11-B-7		
Bulk Carrier	Fwd Aft	26		26		11-B-8		
Container-ship	Fwd Aft	30		30		11-B-8		
General Cargo	Fwd Aft	160	2	162	1.2	11-B-9	1	11
Container-ship	Fwd Aft	41		41		11-C-1		
General Cargo	Fwd Aft	158 30		158 30		11-C-1		
Tanker	Fwd Aft	50		50		11-C-1		



NOTES:

(A) The above continued table gives information related to individual detail designs in the 86 ship survey.

(B) The rows labeled *aft*, ⊠, and fwd refer to locations along the ship length. The mid-ship symbol row covers the mid-length throughout the entire cargo section.

(C) The numbers 1, 2, 3 & 4 in the column for failure mode refer to cracks, buckles, cracks and buckles, and twisted/distorted, respectively.

(D) Probable detail failure causes are estimated to be a combination of fatigue and the other factors indicated in the table by appropriate numbers as follows:

5. Shear
6. Tension
7. Combined Tension & Shear
8. Design
9. Fabrication/Workmanship
10. Welding
11. Neglect
12. Misuse/Abuse
13. Questionable
14. Heavy Seas
15. Collision
16. Other - See Discussion

TABLE A-11 DETAIL FAMILY: STIFFENER ENDS

LOCATION ON SHIP / SHIP TYPE		No. of Sound Details Observed	No. of Failed Details Observed	Total Number Details Observed	Percent Failures	Detail Family Number	Failure Mode	Failure Cause
General Cargo	Fwd Aft	16		16		11-C-2		
Tanker	Fwd Aft	40		40		11-C-2		
Naval	Fwd Aft	40 170 60		40 170 60		11-C-3		
Naval	Fwd Aft	40 60 40		40 60 40		11-C-4		
Container-ship	Fwd Aft	60		60		11-C-5		
Naval	Fwd Aft	13	7	20	35.0	11-C-6	1	8
Bulk Carrier	Fwd Aft	72		72		11-D-1		
Combination Carrier	Fwd Aft	20 20		20 20		11-D-1		
Container-ship	Fwd Aft	60		60		11-D-1		
General Cargo	Fwd Aft	30		30		11-D-1		
Tanker	Fwd Aft	110		110		11-D-1		
Container-ship	Fwd Aft	193		193		11-D-2		
Miscella-neous	Fwd Aft	50 40		50 40		11-D-2		
Tanker	Fwd Aft	30 60		30 60		11-D-2		
Naval	Fwd Aft	200 1060 360		200 1060 360		11-D-3		
Container-ship	Fwd Aft	58	2	60	1.7	11-D-4	1	7

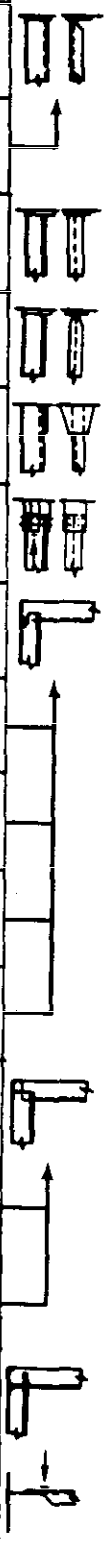
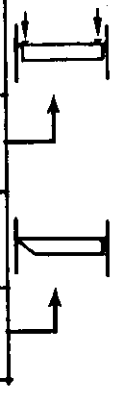


TABLE A-11 DETAIL FAMILY: STIFFENER ENDS

LOCATION ON SHIP / SHIP TYPE		No. of Sound Details Observed	No. of Failed Details Observed	Total Number Details Observed	Percent Failures	Detail Family Number	Failure Mode	Failure Cause
Tanker	Fwd Aft	2108 160	42	2150 160	2.0	11-D-5	1	7
General Cargo	Fwd Aft	60		60		11-E-1		
General Cargo	Fwd Aft	108		108		11-E-2		
Tanker	Fwd Aft	10 120		10 120		11-E-2		
Tanker	Fwd Aft	20 20		20 20		11-E-3		

TABLE A-12 DETAIL FAMILY: PANEL STIFFENERS

LOCATION ON SHIP / SHIP TYPE		No. of Sound Details Observed	No. of Failed Details Observed	Total Number Details Observed	Percent Failures	Detail Family Number	Failure Mode	Failure Cause
Naval	Fwd Aft	6	24	30	80.0	12-A-1	1	5,8
Tanker	Fwd Aft	150 60 330		150 60 330		12-A-1		
General Cargo	Fwd Aft	20		20		12-A-2		
Tanker	Fwd Aft	40		40		12-A-2		



NOTES:

(A) The above continued table gives information related to individual detail designs in the 86 ship survey.

