DEPARTMENT OF TRANSPORTATION
UNITED STATES COAST GUARD

U.S. Coast Guard (G-MMT-4)
Washington, DC 20593
(202) 426-2197

NVIC 11-80
9 Oct 1980

NAVIGATION AND VESSEL INSPECTION CIRCULAR NO. 11-80

Subj: .Structural Plan Review Guidelines for Aluminum Small Passenger Vessel

1. PURPOSE. The attached guidelines for structural plan review of small passenger vessels (Subchapter T) constructed of aluminum are intended to facilitate plan review of such vessels by the local Officer in Charge, Marine Inspection (OCMI), without having to refer the plans to a Coast Guard Merchant Marine Technical (mmt) Branch for review. The guidelines are applicable to hull forms similar to those of commercial crewboats used primarily in the oil exploitation industry. Such boats have deep-Vee hull forms, lengths from 60 to 135 feet, and speeds up to about 24 knots. Boats meeting the guidelines are structurally satisfactory for full Ocean Service applications.

2. DISCUSSION.

   a. The standards specified in Subpart 177.10 of Title 46, Code of Federal Regulations, for small passenger vessels envisioned a fairly simple process for structural plan review. For many years the experience of the local OCMI and the few structural standards and guidelines that were available to him were sufficient for most structural approval purposes.

   b. The industrial crewboat industry in this country began and has flourished over the past three decades primarily within the local boundaries of the New Orleans Marine Inspection Zone. The evolution of the modern crewboat was gradual, and the knowledge and experience of the local OCMI was sufficient for most routine plan approval of aluminum crewboats and similar small passenger vessels. In recent years, however, the structural designs have become more sophisticated, and the boats are being built elsewhere around the country. The absence of published standards has forced the OCMI's to forward plans to District mmt branches for formal structural analysis and review. This has increased both the plan review workload and the turn around time for plans. The lack of established structural standards for these boats has been a problem in mmt as well.

   c. There have been a number of technical papers the subject within the last 10 years, and various organizations are presently working on guidelines or standards that my eventually be applied to these boats. The similarity of hull forms and operational service of crewboats makes possible general guidelines that are applicable to most of these vessels. The plan review guidance which is attached will be used by the Coast Guard for structural plan review and approval of applicable aluminum boats until other acceptable guidance or standards are available.

3. ACTION. Enclosure (1) contains guidelines based on satisfactory historical experience, and it should be used in structural plan review of small passenger vessels which meet the applicability parameters stated within. Vessels which do not meet the applicability parameters should be reviewed by other means or referred to a Merchant Marine Technical Branch for review. These guidelines are not mandatory on the designer, and any other acceptable structural standards such as Lloyd's Rules or American Bureau of Shipping Rules may be used as appropriate.

CLYDE T. LUSK, Jr.
Acting Chief, Office of Merchant Marine Safety

End: (1) Aluminum Small Passenger Vessel Structure Review Guide NON-STANDARD DISTRIBUTION:

Ce: Baltimore (75); San Francisco, Mobile, Guam, Pittsburgh, Providence, Norfolk (50); Galveston (30); Cleveland, Portland, OR, Sturgeon Bay (25); San Diego, Savannah, Buffalo, Corpus Christi (20); Tampa, Milwaukee, Louisville, Detroit, Toledo, Nashville, Anchorage (15); Portland, ME, Duluth, Charleston, Huntington, Minneapolis-St Paul (Dubuque), San Juan (10); Juneau, Cincinnati, Memphis, Wilmington, Paducah, Albany (5) extra

Cm: New Orleans (250); New York (200); Seattle (100); Houston (50); Terminal Is. (LA-LB), Philadelphia (40) extra

Em: Morgan City (200); New London, Houma (30); Ludington (8) extra Ketchikan, Lake Charles (5) extra

Aluminum Small Passenger Vessel Structure Review Guide

Purpose - This guide is intended to facilitate structural plan review of an aluminum small passenger vessel of common hull form and whose design is based on the commercial crewboat used in the offshore oil industry. There is a wealth of successful operational experience with such boats, but the designs are fairly complex and not based on a standard set of rules. This guide will enable a person with limited engineering background to quickly check a design for minimum structural adequacy. Designs of unusual form or application should be reviewed by Merchant Marine Technical personnel. Values given in this guide are average minimums based on hull forms and structural arrangements typical of Gulf of Mexico industrial crewboats built between 1975 and 1980. This guide should not be used for designing the structure of a boat. The minimum scantlings shown herein are to be used as a general indication of the adequacy of' a structural component. There are many other factors involved in the proper design of' a boat which are not considered here, such as serviceability, special operating requirements, and construction practices.

Applicability - A large sampling of aluminum crewboat plans from the files of Commander, Eighth Coast Guard District (mmt) indicated a fairly narrow range for design parameters. The tables and figures in this guide are based on those existing vessels and are generally applicable within the following ranges:

Length (L)	60 ft to 135 ft (See 46 CFR 75.10-19)
Speed	16 kts to 24 kts
Beam	6 ft + .15L (±10%)
Deadrise	13 to 20 degrees
LCG	Midships to 8% of length aft of midships

Displacement generally within range of Figure 3
Vee hull form approximately as shown in Figure 5

The term "crewboat" is used in this guide to refer to any aluminum vessel lying within the above ranges of' parameters.

Summary - The remainder of this guide is organized into the following headings:

Hull Strength - A discussion of the various components that make up a structure, their individual functions, and how each is evaluated for structural adequacy.

Hull Loads - How the various loads acting on structural components are evaluated.

Material Properties - A discussion of maximum allowable stress for various structural components.

Evaluation of Structure - A step-by-step procedure for evaluating the adequacy of' structural components.

Scantling Review Worksheet - A recommended form to use during the structural evaluation.

References - A selected list of reference material used in developing this guide.

Figures - Sketches and graphs to be used during the structural review.

Tables of Section Modulus of various shapes attached to plating (Appendix A).

Worked Example of a Structural Review (Appendix B).

Hull Strength - The structure of a boat is essentially an arrangement of plating and framing. Figure 1 is an example of a typical stiffened structural panel designed to support (or resist) a lateral load on its surface. In a boat, the lateral load is from the water pressure on the outside of the hull. Assume that the four edges of the panel shown are bounded by substantial structures such as bulkheads, decks, or side or bottom structures, so that the edges of the panel remain straight and in place, or very nearly so. Those edges are considered "supported" by the structure that keeps them rigid.

If the plate were fairly small and thick and carrying a light load, no additional stiffening or reinforcement would be required. In normal ship structures such is not the case, so structural shapes such as angles and tees are used to stiffen the panel. The strength of a stiffened panel comes mostly from the stiffeners and not the plating, which means that the majority of the load is carried by the stiffeners. The terminology used in this guide will be to call those stiffeners running longitudinally (fore and aft) "longitudinals" and those running transversely (athwartships) "transverse frames." When the discussion applies to both longitudinals and transverse frames, the terms "frame," "member," and "beam" may be used in a generic sense. Various other terminology is used to describe framing, such as longitudinal frames, (longitudinals), transverses, stiffeners, stringers, shapes, and girders, to name some of the most common. The terms used in this guide are somewhat standard, but other terms may be used elsewhere in the industry. A typical hull structural panel consists of plating, longitudinals, and transverse frames. It is important that the user of this guide become familiar with structural arrangements so that individual structural components can be recognized by their function rather than by their name.

Figure 1 represents a structural arrangement commonly used in crewboats. The larger of the two types of structural frames running from one edge of the panel to the other are the primary strength members of the panel. They are designed to carry the entire load of the panel, and therefore are considered to be supported only at their ends. In typical crewboat designs, these are the transverse frames. Running perpendicular to these are the smaller longitudinals, which are supported by the transverse frames. For the panel shown in Figure 1, the unsupported span of the transverse frames is their entire length, which is also the width of the panel. The longitudinals must carry only the load between transverse frames, so the unsupported span of the longitudinals is the spacing of the transverse frames (not the length of the panel). The plating must carry the load between the longitudinals, so it is considered to have a span equal to the spacing of the longitudinals. In general, the span of plating is the spacing of the attached frames which are closest together, which in most crewboat designs is the spacing of the longitudinals. If a frame were not welded or otherwise firmly attached to the plating, it could not be considered a support for the plating.

Figure 2 shows a typical side and bottom structure for a crewboat. The chine is the dividing line between bottom structure and side structure. The side structure is identical to the stiffened panel of Figure 1, with the fore and aft edges supported by transverse bulkheads, the upper edge by the deck, and the lower edge by the bottom panel. The bottom structure differs from the side structure in that there are two very large longitudinal members called “keelsons." There may be any number of keelsons installed between the keel and chine, and they may or may not be large enough to be considered as supports for the b6ttom transverse frames. Because the width of the bottom panel and the load it carries are larger than those of the side panel, the transverse frames on the bottom would have to be much larger than those on the side to carry the load. Therefore, keelsons are installed to help support the transverse frames. The keelsons shown in Figure 2 also stiffen the bottom pitting and replace longitudinals that otherwise would be located there.
Another important design consideration is continuity of structure. To provide rigidity to the overall structure, the frames must be properly aligned. The deck, side, and bottom transverse frames must all be in the same transverse plane of the boat, and longitudinals must be properly aligned on both sides of a transverse frame or bulkhead. Alignment is necessary to assure that the various loads being carried by the structure will have a smooth and continuous path to follow. In addition to continuity of alignment,

continuity of size is also important to ensure that the structure is capable of transmitting a load to adjacent structure. Side transverse frames in particular must provide a satisfactory load path between the deck and bottom transverse frames, and so they must be sized accordingly.

The foregoing discussion applies primarily to the structure in the mid-portion of the boat. Hull structure toward the ends may be configured differently to withstand particular loads such as wave impact or propeller induced vibration.

Hull Loads - Each area of the boat is designed to accommodate the loading it is expected to encounter. The most severe loads on a crewboat are the loads on the hull bottom due to the combined effects of the advance of the boat into waves and the pitching and heaving accelerations of the boat. The resulting pressures are cal1ed "impact" pressures for lack of a better term, although the physical process is not a true impact in the traditional sense of the word. The maximum pressure of each impact exists only momentarily and over a small portion. of the hull bottom. The location on the hull, the size of the area affected, and the magnitude of maximum impact pressure vary with each wave encounter. The effects of the impact are less severe when considered over a large area of the hull bottom. Figure LI portrays this varying impact pressure profile on the hull bottom. Structural components such as plating and longitudinals must be designed for a higher percentage of the impact pressure than the transverse frames, which support a greater area. Figure 3 shows impact pressure as a function of vessel length and normal operating displacement. Other variables such as speed and longitudinal center of gravity are of secondary importance in their effect on impact pressure for typical crewboats.

The remainder of the hull structure can be reviewed assuming a static (constant) pressure based on extreme but realistic expected loadings as indicated in Figures 5 through 7.

Material Properties - Aluminum has different structural fatigue properties than steel; it does not exhibit an endurance limit and its fatigue life is less than that of steel at a given stress level.. Fatigue should not be confused with fracture or other types of failure. Fatigue is a gradual deterioration of strength due to microscopic cracks which may occur in cases where the loads and resulting stresses are cyclic and of a high magnitude, such as on the bottom structure of a crewboat. The allowable stress of the structure in such a case is determined based on the fatigue properties of the material and a statistical representation of the stresses. For 5086 aluminum alloy the allowable stress for the hull bottom structure is 12 ksi (12,000 psi). Merchant Marine Technical should be consulted for advice on allowable stress when other alloys are used in the hull bottom structure.

Hull structure other than bottom structure is reviewed to an allowable stress which is based on the welded yield strength of the material with a factor of safety applied to it. For vessel structures other than bottom plating, bottom longitudinals, and bottom transverse frames, an allowable stress of 17 ksi should be used for 5000 and 6000 series aluminum alloy shapes and plates. The alloys most commonly used are 5086, 5083, 5056, and 6061. Merchant Marine Technical should be advised of instances where any other alloys are indicated on the structural plans.

Evaluation of' Structure - Table 1 is a formatted worksheet which can be used during structural review of a crewboat. When completely filled in, Table 1 can be made a permanent part of the vessel file for future reference. The procedure for reviewing structural plating and framing is out3ined in Table 1 and follows this general pattern for both plating and framing:

Step 1. Identify component
Step 2. Determine loading (pressure, P)
Step 3. Determine allowable stress (0)

Step 4. Divide pressure by stress (P10)
Step 5. Measure spacing of stiffeners
Step 6. Measure span of frame (framing only)
Step 7. Determine K-factor for frame (framing only)
Step 8. Determine required thickness (plating) or section modulus (framing)
Step 9. Compare results of Step 8 to actual thickness or section modulus

A worked example of a structural review is given in Appendix B. As 9 OCT 1980 can be seen in the example, a numerical precision of 2 or 3 significant figures is sufficient.

Step 1. Structural Component: The structural component to be checked can be identified through comparison of the boat's plans with the components labeled in Figures 4 through 7. Figures 2 and 12 show generally how the component might be situated with respect to surrounding structure. The first (second in the case of hull bottom structure) number after the name of the component refers to a figure identifying the location of the member and other pertinent information in a section view of the hull.

Step 2. Pressure: The design pressure (in pounds per square inch, psi) for review purposes is also shown on Figures 4 through 7. In the case of hull bottom structure and side transverse frames, use the first two figures cited (the first gives the impact portion of the pressure and the second gives the applicable formula to obtain the pressure for use in the Worksheet.) The hull bottom impact pressure on Figure 3 is based on the normal loaded displacement, A(long tons), and the normal operating speed, V (knots). A long ton is 2240 pounds, and a knot is 1.15 miles per hour. Normal loaded displacement is the displacement at which the boat normally operates, not necessarily the full load displacement corresponding to the subdivision draft. If the displacement is unknown, it is acceptable to assume a displacement near the middle of the range of displacements for the boat's length as indicated on Figure 3. The design pressure for certain components is based on the impact pressure from Figure 3 times an "area reduction factor" as follows:

Component	Area Reduction Factor
Bottom Plating	0.6
Bottom Longitudinals	0.6
Bottom Transverse Frames	0.5
Side Transverse Frames	0.2

To this is added a static pressure of 0.444 times the normal loaded draft in feet as shown in Figure 4 for bottom structure; and 0.444 times the head "h" from Figure 5 for side transverse frames.

In cases where pressure is stated as a head "h", the pressure in psi equals 0.444 times h in feet. Although the pressure represents a head of saltwater, it can be used for freshwater service as well.

Step 3. Stress: The allowable stress ( ) of 5086 alloy used for plating, longitudinals, and transverse frames on the hull bottom is 12 ksi (12,000 psi) because of fatigue considerations for those structural components. The remainder of the structure has an allowable stress of 17 ksi. At present only 5086, 5083, 5456, and 6061 alloys are acceptable without the specific approval of Merchant Marine Technical.

Step 4. $\underline{P/\quad}$: Divide the pressure (psi) by the allowable stress (ksi).

Step 5. Spacing: For plating use the spacing of the closest spaced stiffeners to which it is attached. This would generally be the longitudinal frames on the hull bottom, sides, and deck, and the vertical stiffeners on the bulkheads, transom, and deckhouse. For structure members such as longitudinals, transverse frames, and girders use the actual spacing of the member. In all oases give the spacing in inches. Be sure to use the proper scale when measuring dimensions from a drawing.

Step 6. Span of Frames: The span of frames is measured along the length of the frame between supports. Refer to the discussion of hull strength if you are not sure what supports what. In general, the larger member supports the smaller member. In all cases give the span of the member in inches.

For bottom transverse frames only, the span to use in evaluating the frames depends on whether or not the keelsons are considered as effective supports. A later discussion of keelsons explains how to determine this. If keelsons are not effective supports, the span of the bottom transverse frame is from keel to chine. If the keelsons are effective as supporting members, the span of bottom transverse frames is assumed to be half the distance from keel to chine, no matter how many keelsons are installed.

