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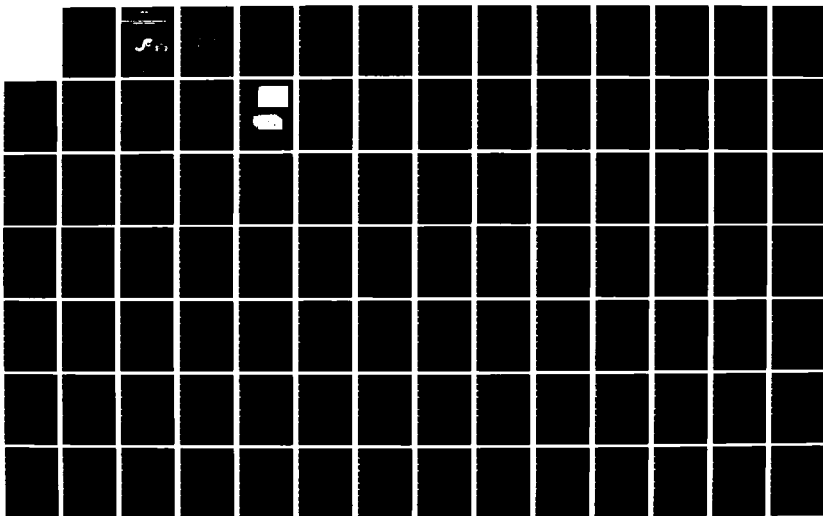
UPDATING OF FILLET WELD STRENGTH PARAMETERS FOR  
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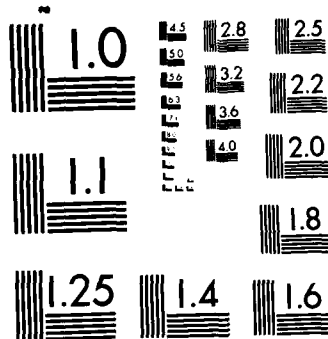
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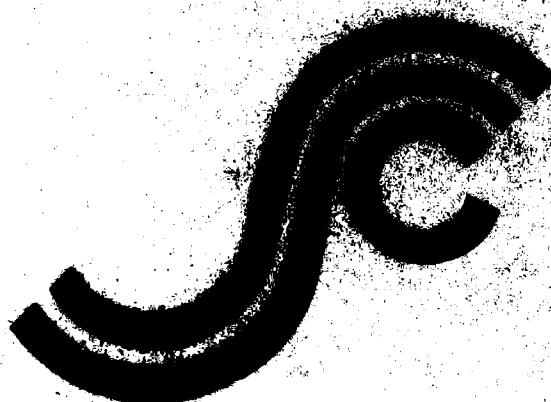
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# UPDATING OF FILLET WELD STRENGTH PARAMETERS FOR COMMERCIAL SHIPBUILDING

AD-A162 485



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Structure  
Committee**

An Interagency Advisory Committee  
Dedicated to the Improvement of Marine Structures SR-1286

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This report presents a possible alternate method of assessing fillet weld requirements vis-a-vis the American Bureau of Shipping (ABS) weld tables. The recommended methodology is demonstrated on previous designs of a tanker, an OBO and a containership. Results point to cost savings of from 9 to 15 percent of welding costs.

Certainly these results are worthy of further consideration. However, as always, specific designs must be approved by the appropriate authorities.

CLYDE T. LUSK, Jr.  
Rear Admiral, U.S. Coast Guard  
Chairman, Ship Structure Committee

Technical Report Documentation Page

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |  |                                                                                |  |                                                                                                                                                            |  |
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| 16. Abstract<br>A new procedure for sizing fillet welds for commercial ship structures is developed in this report. First the weld sizes required to develop the full strength of the type connections are developed including appropriate corrosion allowances. Service experience data is included by determining the joint efficiencies in the current American Bureau of Shipping (ABS) weld tables. ABS welds are resized and put in a form which is easier to use in a design office, easier to compare to other rule weld sizes, and should help guide further weld size reduction research although significant further reductions in commercial ship fillet weld sizes are not anticipated. In general, the current ABS fillet weld sizes are not excessively conservative so the proposed reductions are relatively small. The new design criteria is applied to three sample ships showing order of magnitude weld cost savings of 9 to 15 percent.<br>Keywords: |  |                                                                                |  |                                                                                                                                                            |  |
| 17. Key Words<br>Fillet Weld<br>Weld Sizing<br>Strength<br>Joint Efficiencies<br>Stress,                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |  | Shear,<br>Electrodes.                                                          |  | 18. Distribution Statement<br>Document is available to the<br>U.S. public through the<br>National Technical Information<br>Service, Springfield, Va. 22161 |  |
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# METRIC CONVERSION FACTORS