(B) The rows labeled aft, ⊠, and fwd refer to locations along the ship length. The mid-ship symbol row covers the mid-length throughout the entire cargo section.

(C) The numbers 1, 2, 3 & 4 in the column for failure mode refer to cracks, buckles, cracks and buckles, and twisted/distorted, respectively.

(D) Probable detail failure causes are estimated to be a combination of fatigue and the other factors indicated in the table by appropriate numbers as follows:

5. Shear
6. Tension
7. Combined Tension & Shear
8. Design
9. Fabrication/Workmanship
10. Welding
11. Neglect
12. Misuse/Abuse
13. Questionable
14. Heavy Seas
15. Collision
16. Other - See Discussion

TABLE A-12 DETAIL FAMILY: PANEL STIFFENERS

LOCATION ON SHIP / SHIP TYPE		No. of Sound Details Observed	No. of Failed Details Observed	Total Number Details Observed	Percent Failures	Detail Family Number	Failure Mode	Failure Cause
Bulk Carrier	Fwd	30		30				
	⊠	600	8	608	1.3	12-A-3	1,2	15
	Aft	60		60				
Combination Carrier	Fwd	120		120				
	⊠	400		400		12-A-3		
	Aft	210		210				
Container-ship	Fwd	150		150				
	⊠	1295	2	1297	0.2	12-A-3	2	15
	Aft	320		320				
General Cargo	Fwd	100		100				(8,11,
	⊠	1731	103	1834	5.6	12-A-3	1,2,4	12,16)
	Aft	215	5	220	2.3		1	11
Miscella-neous	Fwd	40		40				
	⊠	60		60		12-A-3		
	Aft	70		70				
Naval	Fwd	200		200				
	⊠	2100		2100		12-A-3		
	Aft	400		400				
Tanker	Fwd	210		210				
	⊠	670		670		12-A-3		
	Aft	490		490				
Naval	Fwd							
	⊠							
	Aft	150		150		12-A-4		
Tanker	Fwd							
	⊠							
	Aft	90		90		12-A-4		
Combination Carrier	Fwd	60		60		12-A-5		
	⊠							
	Aft							
Container-ship	Fwd							
	⊠	219	3	222	1.4	12-A-5	1	14
	Aft							
General Cargo	Fwd							
	⊠	10		10		12-A-5		
	Aft							
Miscella-neous	Fwd							
	⊠							
	Aft	40		40		12-A-5		
Tanker	Fwd							
	⊠							
	Aft	40		40		12-A-5		
Bulk Carrier	Fwd	291	9	300	3.0		1	14
	⊠	1621	21	1642	1.3	12-A-6	1	7,15
	Aft	460		460				
Combination Carrier	Fwd	40		40				
	⊠	160		160		12-A-6		
	Aft	90		90				

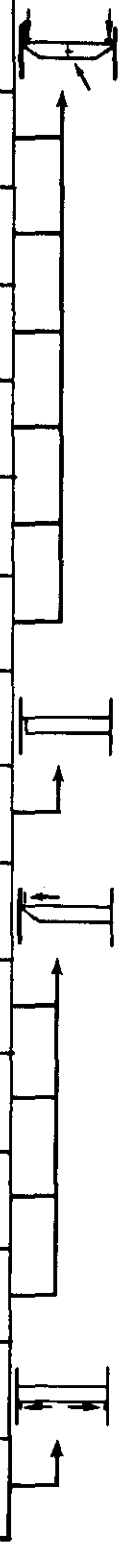
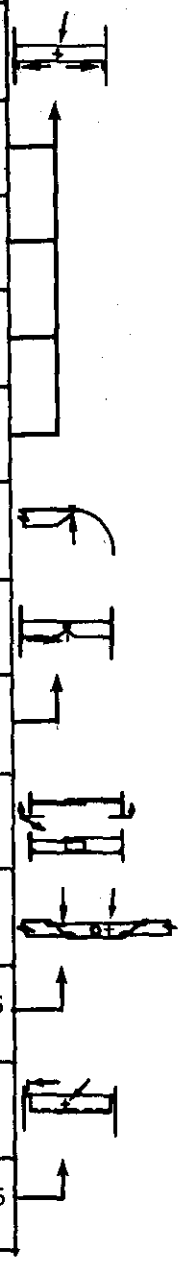