Where the ends of the frames are supported by brackets, measure the span between points about one fourth of the length of each bracket from its toe.

Step 7. K-Factor for Frames: The factor K is really a partial solution to the beam bending equation for fixed end conditions:

$$K = L^2 S / 12{,}000$$

Where: L = Unsupported span of beam (inches)
S = Spacing of beams (inches)

Figures 8 and 9 are graphical solutions to the above equation, and they differ only in the dimensions of the scales. In general, Figure 8 will apply to transverse frames and deck girders, and Figure 9 will apply to longitudinals, and stiffeners on bulkheads, the transom, end the deckhouse. In both cases read up from the horizontal axis (unsupported span) until the appropriate curve for stiffener spacing is found. The K axis is logarithmic so be careful interpolating intermediate values of K.

Step 8. Required Plating Thickness: To find the required thickness for plating use Figure 10. Find the stiffener spacing on the horizontal axis and the value of P10- on the vertical axis. The band that contains the point where these values intersect on the graph is the required plating thickness. The thickness of plating of decks carrying cargo must not be less than that indicated on the line marked "minimum for cargo deck plating." Also, if the point of intersection falls above the horizontal line where the P/ ratio equals 1.4, then the stiffeners may be spaced too closely together for the plate to achieve the level of effectiveness assumed in the tables in Appendix A. This is discussed more in Step 9.

Frame Size Required: Section modulus is a term used to denote the strength of' a beam. It is a function solely of the cross sectional dimensions of' the beam, and it is independent of material, structural constraints, or any other factor. The bending moment (force) on a beam and the resultant stress in the beam are related by the beam's section modulus. In Table 1 the required section modulus for structural members is calculated by multiplying the P/ ratio by K. The units for section modulus thus obtained are in inches cubed (in^3).

Step 9. Actual Plating Thickness: The actual thickness of the plating at the location being checked should be indicated on the structural drawing. This thickness is compared to the calculated required plating thickness to determine acceptability.

Actual Frame Size: If' a stiffener or frame is welded directly to a plate, the plate contributes to the strength of the frame, and a portion of' the plate can be considered as an integral part of' the frame. Figure 11 shows two conventional framing systems: in the "fixed frame" design the transverse frame is attached directly to the hull plating so the section modulus of the frame would include the contribution of the plating; in the “floating frame" design, the transverse frame is not attached directly to the plating, so the section modulus of the frame does not include any effect from the plating. In both cases shown in Figure 11 the longitudinals are attached to the plating, and their section modulus would include the effect of' the plating. In the case where a frame and plate are attached, only the portion of' the plate in close proximity to the frame really contributes to the strength of' the frame For aluminum structures the Coast Guard uses 38 times (38t) the thickness of the plating as effective in this manner. If' the spacing of' the attached frames is less than 38t, then only the actual spacing between frames contributes to the strength of' the frame. The actual spacing of' plating stiffeners should always be checked against 38t; and If it is less than 38t, The tables of' Appendix A should not be used because they would overestimate the strength of' the frame. Those tables list the section modulus of' frames by themselves and also attached to plating of' various thickness assuming that 38t of' the plating effectively contributes to the frame's strength. As an example of' how the tables are read, page A-1 shows that a 3.00 X 1.50 x 1/4 Bulb Tee attached to 3/8 inch plate has a section modulus of' 1.73 inches cubed (in^3). That shape has a section modulus of' 0.64 in^3 if it is not attached to any plating.

If' a beam is attached to plating but the effective width of the plating is less than 38t, the section modulus of' the combined beam and plate will be between those values given for an unattached beam and an attached beam. The actual be calculated by methods explained in most section modulus in such a case can structural reference books.

A structural handbook should be used to find the section modulus of' a frame which is not attached to plate. Since section modulus is a geometric property and not a material property steel and aluminum members of' the same geometry have the same section modulus, so any handbook that shows the proper shape can be used to determine the section modulus. There may be minor variations in the section moduli of steel and aluminum sections of the same size due to differences in production practices (extrusion of aluminum versus rolling of steel). The variations are usually the results of different radii of the corners. Most structural manuals list section properties of a beam with respect to two axes; the axis that should be used is perpendicular to the direction of the applied load. Some handbooks and manuals that can be used are listed later as References.

If the actual section modulus of the frame is equal to or greater than the required section modulus of the frame, it is acceptable. <u>It is not good engineering practice to trade off the sizes of structural components. such as accepting a stiffened that is a little too small because the plating to which it is attached is thicker than required</u>. This is because plating and framing play different roles in supporting external loads. Likewise, the sizes of longitudinals and transverse frames cannot be traded off to obtain equivalent strength.

Keel: The keel is a substantial structural component that runs the entire length of' the boat in the middle of the hull bottom. The bottom transverse frames rely on the rigidity of the keel as their lower support. The keel must also withstand loads from drydocking and low speed groundings. The size and shape of the keel may vary from boat to boat, but it is often a flat bar up to an inch thick, and it is sometimes capped with a heavy flange. The keel’s area and section modulus should be equivalent to that of a flat bar whose thickness in inches is L/110 and whose height is L/11, where L is the length of' the boat in feet.

<u>Keelsons</u>: Keelsons may be Installed for reasons other than to support the hull bottom structure. Since a hull bottom panel is a grillage structure, two small keelsons may provide the same strength and degree of support as a single large keelson. To be considered effective as strength members, the total area and section modulus of all keelsons on a bottom panel should be equivalent to that of a single flat bar whose thickness and height are L/160 and L/10 respectively, where L is the length of the boat. If the keelsons are undersized, they should not be rejected, but they cannot be considered effective in supporting the bottom transverse frames.

The section modulus of a flat bar section of thickness "t" and height "h" is

$$S.M. = h^2 t / 6$$

Bottom plating to which keels and keelsons are attached is not included in determining the section modulus of those members. Appendix A includes areas and section moduli of sections that are commonly used for keels and keelsons.

Stanchions: Decks, especially exterior decks designed to carry cargo, are often supported by stanchions which run from the hull bottom structure to the deck structure. Figure 12 shows a stanchion running up to the deck girder which it supports. Brackets are normally installed at the ends of stanchions, but they have been omitted from the figure for clarity. In Figure 13 stanchion length is measured from bracket to bracket, extending into the bracket one fourth of the bracket length from the toe. If no bracket is installed, the length is measured to the face of the flange of the girder, keelson, or other structural component to which the stanchion is attached. The area of deck which is considered to be supported by a stanchion is that portion or deck which is closer to the stanchion than to other main supporting structures such as hull sides, bulkheads, or other stanchions. This area is assumed to be the sum of the half-lengths of the girders on each side of the attention times the sum of the half-lengths of the transverse frames on each side of the girder. This area is that of a rectangle whose length on one side is equal to half the length of a girder on one side of the stanchion plus half the length of the girder on the other side of the stanchion, and whose dimension on the other side is equal to half the length of a frame on one side of the stanchion plus half the length of the frame on the other side of the stanchion. In Figure 13, the intersection of "Area of Deck Supported" and "Stanchion Length" must be below the line representing stanchion size; so when using that figure, read up to find the required stanchion size.

Decks: Decks may be framed either transversely or longitudinally. In either case the frames that directly support the plating are supported by orthogonal (perpendicular) beams or girders. Table 1 identifies the frames supporting the deck plating as "longitudinals" although in some cases they may actually run transversely. The various structural components of the deck are based on the same design pressure and allowable stress. This is indicated by a ditto (") in Table 1.

General Structural Configuration: The structural plans for a vessel may show that frame spacing is non-uniform in a particular area or that the structural arrangement differs from that described in this guide. If the purpose of a structural component is unclear or the proper approach to take in evaluating it is uncertain, Merchant Marine Technical should be consulted. Techniques used in evaluating a vessel's structure are largely learned through the experience gained over many structural evaluations. When a structural plan is being reviewed, it may be necessary to check several identical components to determine which is the most critical in the structure. For example, a tank bulkhead may have two strakes of plate, with the lower one thicker than the upper one. Each strake should be checked; the head used to determine pressure for each one would be from the appropriate reference line (1; feet above the deck in this case) down to the lower edge of the strake. The ability to perceive which area of structure is critical and should be checked only comes with the confidence gained through repeated exercises in structural evaluation.

References

Books

Simpson, Tracy W. Aluminum Boats. Oakland: Kaiser Aluminum & Chemical Sales, Inc. 19614.

Aluminum Afloat. Pittsburgh: Aluminum Company of America. 1968.

Rules for Building and Classing Aluminum Vessels 1975. New York: American Bureau of' Shipping.

Articles and Reports

Allen, Raymond G., and Robert R. Jones. "A Simplified Method for Determining Structural Design-Limit Pressures on High Performance Marine Vehicles." Prepared for the AIMISNAME Advanced Marine Vehicles Conference, San Diego. (April 17, 1978).

Altenburg, C. J., and others. "Design Considerations for Aluminum Hull Structures Study of Aluminum Bulk Carrier." Ship Structure Committee Report SSC-218. Washington: U. S. Coast Guard Headquarters. 1971.

Blaze, Gary C. "The 5000-Series Alloys Suitable for Welded Structural Applications." Alcoa Green Letter. New Kensington: Aluminum Company of America. Rev. March 19714.

Grant, James E., and others. "Considerations for the Structural Detailing of Aluminum Ships." Alcoa Center: Aluminum Company of America. November 19714.

Heller, S. R., and N. H. Jasper. "On the Structural Design of Planing Craft." Proceedings of the Royal Institute of Naval Architecture. London. 1961, pp. 49-65.

Henrickson, William A., and John S. Spencer. "A Synthesis of Aluminum Crewboat Structural Design." Prepared for presentation at the Gulf Section of the Society of Naval Architects and Marine Engineers. (October 15, 1980).

Mindlin, Harold, and Carl E. Jaske. "Summary Report on Fatigue Properties of 5083, 5086, and 51456 Aluminum-Alloy Sheet and Plate." Richmond: Reynolds Metals Company. October 1968.

Silvia, Peter A. "Structural Design of Planing Craft, A State of the Art Survey." Prepared for presentation at the Chesapeake Section of the Society or Naval Architects and Marine Engineers. (March 9, 1978).

Spencer, John S. "Structural Design of Aluminum Crewboats." Marine Technology. New York: Society of Naval Architects and Marine Engineers. (July 1975) pp. 267-2714.

Manuals

Lev, Frank M., and Natale S. Nappi. "Properties of' Combined Aluminum Beam and Plate." Report 4336. Bethesda: Naval Ship Research and Development Center. March 1974.

Manual of Steel Construction. New York: American Institute of Steel Construction, Inc. 1967.

"Aluminum Construction Manual, Specifications for Aluminum Structures." New York: The Aluminum Association. April 1976.

"Aluminum Construction Manual, Section 3, Engineering Data for Aluminum Structures." New York: The Aluminum Association. January 1975.

"Aluminum Standards and Data." New York: The A3uminum Association. March 1979.

SCANTLING REVIEW WORKSHEET

Shipyard ______________________ Hull ____________ Date ____________

Vessel Name ____________________ O.N. ____________ Reviewer ____________

Structural Component	See Figs.	Pres. psi	Stress σ, ksi	P/σ	Spcng in	Span in	K	Size Req'd	Size Act'l.
Bottom Structure (See Figure 2)									
1. Keel	Area and S.M. equivalent to L/11 x L/110 Flat Bar								
2. Keelsons	Area and S.M. equivalent to L/10 x L/160 Flat Bar								
3. Plating	3,4,10		12			------	------		
4. Longitudinals	3,4,9		12						
5. Transverses	3,4,8		12						
Side Structure (See Figure 2)									
6. Plating	5,10		17			------	------		
7. Longitudinals	5,9		17						
8. Transverses	3,5,8		17						
Exterior Decks (See Figure 12)									
9. Plating	6,10		17			------	------		
10. Longitudinals	6,9	"	17	"					
11. Transverses	6,8	"	17	"					
12. Girders	6,8	"	17	"					
13. Stanchions	6,13	-------	--	------	------	------	------		
Interior Decks (See Figure 12)									
14. Plating	6,10		17			------	------		
15. Longitudinals	6,9	"	17	"					
16. Transverses	6,8	"	17	"					
17. Girders	5,8	"	17	"					
Transom & Collision Bulkhead									
18. Plating	7,10		17			------	------		
19. Stiffeners	7,9		17						
20. Headers	7,8		17						
Watertight Bulkheads									
21. Plating	7,10		17			------	------		
22. Stiffeners	7,9		17						
23. Headers	7,8		17						
Deckhouse									
24. Front Plating	6,10		17			------	------		
25. Front Stiffeners	6,9		17						
26. Side Plating	6,10		17			------	------		
27. Side Stiffeners	6,9		17						
28. Back Plating	5,10		17			------	------		
29. Back Stiffeners	6,9		17						
30. Top Plating	6,10		17			------	------		
31. Top Stiffeners	6,9		17						

Table 1

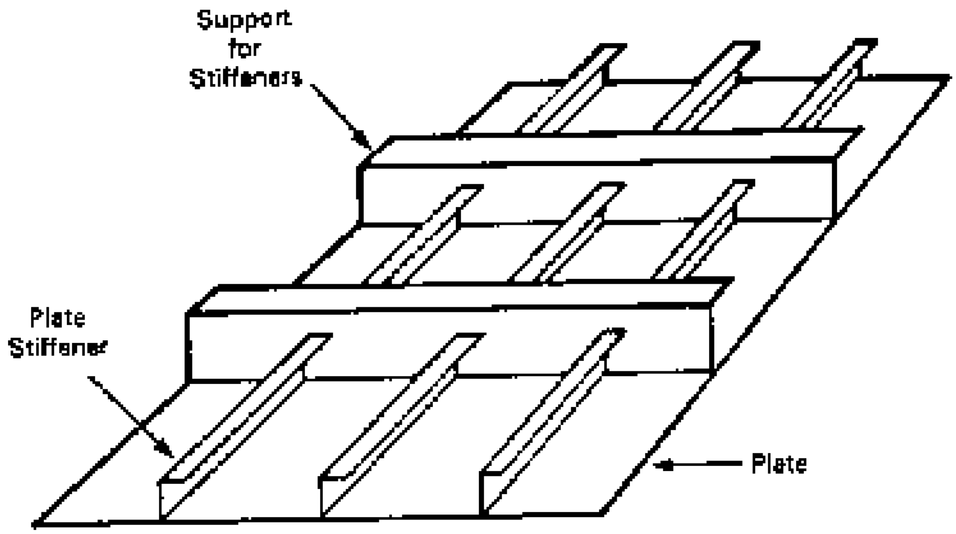
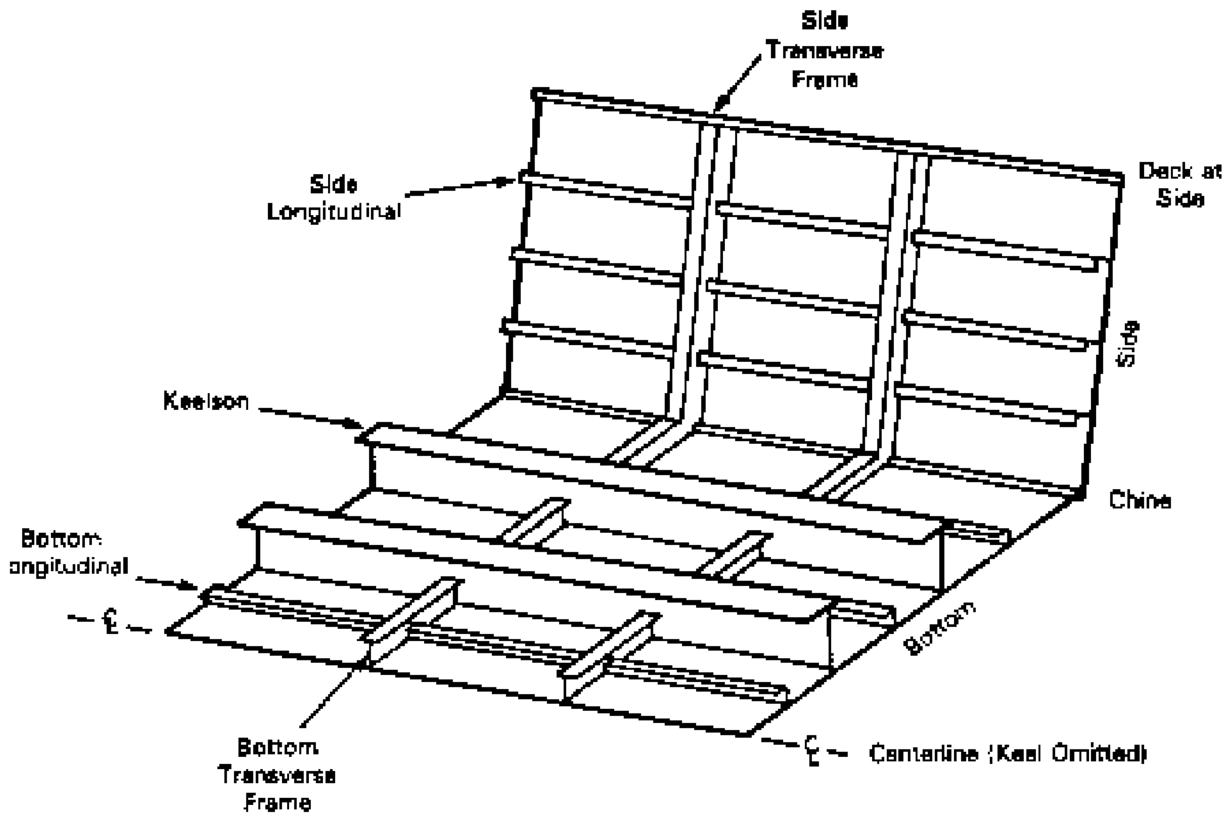


Figure 1: Typical Stiffened Panel



Note: View between adjacent transverse bulkheads
Longitudinals serve to stiffen plating.
Transverse frames support longitudinals.
Keelsons support bottom transverse frames.

Figure 2: Typical Bottom and Side Structure

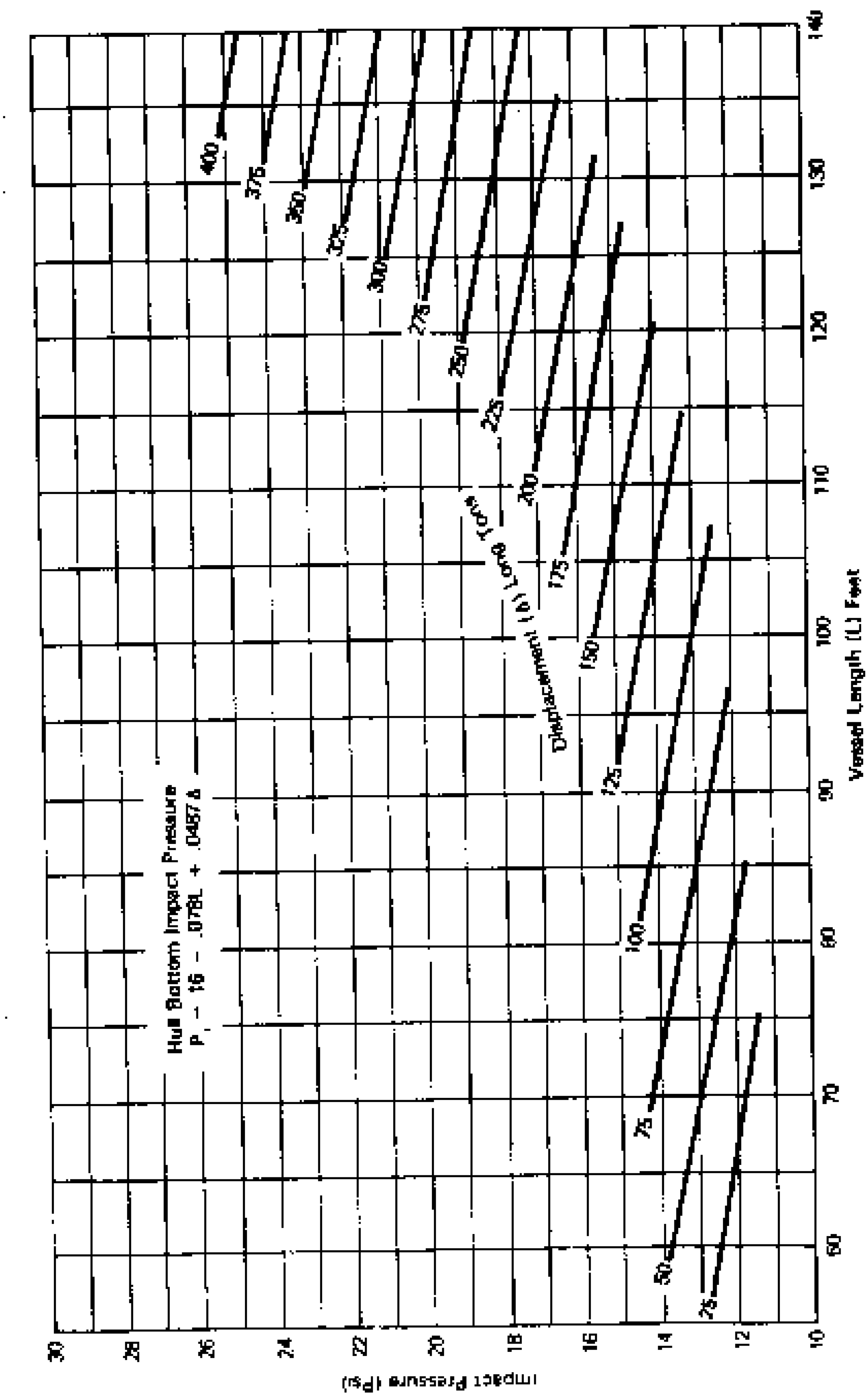
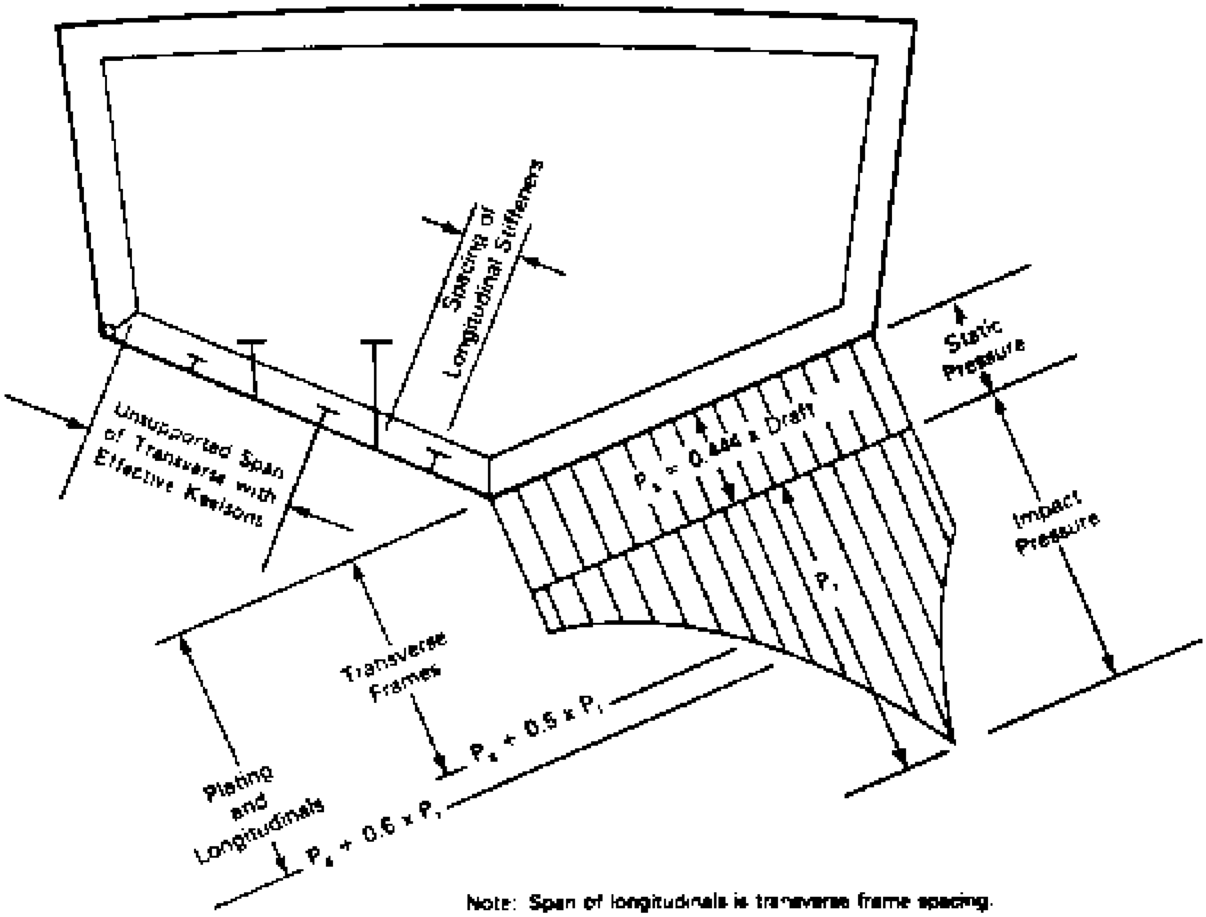
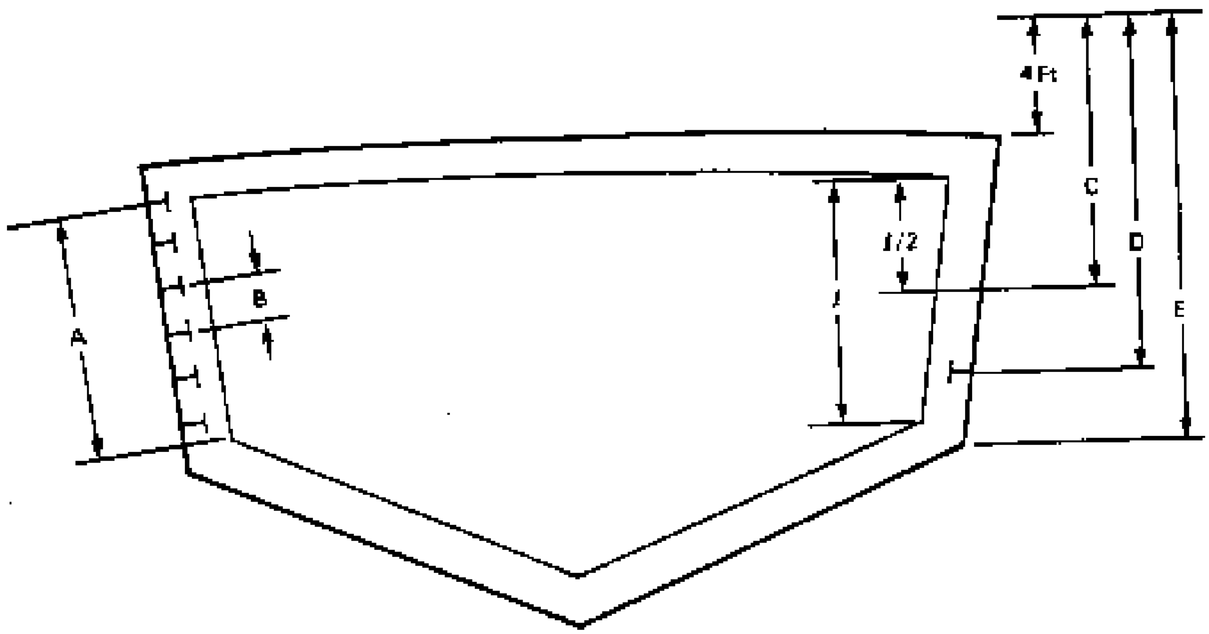


Figure 3: Hull Bottom Impact Pressure



Note: Span of longitudinals is transverse frame spacing.
If keelsons are not effective as supports,
span of transverse frame is from keel to chine.

Figure 4: Bottom Structure



Note: A Span of transverse frame
B Spacing of longitudinal stiffener
C Head for transverse frame
D Head for longitudinal stiffener
E Head for plating

Pressure equals 0.444 times head (feet)

Note: Design pressure for transverse frame is 0.2 times impact pressure plus head pressure

Figure 5: Side Structure

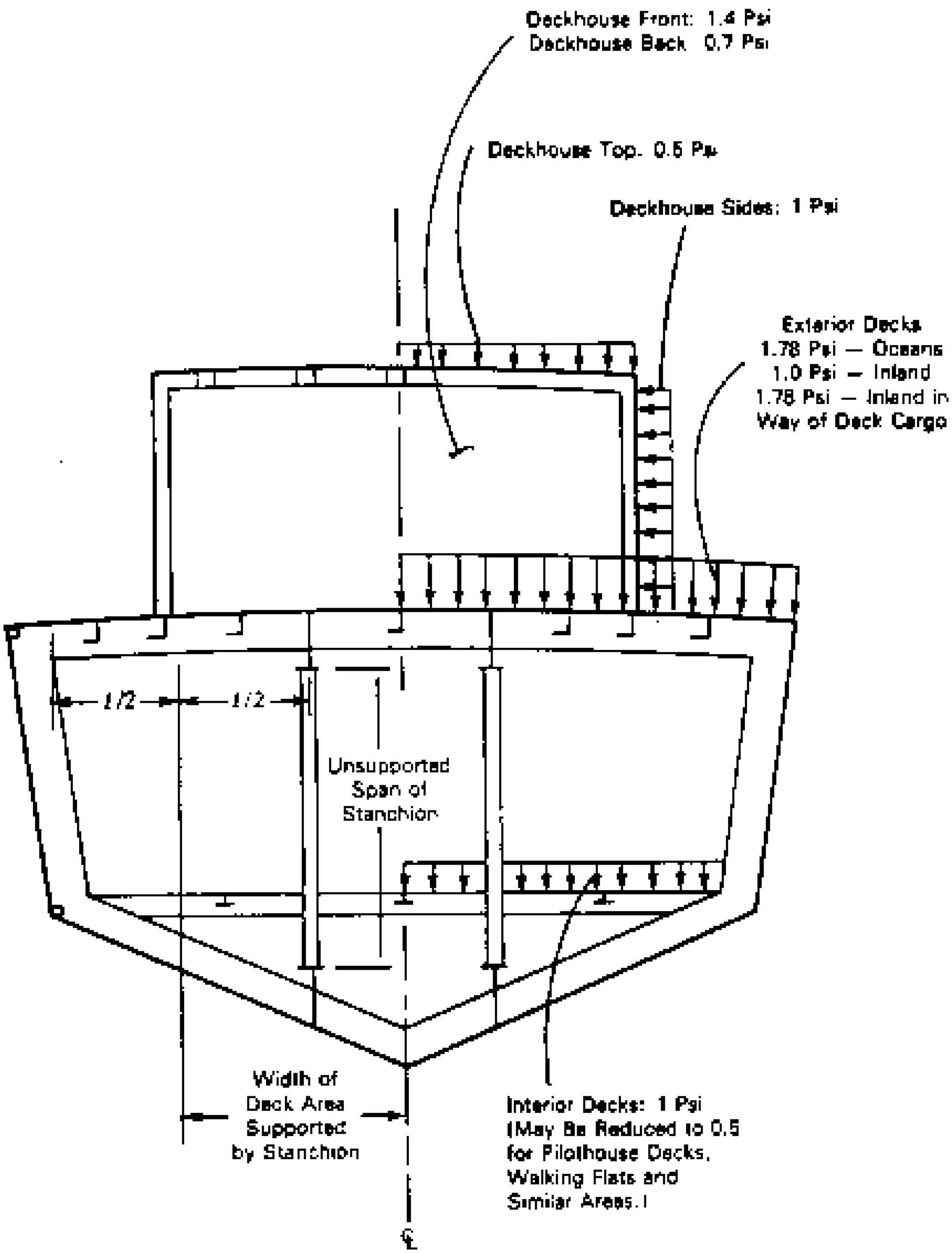
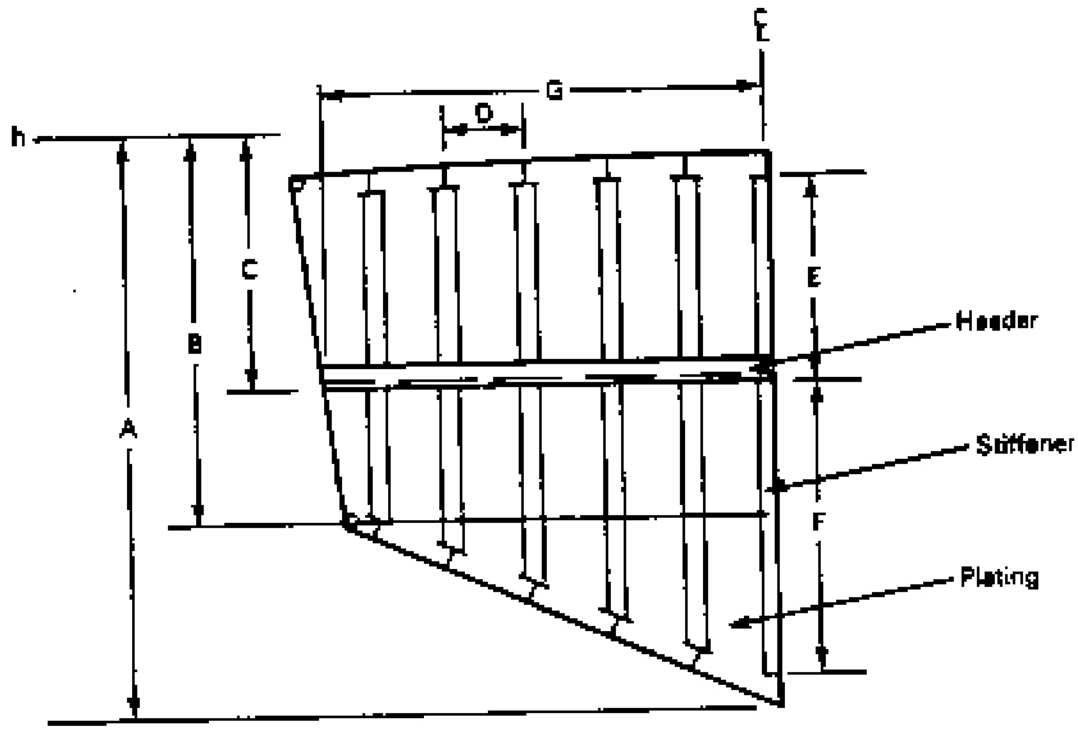