TABLE A-12 DETAIL FAMILY: PANEL STIFFENERS

LOCATION ON SHIP / SHIP TYPE		No. of Sound Details Observed	No. of Failed Details Observed	Total Number Details Observed	Percent Failures	Detail Family Number	Failure Mode	Failure Cause
Container-ship	Fwd	40		40				
	⊠	623	2	625	0.3	12-A-6	1,2	15
	Aft	60		60				
General Cargo	Fwd							
	⊠	2283	60	2343	2.6	12-A-6	1,2,4	(8,11, 12,15)
	Aft	70		70				
Miscella-neous	Fwd	20		20				
	⊠	20		20		12-A-6		
	Aft	30		30				
Naval	Fwd	50		50				
	⊠	400		400		12-A-6		
	Aft	80		80				
Tanker	Fwd	80		80				
	⊠	260		260		12-A-6		
	Aft	230		230				
Naval	Fwd							
	⊠	0	10	10	100.0	12-A-7	1	5,8
	Aft							
Bulk Carrier	Fwd							
	⊠							
	Aft	17	3	20	15.0	12-A-8	1	8
Naval	Fwd	50		50				
	⊠	330		330		12-A-8		
	Aft	110		110				
Bulk Carrier	Fwd							
	⊠	30		30		12-A-9		
	Aft	50		50				
Combination Carrier	Fwd							
	⊠	702	8	710	1.1	12-A-10	1	5,10
	Aft							
General Cargo	Fwd							
	⊠	131	27	158	17.1	12-A-10	1,2	10,12,15
	Aft							
Container-ship	Fwd	50		50				
	⊠	470	25	495	5.1	12-B-1	1,2	11
	Aft	220		220				
General Cargo	Fwd							
	⊠	93	20	113	17.7	12-B-1	2,4	8,12,15
	Aft							



NOTES:

(A) The above continued table gives information related to individual detail designs in the 86 ship survey.

(B) The rows labeled aft, ⊠, and fwd refer to locations along the ship length. The mid-ship symbol row covers the mid-length throughout the entire cargo section.

(C) The numbers 1, 2, 3 & 4 in the column for failure mode refer to cracks, buckles, cracks and buckles, and twisted/distorted, respectively.

(D) Probable detail failure causes are estimated to be a combination of fatigue and the other factors indicated in the table by appropriate numbers as follows:

5. Shear
6. Tension
7. Combined Tension & Shear
8. Design
9. Fabrication/Workmanship
10. Welding
11. Neglect
12. Misuse/Abuse
13. Questionable
14. Heavy Seas
15. Collision
16. Other - See Discussion

TABLE A-12 DETAIL FAMILY: PANEL STIFFENERS

SHIP TYPE / LOCATION ON SHIP		No. of Sound Details Observed	No. of Failed Details Observed	Total Number Details Observed	Percent Failures	Detail Family Number	Failure Mode	Failure Cause
Bulk Carrier	Fwd	93		93		12-B-2		
	Aft							
Container-ship	Fwd	20		20		12-B-2		
	Aft	40		40				
General Cargo	Fwd	50		50				
		171	165	336	49.1	12-B-2	1	5,11,16
	Aft	60		60				
Naval	Fwd	60		60		12-B-2		
	Aft							
Tanker	Fwd	30		30		12-B-2		
	Aft	50		50				
Bulk Carrier	Fwd	30		30				
		325		325		12-B-3		
	Aft	20		20				
Combination Carrier	Fwd	90		90				
		270		270		12-B-3		
	Aft	190		190				
Container-ship	Fwd	60		60				
		897	1	898	0.1	12-B-3	2,4	8,14,15
	Aft	116	4	120	3.3		1	11,12
General Cargo	Fwd	50		50				
		1508	26	1534	1.7	12-B-3	2,4	12,15
	Aft	80		80				
Miscella-neous	Fwd	20		20				
		30		30		12-B-3		
	Aft	30		30				
Naval	Fwd	20		20				
		70		70		12-B-3		
	Aft	20		20				
Tanker	Fwd	110		110				
		210		210		12-B-3		
	Aft	200		200				
Bulk Carrier	Fwd	10		10				
		581		581		12-B-4		
	Aft	20		20				
Combination Carrier	Fwd	30		30				
		70		70		12-B-4		
	Aft	60		60				
Container-ship	Fwd	20		20				
		30		30		12-B-4		
	Aft	30		30				
General Cargo	Fwd	10		10				
		617	38	655	5.8	12-B-4	1,4	(11,12,
	Aft	40		40				14,15)