Figure 6: Deck and Deckhouse Design Pressures

Note: Collision bulkhead and transom h is 4 ft above deck at side.
Tank bulkhead h is to top of vent or overflow
Watertight bulkhead h is to deck at side.



Pressure = 0.444 Times Head

Component	Head (Ft)	Spacing (In)	Span (In)
Plating	A	D	—
Stiffener	B	D	F
Header	C	E or F	G or 2G

Note: Header spacing is larger of E or F.
Header span is 2G if there is no centerline support such as a longitudinal bulkhead

Figure 7: Bulkheads and Transom

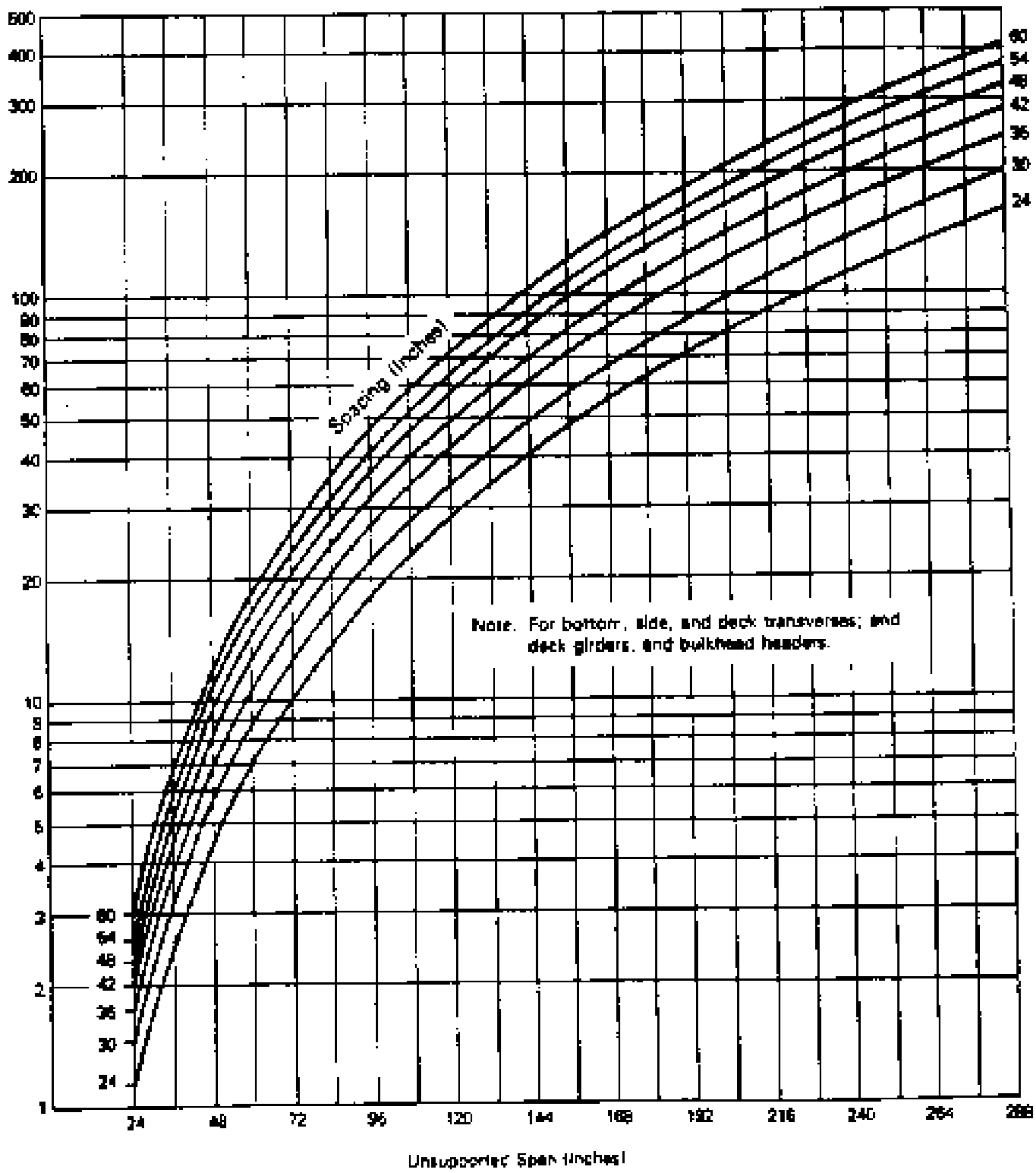


Figure 8: K Factor for Main Supporting Members

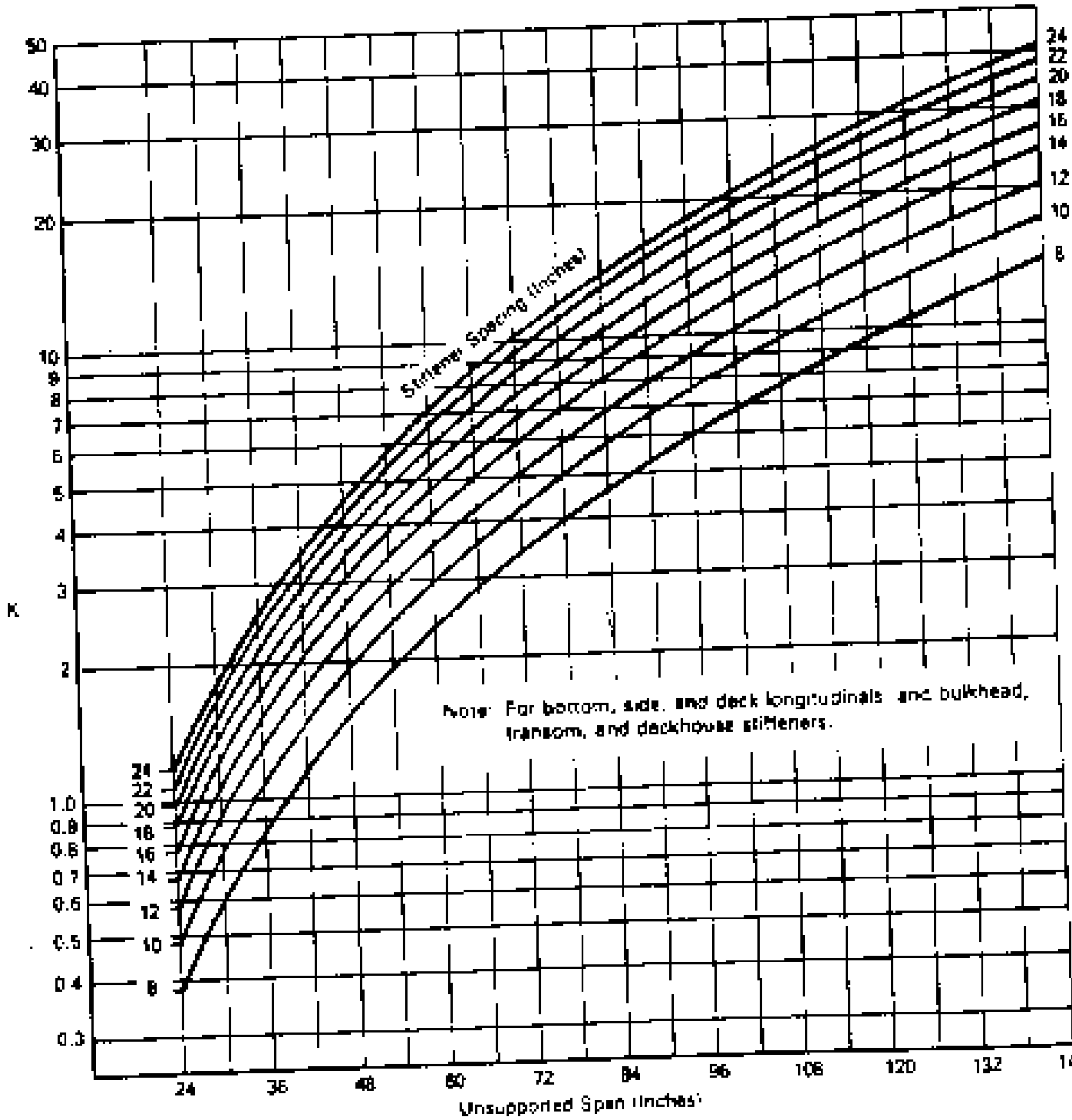


Figure 9: K Factor for Panel Stiffeners

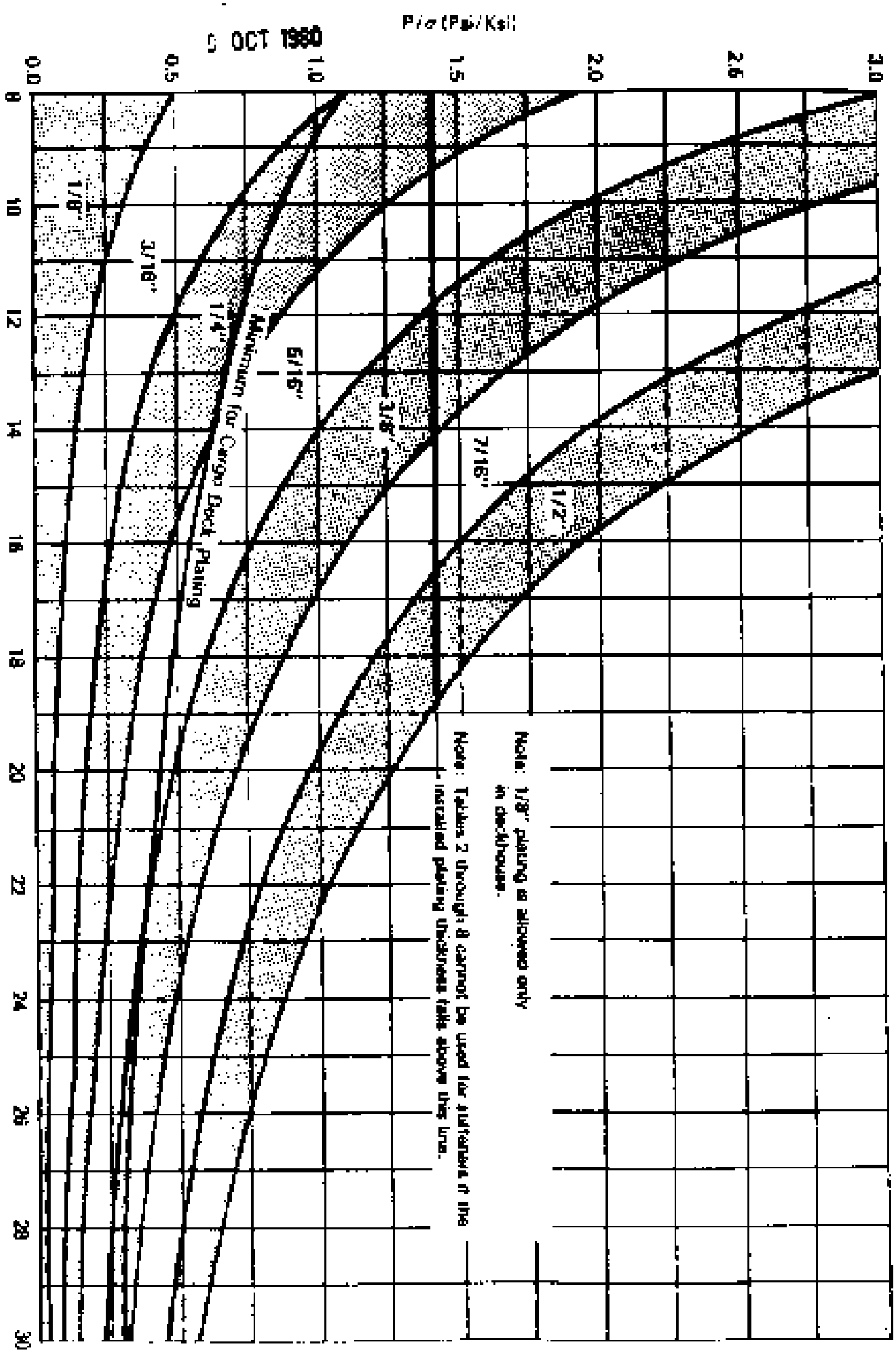


Figure 10: Required Plating Thickness

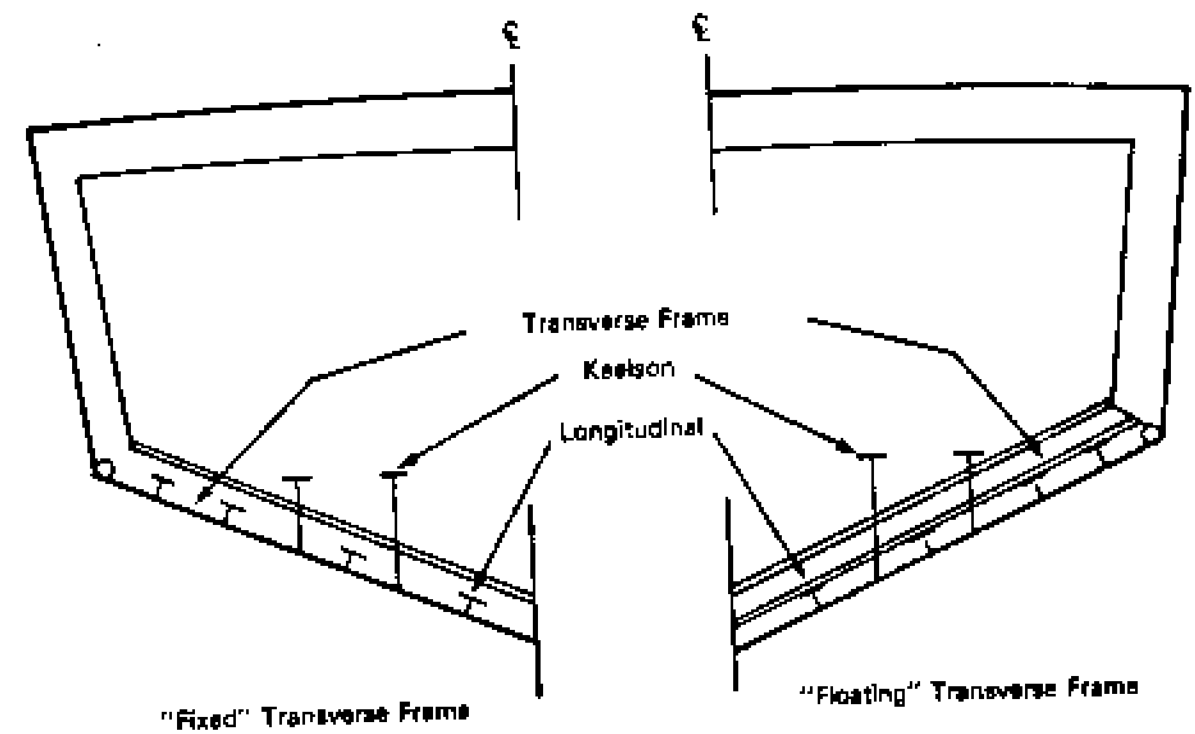


Figure 11: Typical Transverse Frame Arrangements

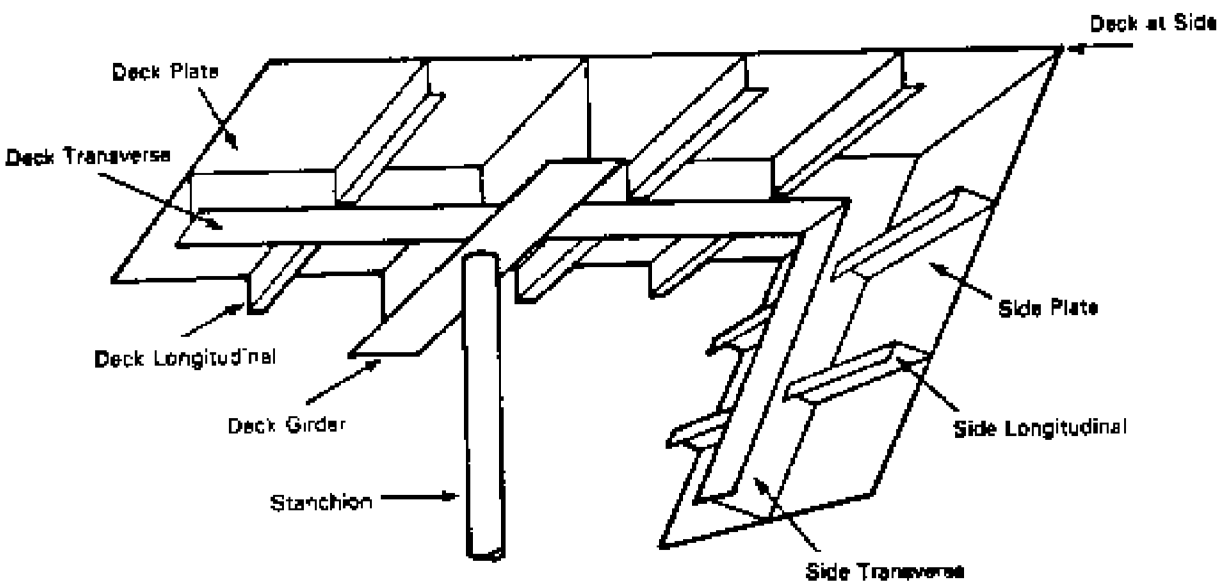


Figure 12: Typical Under Deck Structure

9 OCT 196

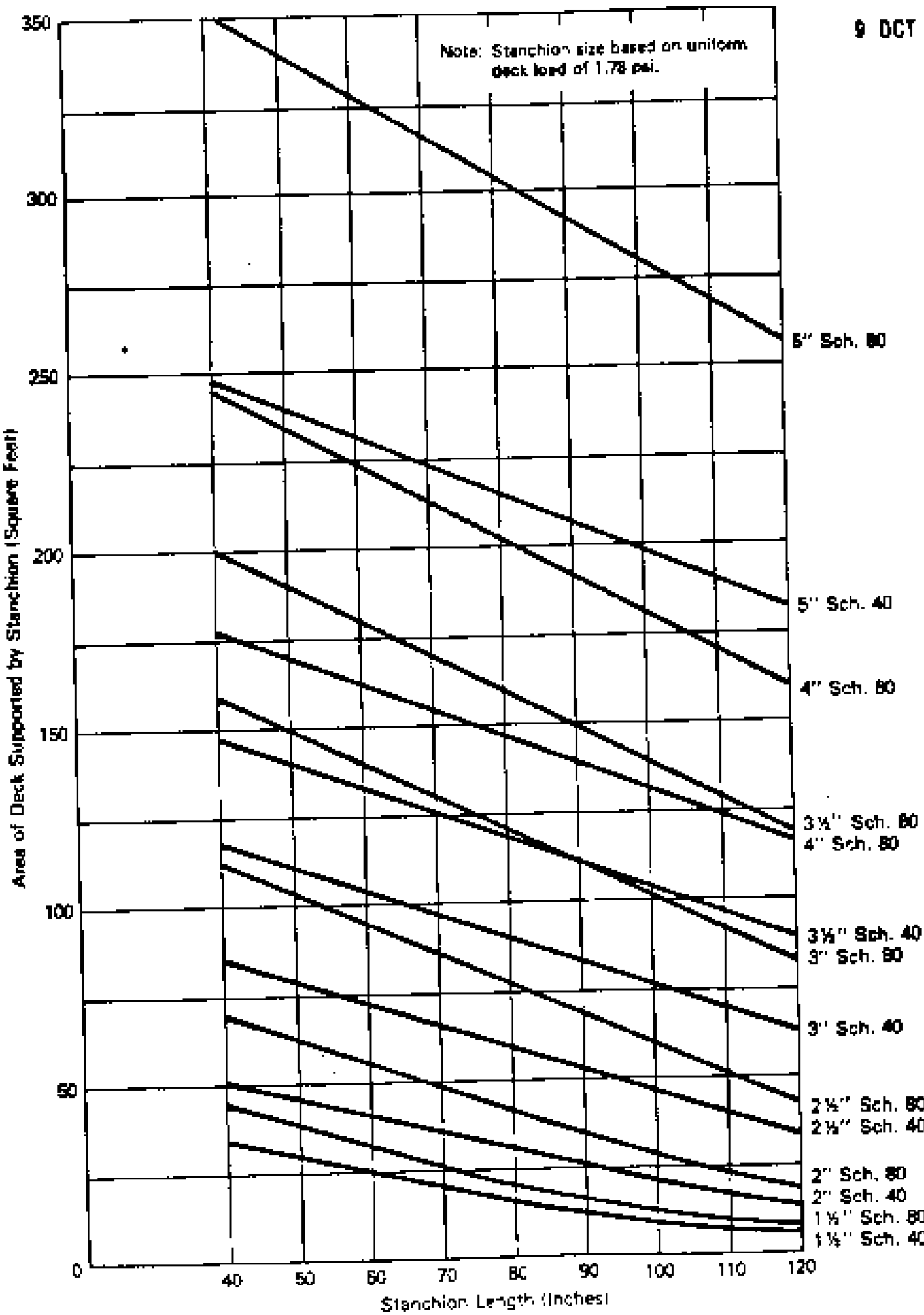
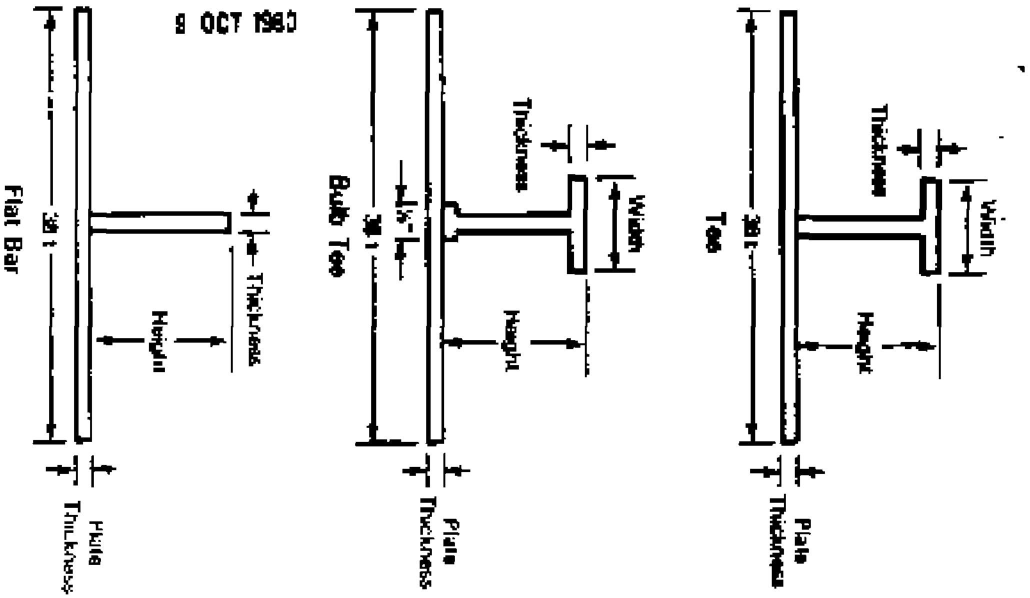
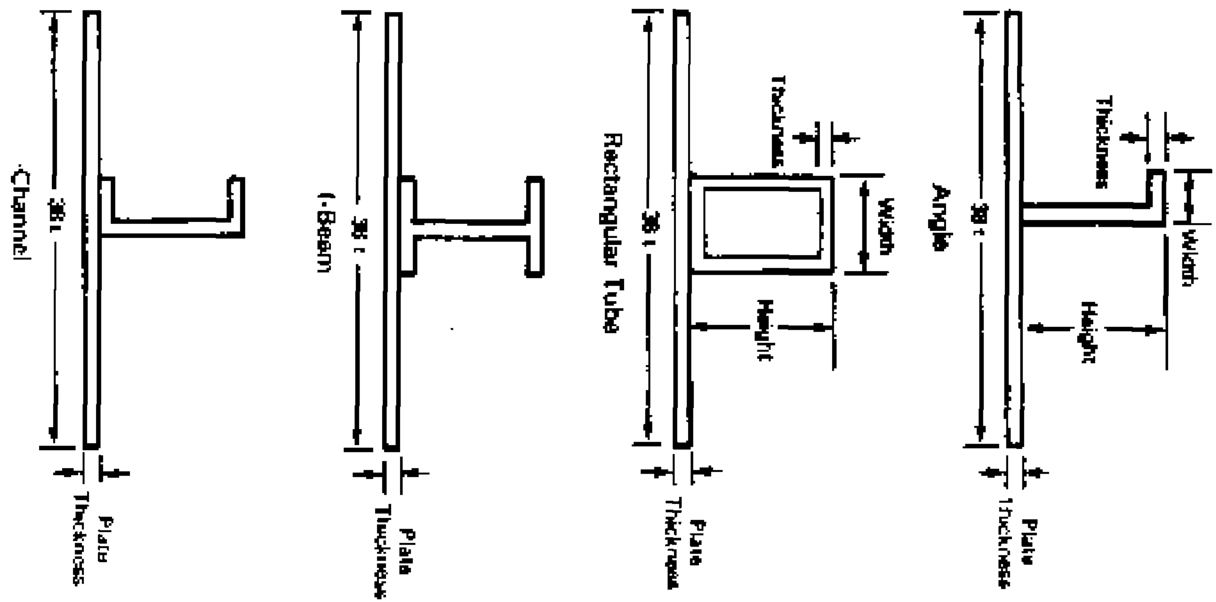


Figure 13: Required Stanchion Size

9 OCT 1980

Figure 14: Structural Shapes





Channel
36 t
Plate Thickness
I-Beam
36 t
Plate Thickness
Rectangular Tube
36 t
Thickness
Width
Height
Plate Thickness
Angle
36 t
Thickness
Width
Height
Plate Thickness

MEMBERS ON 38t PLATE
SECTION MODULUS (in^3)

Name Height x Width x Thickness		None	Attached Plate Thickness (in) 1/8	3/16	1/4	5/16	3/8	1/2
2.00 x 0.75 x 3/16	Bulb Tee	0.23	0.41	0.44	0.47	0.50	0.53	0.62
2.00 x 0.75 x 1/4	Bulb Tee	0.28	0.49	0.55	0.58	0.62	0.65	0.75
2.00 x 0.87 x 3/16	Bulb Tee	0.24	0.45	0.49	0.52	0.54	0.58	0.67
2.00 x 0.87 x 1/4	Bulb Tee	0.29	0.54	0.60	0.64	0.68	0.71	0.82
2.00 x 1.00 x 3/16	Bulb Tee	0.25	0.49	0.53	0.56	0.59	0.62	[illegible]
2.00 x 1.00 x 1/4	Bulb Tee	0.29	0.59	0.65	0.70	0.73	0.77	[illegible]