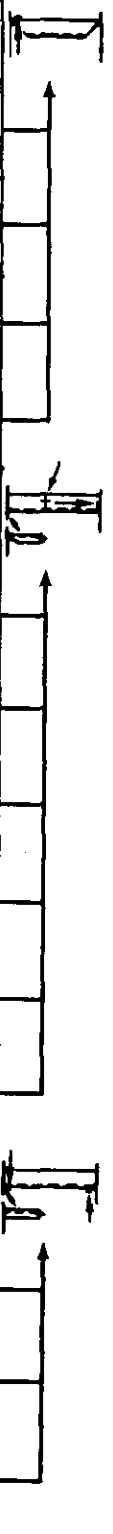
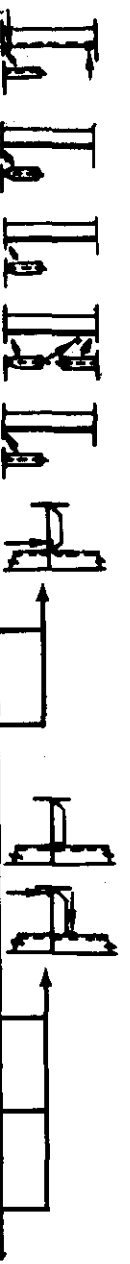


TABLE A-12 DETAIL FAMILY: PANEL STIFFENERS

LOCATION ON SHIP / SHIP TYPE		No. of Sound Details Observed	No. of Failed Details Observed	Total Number Details Observed	Percent Failures	Detail Family Number	Failure Mode	Failure Cause
Tanker	Fwd Aft	17	3	20	15.0	12-B-4	1	14
Naval	Fwd Aft	20 210 40		20 210 40		12-B-5		
Naval	Fwd Aft	10 20 20		10 20 20		12-B-6		
Naval	Fwd Aft	10 1694	6	10 1700	0.4	12-B-7	2	15
Naval	Fwd Aft	330 3400 700		330 3400 700		12-B-8		
Container-ship	Fwd Aft	120		120		12-C-1		
General Cargo	Fwd Aft	60	10	70	14.3	12-C-1	1	8
Tanker	Fwd Aft	10 30		10 30		12-C-1		
Naval	Fwd Aft	20 50 180		20 50 180		12-C-2		
Bulk Carrier	Fwd Aft	90 304 190	3	90 307 190	1.0	12-C-3	1	6,8,11
Container-ship	Fwd Aft	596		596		12-C-3		
Miscella-neous	Fwd Aft	50 310 60		50 310 60		12-C-3		
Tanker	Fwd Aft	350 4882 370	18	350 4900 370	0.4	12-C-3	1	7,10



NOTES:

(A) The above continued table gives information related to individual detail designs in the 86 ship survey.

(B) The rows labeled aft, ⊠, and fwd refer to locations along the ship length. The mid-ship symbol row covers the mid-length throughout the entire cargo section.

(C) The numbers 1, 2, 3 & 4 in the column for failure mode refer to cracks, buckles, cracks and buckles, and twisted/distorted, respectively.

(D) Probable detail failure causes are estimated to be a combination of fatigue and the other factors indicated in the table by appropriate numbers as follows:

5. Shear
6. Tension
7. Combined Tension & Shear
8. Design
9. Fabrication/Workmanship
10. Welding
11. Neglect
12. Misuse/Abuse
13. Questionable
14. Heavy Seas
15. Collision
16. Other - See Discussion

TABLE A-12 DETAIL FAMILY: PANEL STIFFENERS

LOCATION ON SHIP / SHIP TYPE		No. of Sound Details Observed	No. of Failed Details Observed	Total Number Details Observed	Percent Failures	Detail Family Number	Failure Mode	Failure Cause
Combination Carrier	Fwd	50		50		12-C-4		
	Aft	120		120				
		50		50				
Container-ship	Fwd	50		50		12-C-4		
	Aft	300		300				
		90		90				
Miscella-neous	Fwd	30		30		12-C-4		
	Aft	230		230				
		50		50				
Tanker	Fwd	240		240		12-C-4		
	Aft	2200		2200				
		120		120				
Bulk Carrier	Fwd	96		96		12-C-5		
	Aft							
General Cargo	Fwd							
	Aft	68	12	80	15.0	12-C-5	1,2	14
Naval	Fwd	50		50		12-C-5		
	Aft	1000		1000				
		110		110				
Tanker	Fwd	90		90		12-C-5		
	Aft	740		740				
		180		180				
Bulk Carrier	Fwd	30		30		12-C-6		
	Aft	358		358				
		70		70				
Naval	Fwd	20		20		12-C-6		
	Aft	80		80				
		30		30				
Tanker	Fwd							
	Aft	110		110		12-C-6		
Tanker	Fwd							
	Aft	400		400		12-C-7		
		60		60				
Bulk Carrier	Fwd	200		200		12-C-8		
	Aft							
		60		60				
Combination Carrier	Fwd	30		30		12-C-8		
	Aft							
		80		80				
Container-ship	Fwd							
	Aft	50		50		12-C-8		
Tanker	Fwd	50		50		12-C-8		
	Aft	410		410				
		90		90				