2.50 x 1.00 x 3/16	Bulb Tee	0.36	0.67	0.73	0.77	0.80	0.84	0.93
2.50 x 1.00 x 1/4	Bulb Tee	0.43	0.82	0.91	0.96	1.01	1.05	1.15
2.50 x 1.25 x 3/16	Bulb Tee	0.37	0.77	0.84	0.88	0.92	0.95	1.05
2.50 x 1.25 x 1/4	Bulb Tee	0.45	0.94	1.04	1.10	1.15	1.20	1.31
2.50 x 1.50 x 3/16	Bulb Tee	0.38	0.87	0.94	0.99	1.03	1.07	1.17
2.50 x 1.50 x 1/4	Bulb Tee	0.47	1.06	1.17	1.24	1.30	1.35	1.46
3.00 x 1.25 x 3/16	Bulb Tee	0.50	0.99	1.08	1.14	1.18	1.22	1.32
3.00 x 1.25 x 1/4	Bulb Tee	0.62	1.22	1.35	1.43	1.50	1.55	1.66
3.00 x 1.50 x 3/16	Bulb Tee	0.52	1.11	1.21	1.27	1.32	1.36	1.46
3.00 x 1.50 x 1/4	Bulb Tee	0.64	1.37	1.51	1.60	1.67	1.73	1.85
3.00 x 1.75 x 3/16	Bulb Tee	0.53	1.23	1.34	1.40	1.45	1.50	1.60
3.00 x 1.75 x 1/4	Bulb Tee	0.65	1.51	1.67	1.77	1.84	1.91	2.03
3.25 x 1.50 x 3/16	Bulb Tee	0.59	1.24	1.35	1.42	1.47	1.52	1.62
3.25 x 1.50 x 1/4	Bulb Tee	0.74	1.53	1.69	1.79	1.87	1.93	2.05
3.25 x 1.75 x 3/16	Bulb Tee	0.61	1.37	1.49	1.56	1.62	1.67	1.77
3.25 x 1.75 x 1/4	Bulb Tee	0.76	1.59	1.87	1.98	2.06	2.12	2.25
3.25 x 2.00 x 3/16	Bulb Tee	0.62	1.49	1.62	1.71	1.77	1.82	1.93
3.25 x 2.00 x 1/4	Bulb Tee	0.77	1.85	2.04	2.16	2.25	2.32	2.45
3.50 x 1.50 x 1/4	Bulb Tee	0.84	1.70	1.88	1.99	2.08	2.14	2.27
3.50 x 1.50 x 5/16	Bulb Tee	0.98	1.97	2.21	2.37	2.48	2.57	2.72
3.50 x 1.75 x 1/4	Bulb Tee	0.86	1.87	2.07	2.19	2.29	2.35	2.49
3.50 x 1.75 x 5/16	Bulb Tee	1.01	2.18	2.44	2.61	2.72	2.82	2.99
3.50 x 2.00 x 1/4	Bulb Tee	0.88	2.04	2.25	2.39	2.48	2.56	2.70
3.50 x 2.00 x 5/16	Bulb Tee	1.03	2.38	2.66	2.84	2.97	3.07	3.25
3.75 x 1.75 x 1/4	Bulb Tee	0.97	2.05	2.27	2.41	2.51	2.59	2.73
3.75 x 1.75 x 5/16	Bulb Tee	1.14	2.40	2.68	2.87	3.00	3.11	3.28
3.75 x 2.00 x 1/4	Bulb Tee	1.00	2.23	2.47	2.62	2.73	2.81	2.96
3.75 x 2.00 x 5/16	Bulb Tee	1.17	2.61	2.92	3.13	3.27	3.38	3.56
3.75 x 2.25 x 1/4	Bulb Tee	1.02	2.42	2.67	2.83	2.94	3.03	3.19
3.75 x 2.25 x 5/16	Bulb Tee	1.19	2.83	3.16	3.38	3.53	3.65	3.85

9 OCT 1990

MEMBERS ON 38t PLATE
SECTION MODULUS (in^3)

Name Height x Width x Thickness				Attached Plate Thickness (in)				
		None	1/8	3/16	1/4	5/16	3/8	1/2
4.00 x 1.75 x 1/4	Bulb Tee	1.09	2.24	2.49	2.64	2.75	2.83	2.98
4.00 x 1.75 x 5/16	Bulb Tee	1.28	2.62	2.94	3.15	3.29	3.40	3.59
4.00 x 2.00 x 1/4	Bulb Tee	1.11	2.44	2.70	2.87	2.98	3.07	3.23
4.00 x 2.00 x 5/16	Bulb Tee	1.31	2.85	3.19	3.42	3.57	3.69	3.89
4.00 x 2.25 x 1/4	Bulb Tee	1.14	2.63	2.91	3.09	3.21	3.31	3.47
4.00 x 2.25 x 5/16	Bulb Tee	1.34	3.08	3.45	3.69	3.85	3.98	4.19
4.25 x 2.00 x 1/4	Bulb Tee	1.24	2.54	2.93	3.12	3.24	3.34	3.50
4.25 x 2.00 x 5/16	Bulb Tee	1.46	3.10	3.47	3.72	3.89	4.02	4.23
4.25 x 2.25 x 1/4	Bulb Tee	1.26	2.85	3.16	3.36	3.49	3.59	3.76
4.25 x 2.25 x 5/16	Bulb Tee	1.49	3.34	3.74	4.01	4.19	4.33	4.55
4.25 x 2.50 x 1/4	Bulb Tee	1.29	3.06	3.39	3.59	3.74	3.84	4.02
4.25 x 2.50 x 5/16	Bulb Tee	1.52	3.47	4.01	4.29	4.49	4.63	4.87
4.50 x 2.00 x 1/4	Bulb Tee	1.37	2.86	3.17	3.38	3.51	3.62	3.79
4.50 x 2.00 x 5/16	Bulb Tee	1.62	3.35	3.76	4.03	4.22	4.36	4.58
4.50 x 2.25 x 1/4	Bulb Tee	1.40	3.08	3.41	3.63	3.77	3.89	4.07
4.50 x 2.25 x 5/16	Bulb Tee	1.66	3.61	4.05	4.33	4.53	4.68	4.92
4.50 x 2.50 x 1/4	Bulb Tee	1.42	3.29	3.65	3.88	4.03	4.15	4.34
4.50 x 2.50 x 5/16	Bulb Tee	1.69	3.74	4.39	4.64	4.85	5.01	5.26

MEMBERS ON 30t PLATE
SECTION MODULUS (in^3)

Name Height x Width x Thickness		None	Attached Plate Thickness (in) 1/8	3/16	1/4	5/16	3/8	1/2
2.00 x 1.00 x 3/16	Tee	0.16	0.49	0.53	0.56	0.59	0.62	0.71
2.00 x 1.00 x 1/4	Tee	0.21	0.59	0.65	0.70	0.73	0.77	0.87
2.00 x 1.50 x 3/16	Tee	0.18	0.64	0.70	0.74	0.77	0.81	0.91
2.00 x 1.50 x 1/4	Tee	0.23	0.78	0.87	0.92	0.96	1.01	1.12
2.00 x 2.00 x 3/16	Tee	0.19	0.80	0.87	0.91	0.95	0.99	1.10
2.00 x 2.00 x 1/4	Tee	0.24	0.97	1.08	1.14	1.20	1.25	1.37
3.00 x 1.00 x 3/16	Tee	0.35	0.87	0.96	1.01	1.05	1.09	1.17
3.00 x 1.00 x 1/4	Tee	0.47	1.07	1.19	1.27	1.32	1.37	1.48
3.00 x 1.50 x 3/16	Tee	0.39	1.10	1.21	1.27	1.32	1.36	1.46
3.00 x 1.50 x 1/4	Tee	0.51	1.36	1.51	1.60	1.67	1.73	1.85
3.00 x 1.75 x 3/16	Tee	0.40	1.22	1.34	1.40	1.45	1.50	1.60
3.00 x 1.75 x 1/4	Tee	0.52	1.50	1.67	1.77	1.84	1.91	2.03
3.00 x 2.00 x 3/16	Tee	0.41	1.34	1.46	1.53	1.59	1.64	1.74
3.00 x 2.00 x 1/4	Tee	0.54	1.65	1.83	1.94	2.02	2.08	2.22
4.00 x 1.00 x 3/16	Tee	0.62	1.33	1.47	1.56	1.62	1.67	1.76
4.00 x 1.00 x 1/4	Tee	0.82	1.64	1.84	1.97	2.05	2.12	2.25
4.00 x 1.50 x 3/16	Tee	0.67	1.64	1.81	1.91	1.98	2.03	2.14
4.00 x 1.50 x 1/4	Tee	0.89	2.03	2.27	2.42	2.52	2.60	2.74
4.00 x 2.00 x 3/16	Tee	0.71	1.95	2.15	2.26	2.34	2.40	2.52
4.00 x 2.00 x 1/4	Tee	0.93	2.41	2.70	2.87	2.98	3.07	3.23
5.00 x 1.00 x 1/4	Tee	1.25	2.30	2.60	2.79	2.92	3.02	3.17
5.00 x 1.00 x 5/16	Tee	1.54	2.69	3.07	3.32	3.49	3.62	3.82
5.00 x 1.00 x 3/8	Tee	1.87	3.04	3.48	3.79	4.01	4.17	4.42
5.00 x 1.50 x 1/4	Tee	1.34	2.79	3.14	3.35	3.50	3.61	3.78
5.00 x 1.50 x 5/16	Tee	1.66	3.27	3.71	4.00	4.20	4.35	4.57
5.00 x 1.50 x 3/8	Tee	1.96	3.70	4.22	4.58	4.83	5.02	5.30
5.00 x 2.00 x 1/4	Tee	1.42	3.27	3.66	3.91	4.08	4.20	4.39
5.00 x 2.00 x 5/16	Tee	1.75	3.84	4.34	4.67	4.90	5.07	5.32
5.00 x 2.00 x 3/8	Tee	2.07	4.27	4.95	5.37	5.65	5.87	6.19
6.00 x 1.00 x 1/4	Tee	1.77	3.06	3.47	3.74	3.92	4.06	4.26
6.00 x 1.00 x 5/16	Tee	2.18	3.59	4.10	4.45	4.70	4.88	5.14
6.00 x 1.00 x 3/8	Tee	2.58	4.06	4.66	5.10	5.41	5.63	5.97
6.00 x 1.50 x 1/4	Tee	1.89	3.63	4.10	4.41	4.62	4.76	4.98
6.00 x 1.50 x 5/16	Tee	2.34	4.28	4.86	5.26	5.54	5.74	6.04
6.00 x 1.50 x 3/8	Tee	2.77	4.86	5.54	6.04	6.39	6.65	7.02
6.00 x 2.00 x 1/4	Tee	2.00	4.21	4.74	5.08	5.31	5.47	5.71
6.00 x 2.00 x 5/16	Tee	2.47	4.96	5.62	6.07	6.38	6.61	6.93
6.00 x 2.00 x 3/8	Tee	2.93	5.53	6.42	6.98	7.37	7.66	8.08

MEMBERS ON 38t PLATE
SECTION MODULUS (in^3)

Name Height x Width x Thickness		None	Attached Plate Thickness (in) 1/8	3/16	1/4	5/16	3/8	1/2
7.00 x 1.50 x 1/4	Tee	2.53	4.57	5.17	5.58	5.86	6.05	6.33
7.00 x 1.50 x 5/16	Tee	3.13	5.39	6.13	6.66	7.04	7.31	7.68
7.00 x 1.50 x 3/8	Tee	3.71	6.15	7.00	7.65	8.12	8.47	8.95
7.00 x 2.00 x 1/4	Tee	2.66	5.23	5.90	6.35	6.66	6.88	7.18
7.00 x 2.00 x 5/16	Tee	3.29	6.19	7.01	7.60	8.01	8.31	8.72
7.00 x 2.00 x 3/8	Tee	3.91	6.92	8.02	8.74	9.26	9.64	10.18
7.00 x 2.50 x 1/4	Tee	2.77	5.89	6.63	7.13	7.46	7.70	8.03
7.00 x 2.50 x 5/16	Tee	3.43	6.56	7.89	8.53	8.99	9.31	9.77
7.00 x 2.50 x 3/8	Tee	4.08	7.17	9.04	9.83	10.40	10.82	11.41
8.00 x 2.00 x 1/4	Tee	3.42	6.34	7.17	7.74	8.13	8.41	8.79
8.00 x 2.00 x 5/16	Tee	4.23	7.52	8.52	9.26	9.79	10.17	10.69
8.00 x 2.00 x 3/8	Tee	5.03	8.44	9.76	10.66	11.32	11.81	12.48
8.00 x 2.50 x 1/4	Tee	3.55	7.09	7.99	8.62	9.04	9.35	9.76
8.00 x 2.50 x 5/16	Tee	4.40	7.94	9.51	10.32	10.89	11.31	11.88
8.00 x 2.50 x 3/8	Tee	5.24	8.74	10.91	11.89	12.61	13.15	13.88
8.00 x 3.00 x 1/4	Tee	3.67	7.32	8.82	9.49	9.95	10.28	10.72
8.00 x 3.00 x 5/16	Tee	4.55	8.16	10.50	11.38	12.00	12.45	13.06
8.00 x 3.00 x 3/8	Tee	5.41	8.99	12.06	13.13	13.91	14.49	15.28
9.00 x 2.00 x 5/16	Tee	5.27	8.95	10.13	11.05	11.70	12.18	12.83
9.00 x 2.00 x 3/8	Tee	6.27	10.08	11.62	12.72	13.54	14.15	14.99
9.00 x 2.00 x 1/2	Tee	8.22	11.95	14.31	15.71	16.84	17.71	18.96
9.00 x 2.50 x 5/16	Tee	5.48	9.43	11.25	12.23	12.94	13.46	14.16
9.00 x 2.50 x 3/8	Tee	6.53	10.43	12.92	14.10	14.99	15.65	16.56
9.00 x 2.50 x 1/2	Tee	8.56	12.38	15.94	17.46	18.68	19.63	20.98
9.00 x 3.00 x 5/16	Tee	5.67	9.69	12.36	13.41	14.18	14.74	15.49
9.00 x 3.00 x 3/8	Tee	6.75	10.73	14.21	15.48	16.44	17.15	18.12
9.00 x 3.00 x 1/2	Tee	8.86	12.76	17.56	19.20	20.52	21.55	23.00
9.00 x 3.50 x 5/16	Tee	5.83	9.92	13.46	14.60	15.42	16.01	16.82
9.00 x 3.50 x 3/8	Tee	6.94	10.99	15.49	16.86	17.88	18.65	19.69
9.00 x 3.50 x 1/2	Tee	9.11	13.09	18.15	20.94	22.36	23.46	25.02

MEMBERS ON 38t PLATE
SECTION MODULUS (in^3)

Name Height x Thickness		None	1/8	3/16	1/4	5/16	3/8	1/2
			Attached Plate Thickness (in)					
1.00 x 1/8	Flat Bar	0.02	0.04	0.05	0.06	0.08	0.11	0.22
1.00 x 3/16	Flat Bar	0.03	0.06	0.07	0.08	0.10	0.14	0.25
1.50 x 1/8	Flat Bar	0.04	0.09	0.10	0.11	0.13	0.15	0.24
1.50 x 3/16	Flat Bar	0.07	0.13	0.15	0.16	0.18	0.21	0.30
1.50 x 1/4	Flat Bar	0.09	0.17	0.20	0.21	0.24	0.27	0.36
1.75 x 1/8	Flat Bar	0.06	0.12	0.13	0.14	0.16	0.18	0.26
1.75 x 3/16	Flat Bar	0.09	0.18	0.20	0.21	0.23	0.26	0.34
1.75 x 1/4	Flat Bar	0.12	0.23	0.25	0.28	0.31	0.33	0.43
2.00 x 3/16	Flat Bar	0.12	0.23	0.25	0.27	0.29	0.32	0.40
2.00 x 1/4	Flat Bar	0.16	0.30	0.33	0.36	0.38	0.41	0.50
2.00 x 5/16	Flat Bar	0.20	0.36	0.41	0.44	0.47	0.51	0.60
2.50 x 3/16	Flat Bar	0.19	0.35	0.39	0.41	0.44	0.46	0.54
2.50 x 1/4	Flat Bar	0.26	0.45	0.50	0.54	0.57	0.60	0.69
2.50 x 5/16	Flat Bar	0.32	0.54	0.62	0.66	0.71	0.74	0.84
3.00 x 3/16	Flat Bar	0.28	0.49	0.54	0.58	0.61	0.64	0.71
3.00 x 1/4	Flat Bar	0.37	0.62	0.70	0.76	0.80	0.83	0.92
3.00 x 5/16	Flat Bar	0.46	0.75	0.86	0.93	0.98	1.03	1.13
3.00 x 3/8	Flat Bar	0.56	0.87	1.01	1.10	1.17	1.22	1.34
3.50 x 1/4	Flat Bar	0.51	0.82	0.94	1.01	1.06	1.10	1.19
3.50 x 5/16	Flat Bar	0.63	0.99	1.14	1.23	1.30	1.36	1.47
3.50 x 3/8	Flat Bar	0.76	1.15	1.34	1.46	1.54	1.62	1.75
4.00 x 1/4	Flat Bar	0.66	1.05	1.20	1.29	1.35	1.41	1.51
4.00 x 5/16	Flat Bar	0.83	1.26	1.46	1.58	1.67	1.74	1.86
4.00 x 3/8	Flat Bar	1.00	1.47	1.70	1.86	1.97	2.06	2.22
4.00 x 1/2	Flat Bar	1.33	1.86	2.17	2.40	2.56	2.69	2.90