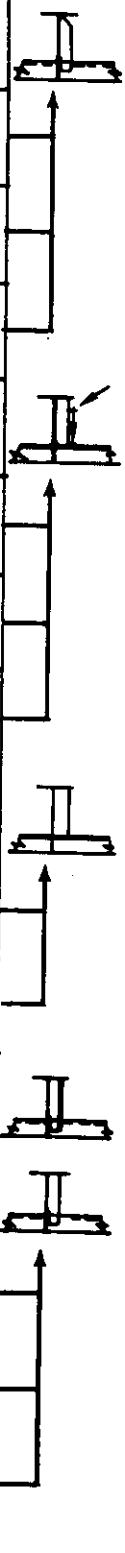


TABLE A-12 DETAIL FAMILY: PANEL STIFFENERS

LOCATION ON SHIP / SHIP TYPE		No. of Sound Details Observed	No. of Failed Details Observed	Total Number Details Observed	Percent Failures	Detail Family Number	Failure Mode	Failure Cause	
Tanker	Fwd Mid Aft	60 390 80		60 390 80		12-C-9			
Naval	Fwd Mid Aft	240		240		12-D-1			
Container-ship	Fwd Mid Aft	376	54	430	12.6	12-D-2	1	(8,10, 14,15)	
Tanker	Fwd Mid Aft	20 290 40		20 290 40		12-D-2			
General Cargo	Fwd Mid Aft	80		80		12-D-3			
Bulk Carrier	Fwd Mid Aft	12		12		12-D-4			
Container-ship	Fwd Mid Aft	1277	92	1369	6.7	12-D-4	1,2	8,10,15	
Combination Carrier	Fwd Mid Aft	70		70		12-D-5			
General Cargo	Fwd Mid Aft	20		20		12-D-5			
Container-ship	Fwd Mid Aft	658	8	666	1.2	12-D-6	1,2	8,14	
Combination Carrier	Fwd Mid Aft	40 110		40 110		12-E-1			
Container-ship	Fwd Mid Aft	40		40		12-E-1			
Container-ship	Fwd Mid Aft	171	10	181	5.5	12-E-2	1	12	

NOTES:

(A) The above continued table gives information related to individual detail designs in the 86 ship survey.

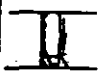
(B) The rows labeled aft, Mid, and fwd refer to locations along the ship length. The mid-ship symbol row covers the mid-length throughout the entire cargo section.

(C) The numbers 1, 2, 3 & 4 in the column for failure mode refer to cracks, buckles, cracks and buckles, and twisted/distorted, respectively.

(D) Probable detail failure causes are estimated to be a combination of fatigue and the other factors indicated in the table by appropriate numbers as follows:

5. Shear
6. Tension
7. Combined Tension & Shear
8. Design
9. Fabrication/Workmanship
10. Welding
11. Neglect
12. Misuse/Abuse
13. Questionable
14. Heavy Seas
15. Collision
16. Other - See Discussion

TABLE A-12 DETAIL FAMILY: PANEL STIFFENERS

LOCATION ON SHIP / SHIP TYPE		No. of Sound Details Observed	No. of Failed Details Observed	Total Number Details Observed	Percent Failures	Detail Family Number	Failure Mode	Failure Cause	
Container-ship	Fwd Aft	60 80		60 80		12-E-3			
Container-ship	Fwd Aft	59	1	60	1.7	12-F-1	1	5,10	
Container-ship	Fwd Aft	69	1	70	1.4	12-F-2	1	15	
Container-ship	Fwd Aft	76	4	80	5.0	12-F-3	1	7,8	
Tanker	Fwd Aft	20 60		20 60		12-F-4			
Container-ship	Fwd Aft	143 88	2	143 90	2.2	12-F-5	1	7	

* U S GOVERNMENT PRINTING OFFICE · 1980