MEMBERS ON 3Bt PLATE
SECTION MODULUS (in^3)

Name Height x Width x Thickness		None	Attached Plate Thickness (in) 1/8	3/16	1/4	5/16	3/8	1/2
2.00 x 1.50 x 3/16	Angle	0.18	0.64	0.70	0.74	0.77	0.81	0.91
2.00 x 1.50 x 1/4	Angle	0.23	0.78	0.87	0.92	0.96	1.0[illegible]	1.12
2.00 x 2.00 x 3/16	Angle	0.19	0.80	0.87	0.91	0.95	0.99	1.10
2.00 x 2.00 x 1/4	Angle	0.24	0.97	1.08	1.14	1.20	1.25	1.37
2.00 x 2.00 x 5/16	Angle	0.30	1.12	1.26	1.34	1.41	1.48	1.62
2.50 x 1.50 x 3/16	Angle	0.27	0.86	0.94	0.99	1.03	1.07	1.16
2.50 x 1.50 x 1/4	Angle	0.36	1.06	1.17	1.24	1.30	1.35	1.46
2.50 x 1.50 x 5/16	Angle	0.44	1.22	1.37	1.47	1.54	1.60	1.73
2.50 x 2.00 x 3/16	Angle	0.29	1.06	1.15	1.21	1.26	1.30	1.40
2.50 x 2.00 x 1/4	Angle	0.38	1.30	1.44	1.52	1.59	1.65	1.77
2.50 x 2.00 x 5/16	Angle	0.46	1.50	1.69	1.80	1.89	1.96	2.11
2.50 x 2.50 x 3/16	Angle	0.30	1.25	1.36	1.43	1.48	1.53	1.64
2.50 x 2.50 x 1/4	Angle	0.39	1.54	1.70	1.80	1.88	1.94	2.08
2.50 x 2.50 x 5/16	Angle	0.48	1.65	2.00	2.14	2.24	2.32	2.48
3.00 x 1.50 x 1/4	Angle	0.51	1.35	1.51	1.60	1.67	1.73	1.85
3.00 x 1.50 x 5/16	Angle	0.63	1.58	1.78	1.90	1.99	2.06	2.20
3.00 x 2.00 x 1/4	Angle	0.54	1.65	1.83	1.94	2.02	2.08	2.22
3.00 x 2.00 x 5/16	Angle	0.66	1.92	2.16	2.30	2.4[illegible]	2.49	2.65
3.00 x 2.50 x 1/4	Angle	0.56	1.93	2.15	2.28	2.37	2.44	2.58
3.00 x 2.50 x 5/16	Angle	0.68	2.09	2.53	2.71	2.83	2.93	3.10
3.00 x 3.00 x 1/4	Angle	0.57	2.02	2.46	2.61	2.7[illegible]	2.80	2.95
3.00 x 3.00 x 5/16	Angle	0.70	2.14	2.91	3.11	3.25	3.36	3.55
3.50 x 2.50 x 1/4	Angle	0.75	2.36	2.62	2.78	2.89	2.98	3.13
3.50 x 2.50 x 5/16	Angle	0.92	2.55	3.10	3.31	3.46	3.58	3.77
3.50 x 2.50 x 3/8	Angle	1.09	2.70	3.52	3.79	3.98	4.13	4.37
3.50 x 3.00 x 1/4	Angle	0.77	2.46	2.99	3.17	3.29	3.39	3.56
3.50 x 3.00 x 5/16	Angle	0.95	2.61	3.54	3.78	3.95	4.08	4.30
3.50 x 3.00 x 3/8	Angle	1.12	2.76	4.02	4.33	4.55	4.72	4.98
4.00 x 3.00 x 1/4	Angle	1.00	2.91	3.54	3.76	3.91	4.02	4.2[illegible]
4.00 x 3.00 x 5/16	Angle	1.23	3.12	4.20	4.49	4.70	4.85	5.09
4.00 x 3.00 x 3/8	Angle	1.45	3.32	4.78	5.16	5.42	5.61	5.9[illegible]
4.00 x 3.00 x 1/2	Angle	1.88	3.70	5.76	6.30	6.68	6.97	7.40

9 OCT 1980

MEMBERS ON 38t PLATE
SECTION MODULUS (in^3)

Name Height x Weight		Attached Plate Thickness (in) None	1/8	3/16	1/4	5/16	3/8	1/2
3.00 x 1.96	Std I-Beam	1.68	1.87	1.99	2.08	2.16	2.22	2.36
3.00 x 2.25	Std I-Beam	1.80	2.04	2.18	2.29	2.39	2.47	2.63
3.00 x 2.59	Std I-Beam	1.95	2.22	2.40	2.54	2.66	2.76	2.95
4.00 x 2.64	Std I-Beam	3.03	3.31	3.50	3.65	3.77	3.87	4.04
4.00 x 3.28	Std I-Beam	3.39	3.75	4.01	4.23	4.40	4.54	4.78
5.00 x 3.43	Std I-Beam	4.90	5.28	5.56	5.79	5.97	6.12	6.37
5.00 x 4.23	Std I-Beam	5.48	5.95	6.32	6.64	6.91	7.13	7.48
5.00 x 5.10	Std I-Beam	6.09	6.64	7.10	7.52	7.88	8.17	8.64
6.00 x 4.30	Std I-Beam	7.35	7.84	8.21	8.54	8.81	9.03	9.38
6.00 x 5.10	Std I-Beam	8.04	8.67	9.09	9.52	9.89	10.19	10.66
6.00 x 5.96	Std I-Beam	8.77	9.42	9.99	10.53	11.00	11.39	11.99
8.00 x 6.35	Std I-Beam	14.39	15.07	15.69	16.27	16.78	17.21	17.87
8.00 x 7.96	Std I-Beam	16.21	17.06	17.87	18.68	19.42	20.05	21.05
8.00 x 8.81	Std I-Beam	17.18	18.10	18.99	19.91	20.76	21.49	22.67

Name Height x Weight		Attached Plate Thickness (in) None	1/8	3/16	1/4	5/16	3/8	1/2
2.00 x 0.78	Wide I-Beam	0.48	0.55	0.58	0.61	0.63	0.66	0.76
2.00 x 1.43	Wide I-Beam	0.78	0.91	0.98	1.03	1.08	1.13	1.26
2.50 x 1.80	Wide I-Beam	1.16	1.35	1.46	1.54	1.61	1.67	1.81
4.00 x 4.76	Wide I-Beam	5.40	5.74	6.03	6.30	6.54	6.74	7.09
5.00 x 6.49	Wide I-Beam	9.58	9.98	10.37	10.75	11.10	11.41	11.92
6.00 x 4.16	Wide I-Beam	7.25	7.70	8.06	8.37	8.62	8.83	9.16
6.00 x 7.85	Wide I-Beam	14.75	15.18	15.61	16.06	16.48	16.86	17.49
6.00 x 8.30	Wide I-Beam	15.12	15.60	16.07	16.56	17.03	17.45	18.16
6.00 x 9.18	Wide I-Beam	15.87	16.41	16.95	17.54	18.10	18.60	19.46

8 OCT 1980

MEMBERS ON 38t PLATE
SECTION MODULUS (in^3)

Name Height x Weight		None	1/8	3/16	1/4	5/16	3/8	1/2
3.00 x 1.42	Std Channel	1.10	1.30	1.40	1.47	1.52	1.57	1.68
3.00 x 1.48	Std Channel	1.13	1.33	1.43	1.51	1.57	1.62	1.73
3.00 x 1.73	Std Channel	1.24	1.47	1.60	1.70	1.77	1.84	1.97
3.00 x 1.95	Std Channel	1.33	1.59	1.75	1.86	1.95	2.03	2.17
3.00 x 2.07	Std Channel	1.38	1.66	1.82	1.95	2.04	2.13	2.28
4.00 x 1.85	Std Channel	1.92	2.20	2.36	2.47	2.55	2.62	2.75
4.00 x 2.16	Std Channel	2.10	2.43	2.63	2.77	2.88	2.97	3.13
4.00 x 2.50	Std Channel	2.29	2.67	2.91	3.09	3.23	3.34	3.53
5.00 x 2.32	Std Channel	3.00	3.38	3.62	3.79	3.91	4.02	4.19
5.00 x 3.11	Std Channel	3.56	4.06	4.41	4.68	4.88	5.05	5.31
5.00 x 3.97	Std Channel	4.17	4.76	5.21	5.59	5.89	6.13	6.51
6.00 x 2.83	Std Channel	4.37	4.87	5.19	5.44	5.62	5.77	5.99
6.00 x 3.00	Std Channel	4.52	5.05	5.40	5.67	5.88	6.04	6.29
6.00 x 3.63	Std Channel	5.06	5.68	6.12	6.49	6.77	6.99	7.33
6.00 x 4.48	Std Channel	5.80	6.50	7.06	7.55	7.94	8.25	8.71
8.00 x 4.25	Std Channel	8.46	9.24	9.83	10.34	10.73	11.04	11.50
8.00 x 4.75	Std Channel	9.03	9.87	10.55	11.14	11.61	11.98	12.53
8.00 x 5.62	Std Channel	10.01	10.95	11.75	12.48	13.09	13.58	14.30
8.00 x 6.48	Std Channel	10.99	12.01	12.91	13.77	14.50	15.11	16.01

Name Height x Weight		None	1/8	3/16	1/4	5/16	3/8	1/2
4.00 x 3.32	Spec Channel	3.42	3.78	4.04	4.26	4.44	4.58	4.83
5.00 x 3.10	Spec Channel	4.48	4.84	5.09	5.29	5.45	5.58	5.80
5.00 x 4.74	Spec Channel	5.35	5.92	6.39	6.81	7.16	7.44	7.89
5.00 x 5.82	Spec Channel	7.25	7.78	8.26	8.71	9.10	9.43	9.96
6.00 x 5.77	Spec Channel	8.02	8.71	9.31	9.87	10.35	10.75	11.36
6.00 x 5.93	Spec Channel	9.41	9.99	10.50	10.99	11.41	11.77	12.33
8.00 x 6.59	Spec Channel	13.54	14.35	15.08	15.78	16.39	16.90	17.67
8.00 x 7.86	Spec Channel	15.94	16.79	17.60	18.41	19.14	19.77	20.75

Attached Plate Thickness (in) applies to columns None through 1/2.

MEMBERS ON 38t PLATE
SECTION MODULUS (in^3)

Name Height x Width x Thickness		Attached Plate Thickness (in) None	1/8	3/16	1/4	5/16	3/8	1/2
1.00 x 1.00 x 1/8	Rect Tube	0.11	0.16	0.18	0.20	0.23	0.27	0.40
1.12 x 1.12 x 1/8	Rect Tube	0.15	0.21	0.23	0.25	0.28	0.32	0.44
1.25 x 1.25 x 1/8	Rect Tube	0.19	0.26	0.29	0.31	0.34	.38	0.49
1.25 x 1.25 x 3/16	Rect Tube	0.24	0.34	0.36	0.42	0.46	.50	0.64
1.50 x 1.50 x 1/8	Rect Tube	0.29	0.38	0.41	0.44	0.47	0.51	0.62
1.50 x 1.50 x 3/16	Rect Tube	0.38	0.50	0.56	0.61	0.65	0.70	0.83
2.00 x 1.00 x 1/8	Rect Tube	0.33	0.46	0.51	0.54	0.57	0.61	0.70
2.00 x 1.00 x 3/16	Rect Tube	0.44	0.61	0.69	0.74	0.79	0.83	0.95
2.00 x 2.00 x 1/8	Rect Tube	0.55	0.68	0.73	0.78	0.82	0.86	0.97
2.00 x 2.00 x 3/16	Rect Tube	0.75	0.92	1.01	1.08	1.14	1.20	1.34
2.50 x 1.25 x 1/8	Rect Tube	0.54	0.72	0.79	0.84	0.88	0.92	1.02
2.50 x 1.25 x 3/16	Rect Tube	0.74	0.97	1.08	1.16	1.23	1.28	1.41
2.50 x 2.50 x 1/8	Rect Tube	0.89	1.06	1.15	1.21	1.26	1.31	1.42
2.50 x 2.50 x 3/16	Rect Tube	1.24	1.46	1.59	1.69	1.78	1.85	2.01
3.00 x 2.00 x 1/8	Rect Tube	0.97	1.20	1.30	1.38	1.43	1.49	1.60
3.00 x 2.00 x 3/16	Rect Tube	1.36	1.65	1.81	1.93	2.02	2.[illegible]	2.26
3.00 x 2.00 x 1/4	Rect Tube	1.69	2.02	2.23	2.40	2.53	2.64	2.85
3.00 x 3.00 x 1/8	Rect Tube	1.32	1.53	1.65	1.73	1.80	1.86	1.98
3.00 x 3.00 x 3/16	Rect Tube	1.86	2.13	2.30	2.44	2.55	2.64	2.82
3.00 x 3.00 x 1/4	Rect Tube	2.32	2.63	2.86	3.05	3.20	3.33	3.57

KEELS AND KEELSONS
AREA AND SECTION MODULUS

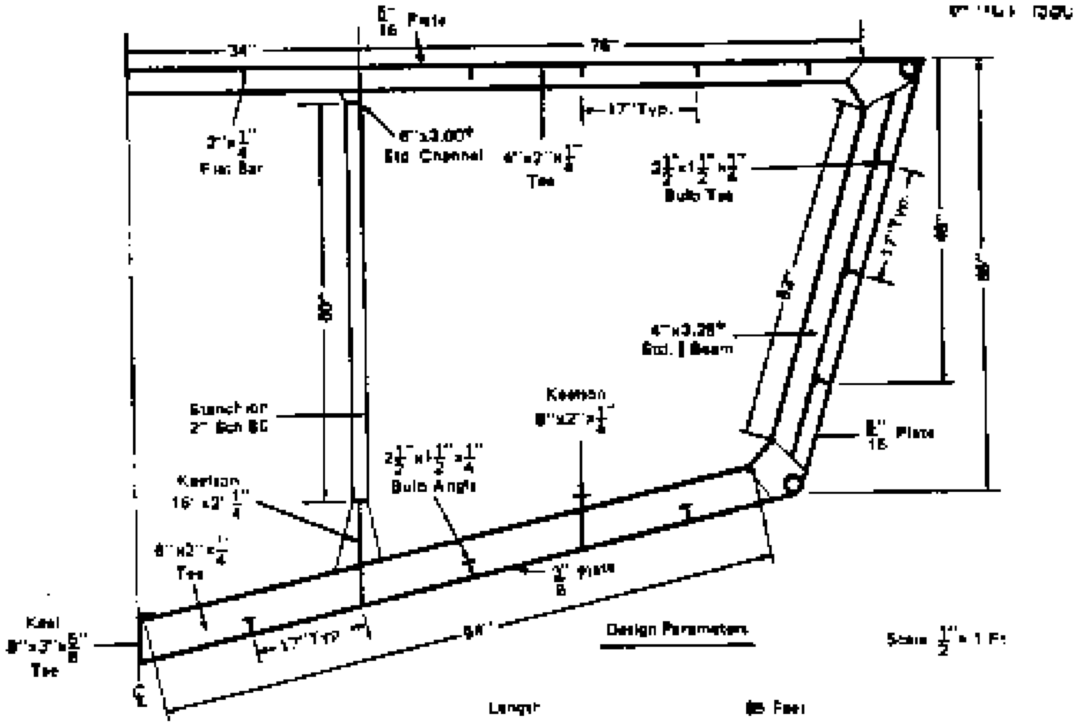
Name Height x Thickness		Area (in^2)	Section Modulus (in^3)
6" x 3/8"	Flat Bar	2.25	2.25
6" x 1/2"	Flat Bar	3.00	3.00
6" x 5/8"	Flat Bar	3.75	3.75
6" x 3/4"	Flat Bar	4.50	4.50
7" x 3/8"	Flat Bar	2.62	3.06
7" x 1/2"	Flat Bar	3.50	4.08
7" x 5/8"	Flat Bar	4.37	5.10
7" x 3/4"	Flat Bar	5.25	6.12
8" x 3/8"	Flat Bar	3.00	4.00
8" x 1/2"	Flat Bar	4.00	5.33
8" x 5/8"	Flat Bar	5.00	6.66
8" x 3/4"	Flat Bar	6.00	8.00
8" x 7/8"	Flat Bar	7.00	9.33
8" x 1"	Flat Bar	8.00	10.66
9" x 1/2"	Flat Bar	4.50	6.75
9" x 5/8"	Flat Bar	5.62	8.43
9" x 3/4"	Flat Bar	6.75	10.12
9" x 7/8"	Flat Bar	7.87	11.81
9" x 1"	Flat Bar	9.00	13.50
10" x 5/8"	Flat Bar	6.25	10.41
10" x 3/4"	Flat Bar	7.50	12.50
10" x 7/8"	Flat Bar	8.75	14.58
10" x 1"	Flat Bar	10.00	16.66
11" x 5/8"	Flat Bar	6.87	12.60
11" x 3/4"	Flat Bar	8.25	15.12
11" x 7/8"	Flat Bar	9.62	17.64
11" x 1"	Flat Bar	11.00	20.16
11" x 1-1/8"	Flat Bar	12.37	22.68
12" x 1/4"	Flat Bar	3.00	6.00
12" x 5/16"	Flat Bar	3.75	7.50
12" x 3/8"	Flat Bar	4.50	9.00
12" x 1/2"	Flat Bar	6.00	12.00
12" x 5/8"	Flat Bar	7.50	15.00
12" x 3/4"	Flat Bar	9.00	10.00
12" x 7/8"	Flat Bar	10.50	18.00
12" x 1"	Flat Bar	12.00	24.00
12" x 1-1/8"	Flat Bar	13.50	27.00

KEELS AND KEELSONS
AREA AND SECTION MODULUS

Name Height x Thickness		Area (in^2)	Section Modulus (in^3)
13" x 3/4"	Flat Bar	9.75	21.12
13" x 7/8"	Flat Bar	11.37	24.64
13" x 1"	Flat Bar	13.00	20.16
13" x 1-1/8"	Flat Bar	14.62	31.68
13" x 1-1/4"	Flat Bar	16.25	35.20
14" x 1/4"	Flat Bar	3.50	8.16
14" x 5/16"	Flat Bar	4.37	10.20
14" x 3/8"	Flat Bar	5.25	12.25
16" x 1/4"	Flat Bar	4.00	10.66
16" x 5/16"	Flat Bar	5.00	13.33
16" x 3/8"	Flat Bar	6.00	16.00
18" x 1/4"	Flat Bar	4.50	13.50
18" x 5/16"	Flat Bar	5.62	16.87
18" x 3/8"	Flat Bar	6.75	20.25

KEELS AND KEELSONS
AREA AND SECTION MODULUS

Name Height x Width x Thickness		Area (in^2)	Section Modulus (in^3)
8" x 2.0" x 1/2"	Capped Plate	4.75	6.58
8" x 2.0" x 5/8"	Capped Plate	5.85	8.07
8" x 2.0" x 3/4"	Capped Plate	6.93	9.50
8" x 2.5" x 1/2"	Capped Plate	5.00	6.86
8" x 2.5" x 5/8"	Capped Plate	6.17	8.42
8" x 2.5" x 3/4"	Capped Plate	7.31	9.93
8" x 3.0" x 1/2"	Capped Plate	5.25	7.10
8" x 3.0" x 5/8"	Capped Plate	6.48	8.72
8" x 3.0" x 3/4"	Capped Plate	7.68	10.29
10" x 2.0" x 1/2"	Capped Plate	5.75	0.03
10" x 2.0" x 3/4"	Capped Plate	8.43	14.57
10" x 2.0" x 1"	Capped Plate	11.00	18.82
10" x 2.5" x 1/2"	Capped Plate	6.00	10.44
10" x 2.5" x 3/4"	Capped Plate	8.81	15.19
10" x 2.5" x 1"	Capped Plate	11.50	19.66
10" x 3.0" x 1/2"	Capped Plate	6.25	10.79
10" x 3.0" x 3/4"	Capped Plate	9.18	15.73
10" x 3.0" x 1"	Capped Plate	12.00	20.39
12" x 2.5" x 1/4"	Flanged Plate	3.56	7.55
12" x 2.5" x 3/8"	Flanged Plate	5.29	11.18
12" x 3.0" x 1/4"	Flanged Plate	3.68	7.79
12" x 3.0" x 3/8"	Flanged Plate	5.48	11.54
12" x 3.5" x 1/4"	Flanged Plate	3.81	8.00
12" x 3.5" x 3/8"	Flanged Plate	5.67	11.86
14" x 2.5" x 1/4"	Flanged Plate	4.06	10.06
14" x 2.5" x 3/8"	Flanged Plate	6.04	14.92
14" x 3.0" x 1/4"	Flanged Plate	4.19	10.37
14" x 3.0" x 3/8"	Flanged Plate	6.23	15.38
14" x 3.5" x 1/4"	Flanged Plate	4.31	10.64
14" x 3.5" x 3/8"	Flanged Plate	6.42	15.79
16" x 2.5" x 1/4"	Flanged Plate	4.56	12.92
16" x 2.5" x 3/8"	Flanged Plate	6.79	19.17
16" x 3.0" x 1/4"	Flanged Plate	4.68	13.29
16" x 3.0" x 3/8"	Flanged Plate	6.98	19.73
16" x 3.5" x 1/4"	Flanged Plate	4.81	13.63
16" x 3.5" x 3/8"	Flanged Plate	7.17	20.25



Length	[illegible] Feet
Displacement	75 Long Tons
Draft (d)	4 Feet
Transverse Frame Spacing	3 Feet
Bulkhead Spacing	15 Feet

SCANTLING REVIEW WORKSHEET

Shipyard FBN LIGHT INDUSTRIES Hull 001 Date 10/15/80
Vessel Name TEE BOAT NO. 1 O.N. ______ Reviewer JSS

Structural Component	See Figs.	Pres. psi	Stress σ, ksi	P/σ	Spcng in	Span in	k	Size Req'd	Size Actl.
Bottom Structure (See Figure 2)									
1. Keel	Area and S.M. equivalent to L/15 x L/110 Flat Bar							[illegible]	O.K.
2. Keelsons	Area and S.M. equivalent to L/10 x L/160 Flat Bar							[illegible]	O.K.
3. Plating	3,4,10	9.58	12	0.80	17	------	------	3/8	3/8
4. Longitudinals	3,4,9	9.58	12	0.80	17	36	1.84	1.97	1.35 TOO SMALL
5. Transverses	3,4,8	8.28	12	0.69	36	47	6.63	4.57	5.47
Side Structure (See Figure 2)									
6. Plating	5,10	4.18	17	0.25	17	------	------	1/4	5/16
7. Longitudinals	5,9	3.55	17	0.21	17	36	1.84	1.39	1.30
8. Transverses	3,5,8	5.58	17	0.33	36	53	8.43	2.78	3.35
Exterior Decks (See Figure 12)									
9. Plating	6,10	1.78	17	0.10	17	------	------	5/16	5/16
10. Longitudinals	6,9	"	17	"	17	36	1.84	0.18	0.38
11. Transverses	6,8	"	17	"	36	76	17.33	1.73	2.98
12. Girders	6,8	"	17	"	76	90	51.30	5.13	5.68
13. Stanchions	6,13	-------	--	------	------	------	------	2" 80	2" 80

<u>Keel</u>

Equivalent Flat Bar:

$t = L/110 = 85/110 = 0.77"$ (width)

$h = L/11 = 85/11 = 7.73"$ (height)

$A = (t)(h) = (0.77)(7.73) = 5.95\ in^2$ (required area)

$S.M. = (h^2)(t)/6 = (7.73^2)(0.77)/6 - 7.67\ in^3$ (required section modulus)

From Page A-12, for an 8"x3"x5/8" Capped Plate

$A = 6.48\ in^2$
$S.M. = 8.72\ in^3$ (keel is satisfactory)

<u>Keelsons</u>

Equivalent Flat Bar:

$t = L/160 = 85/160 = 0.53"$ (width)

$h = L/11 = 85/11 = 7.73"$ (height)

$A = (t)(h) = (0.77)(7.73) = 5.95\ in^2$ (required area)

$S.M. = (h^2)(t)/6 = (7.73^2)(0.77)/6 - 7.67\ in^3$ (required section modulus)

One keelson is a 16"x2"x1/4" Capped Plate, and the other is an 8"x2"xl/4' Tee, neither or which appear on pages A-10 through A-12 for Keels and Keelsons.

The S.M. of' the smaller keelson is found on page A-4: 8"x2"x1/4" Tee on no plate has S.M. = $3.142\ in^3$

The area of' the section can be estimated by multip1ying the sum of the web and flange dimensions (8"+2") by the thickness (1/4"). $A = (8 + 2)(1/4) = 2.50\ in^2$.

A conservative estimate for the area and section modulus of' the 16"x2"x1/4" Capped Plate is obtained by ignoring the 2" flange and treating the section as a flat bar with

$$A = (h)(t) = (16)(1/4) = 4.00\ in^2$$
$$S.M. = (h^2)(t)/6 = (16^2)(1/4)/6 = 10.67\ in^3$$

The combined area of the keelsons is $2.50 + 4.00 = 6.50\ in^2$

The combined S.M. of the keelsons is $3.42 + 10.67 = 14.09\ in^3$

Although the 16"x2"x1/4" Capped Plate keelson is not listed in the tables of Appendix A, its area and S.M. could also have been roughly estimated by comparison to the 16"x2.5"xl/4" Flanged Plate on page A-12, which almost the same size and has almost the same section properties.

Since the combined area and section modulus of the keelsons exceed the required values, the keelsons can be considered as effective supporting members for the transverse frames.

Bottom Structure

Impact Pressure:

L = 85 ft (length overall)
Δ = 75 Long Tons (displacement)

From Figure 3, P1 13.0 psi (impact pressure)

Bottom Plating and Longitudinals:

d = 4.0 ft (draft)

P = (0.6)(Pi) + (0.444)(d) (design pressure)
= (0.6)(13.0) + (0.444)(4.0) = 9.58 psi

= 12 ksi (design stress)
s =- 17" (stiffener spacing)
$P/$ = 0.80

From Figure 10, 3/8" plate is required (plating is satisfactory)

l = 36" (span of longitudinals)
s = 17" (spacing of longitudinals)

From Figure 9, K = 1.84

S.M. = (P/)(K) = (required section modulus)
= (0.80)(1.84) = 1.47 in^3

From Page A-1, 2.50"x1.50"x1/4" Bulb Tee on 3/8 plate has
S.M. = 1.35 in^3 (the section is too small)

Any shape having a section modulus of at least 1.47 in would be acceptable, such as a 3.00"x1.50"x1/4" Bulb Tee, which has a section modulus of' 1.73 in^3 on 3/8" plate.

Bottom Transverse Frames

P = (0.5)(Pi) + (0.444)(d) (design pressure)
= (0.5)(13.0) + (0.444)(4.0) = 8.28 psi

= 12 ksi (design stress)

P/ = 0.69

l = 94/2 = 47" (span of' transverse frame)

One half the length of the transverse frame can be used as the unsupported span because the keelsons are large enough to be considered effective supports.

s = 36" (spacing of transverse frames)

From Figure 8, K = 6.63

S.M. = (P/)(K) (required section modulus)
= (0.69)(6.63) = 4.57 in^3

From Page A-3, a 6.00"x2.00"x1/4" Bulb Tee on 3/8" plate has a
S.M. = 5.47 in^3 (frame is satisfactory)

Side Structure

Plating

h = distance from the bottom of the side plate (chine) to a point 4 feet above the deck at side. (design head)
= 65/12 + 4.0 = 9.42 ft

P = (0.444)(h) (design pressure)
= (0.444)(9.42) = 4.18 psi

= 17 ksi (design stress)

P/ = 0.25

s = 17" (stiffener spacing)

From Figure 10, 1/4" plate is required (5/16" plate is satisfactory)

Longitudinals

h = distance from lowest side longitudinal to a point 4 feet above the deck at side. (design head)
= 48/12 + 4.0 = 8.0 ft

P = 0.444)(h) (design pressure)
= (0444)(8.00) = 3.55 psi

= 17 ksi (design stress)

P/ = 0.21

l = 36" (span of longitudinals)

s = 17” (spacing of longitudinals)

From Figure 9, K = 1.84

S.M. = (P/)(K) (required section modulus)
= (0.21)(1.84) - 0.39 in^3

From Page A-1, a 2.50'1x1.50"xl/4" Bulb Tee on 5/16” plate has
S.M. = 1.30 in^3 (longitudinal is satisfactory)

Side Transverse Frames

h = distance from middle of span of side transverse frame to a point 4 feet above the deck at side (design head)
= (65/12)(1/2) + 4 = 6.71 ft

P = (0.2)(Pi) + (0.444)(h) (design pressure)
= (0.2)(13.0) + (0.444)(6.71) = 5.58 psi

= 17 ksi (design stress)

P/ = 0.33

l = 53” (span of transverse frame)

s = 36” (spacing of transverse frames)

From Figure 8, K = 8.43

S.M. = (P/)(K) (required section modulus)
= (0.34)(8.43) = 2.78 in^3

From Page A-7, a 4.00"x3.28” Std I-Beam not attached to plate has
S.M. = 3.39 in^3 (frame is satisfactory)

Deck Structure

From Figure 6, P = 1.78 psi (design pressure)

= 17 ksi (design stress)

P/ = 0.10

Plating

s = 17” (stiffener spacing)

From Figure 10, 5/16" plate is required for deck plate where deck cargo is carried. (plating is satisfactory)

Longitudinals

l = 36” (span of longitudinals)

s = 17” (spacing of longitudinals)

From Figure 9, K = 1.84

S.M. = (P/)(K) (required section modulus)
= (0.10)(1.84) = 0.18 in^3

From Page A-5, a 2.00"xl/4” Flat Bar on 5/16” plate has
S.M. = 0.38 in^3 (longitudinal is satisfactory)

Deck Transverse Frames

1 = 76" (span of transverse frame)

s = 36" (spacing of transverse frames)

From Figure 8, K = 17.33

S.M. = (P/)(K) (required section modulus)
= (0.10)(17.33) = 1.73 in^3

From Page A-3, a 4.00”x2.00"xl/4” Tee attached to 5/16" plate has
S.M. = 2.98 in^3 (frame is satisfactory)

Deck Girder

l = 15/2 ft = 90” (span of deck girder)

The span of the deck girder is the maximum distance between supports such as bulkheads and other stanchions. In this case it is the distance between the stanchion and a bulkhead.

s = 76" (spacing of' deck girder)

The spacing of' the deck girder is the width of the wider of the two panels on each side of it. In this case, the inboard panel is 68" (2 x 34”), and the outboard panel is 76" wide.

The spacing exceeds the range of Figure 8, 50 USC the expression
$K = (L^2)(s)/12{,}000 = (90^2)(76)/12{,}000 = 51.30$

S.M. = (P/)(K) = (0.10)(51.30) = 5.13 in^3

From Page A-8, a 6.00"x3.00# Std Channel attached to 5/16" plate has
S.M. = 5.88 in^3 (girder is satisfactory)

Stanchion

W = 34 + 76/2 = 72" = 6 ft	(width of panel supported)
S = 15/2 = 7.5 ft	(length of panel supported)
A = (S)(L) = (6)(7.5) = 45 ft^2	(area of panel)
L = 60”	(length of stanchion)

From Figure 13, a 2" Sch 80 Pipe is the minimum size required
(stanchion is satisfactory)