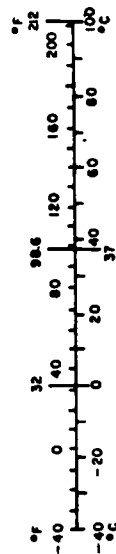
## Approximate Conversions to Metric Measures

| Symbol                     | When You Know          | Multiply by                | To Find             | Symbol          |
|----------------------------|------------------------|----------------------------|---------------------|-----------------|
| <b>LENGTH</b>              |                        |                            |                     |                 |
| in                         | inches                 | 2.5                        | centimeters         | cm              |
| ft                         | feet                   | 30                         | centimeters         | cm              |
| yd                         | yards                  | 0.9                        | meters              | m               |
| mi                         | miles                  | 1.6                        | kilometers          | km              |
| <b>AREA</b>                |                        |                            |                     |                 |
| m <sup>2</sup>             | square inches          | 6.5                        | square centimeters  | cm <sup>2</sup> |
| ft <sup>2</sup>            | square feet            | 0.09                       | square meters       | m <sup>2</sup>  |
| yd <sup>2</sup>            | square yards           | 0.8                        | square meters       | m <sup>2</sup>  |
| mi <sup>2</sup>            | square miles           | 2.6                        | square kilometers   | km <sup>2</sup> |
|                            | acres                  | 0.4                        | hectares            | ha              |
| <b>MASS (weight)</b>       |                        |                            |                     |                 |
| oz                         | ounces                 | 28                         | grams               | g               |
| lb                         | pounds                 | 0.45                       | kilograms           | kg              |
|                            | short tons (2000 lb)   | 0.9                        | tonnes              | t               |
| <b>VOLUME</b>              |                        |                            |                     |                 |
| 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                 | 0.96                       | liters              | l               |
| gal                        | gallons                | 3.8                        | liters              | l               |
| ft <sup>3</sup>            | cubic feet             | 0.03                       | cubic meters        | m <sup>3</sup>  |
| yd <sup>3</sup>            | cubic yards            | 0.76                       | cubic meters        | m <sup>3</sup>  |
| <b>TEMPERATURE (exact)</b> |                        |                            |                     |                 |
| °F                         | Fahrenheit temperature | 5/9 (after subtracting 32) | Celsius temperature | °C              |

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

## Approximate Conversions from Metric Measures

| Symbol                     | When You Know                     | Multiply by       | To Find                | Symbol          |
|----------------------------|-----------------------------------|-------------------|------------------------|-----------------|
| <b>LENGTH</b>              |                                   |                   |                        |                 |
| mm                         | millimeters                       | 0.04              | inches                 | in              |
| cm                         | centimeters                       | 0.4               | inches                 | in              |
| m                          | meters                            | 3.3               | feet                   | ft              |
| in                         | inches                            | 1.1               | yards                  | yd              |
| km                         | kilometers                        | 0.6               | miles                  | mi              |
| <b>AREA</b>                |                                   |                   |                        |                 |
| cm <sup>2</sup>            | square centimeters                | 0.16              | square inches          | in <sup>2</sup> |
| m <sup>2</sup>             | square meters                     | 1.2               | square yards           | yd <sup>2</sup> |
| km <sup>2</sup>            | square kilometers                 | 0.4               | square miles           | mi <sup>2</sup> |
| ha                         | hectares (10,000 m <sup>2</sup> ) | 2.5               | acres                  | ac              |
| <b>MASS (weight)</b>       |                                   |                   |                        |                 |
| g                          | grams                             | 0.035             | ounces                 | oz              |
| kg                         | kilograms                         | 2.2               | pounds                 | lb              |
| t                          | tonnes (1000 kg)                  | 1.1               | short tons             | st              |
| <b>VOLUME</b>              |                                   |                   |                        |                 |
| 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 <sup>3</sup>             | cubic meters                      | 35                | cubic feet             | ft <sup>3</sup> |
| m <sup>3</sup>             | cubic meters                      | 1.3               | cubic yards            | yd <sup>3</sup> |
| <b>TEMPERATURE (exact)</b> |                                   |                   |                        |                 |
| °C                         | Celsius temperature               | 9/5 (then add 32) | Fahrenheit temperature | °F              |



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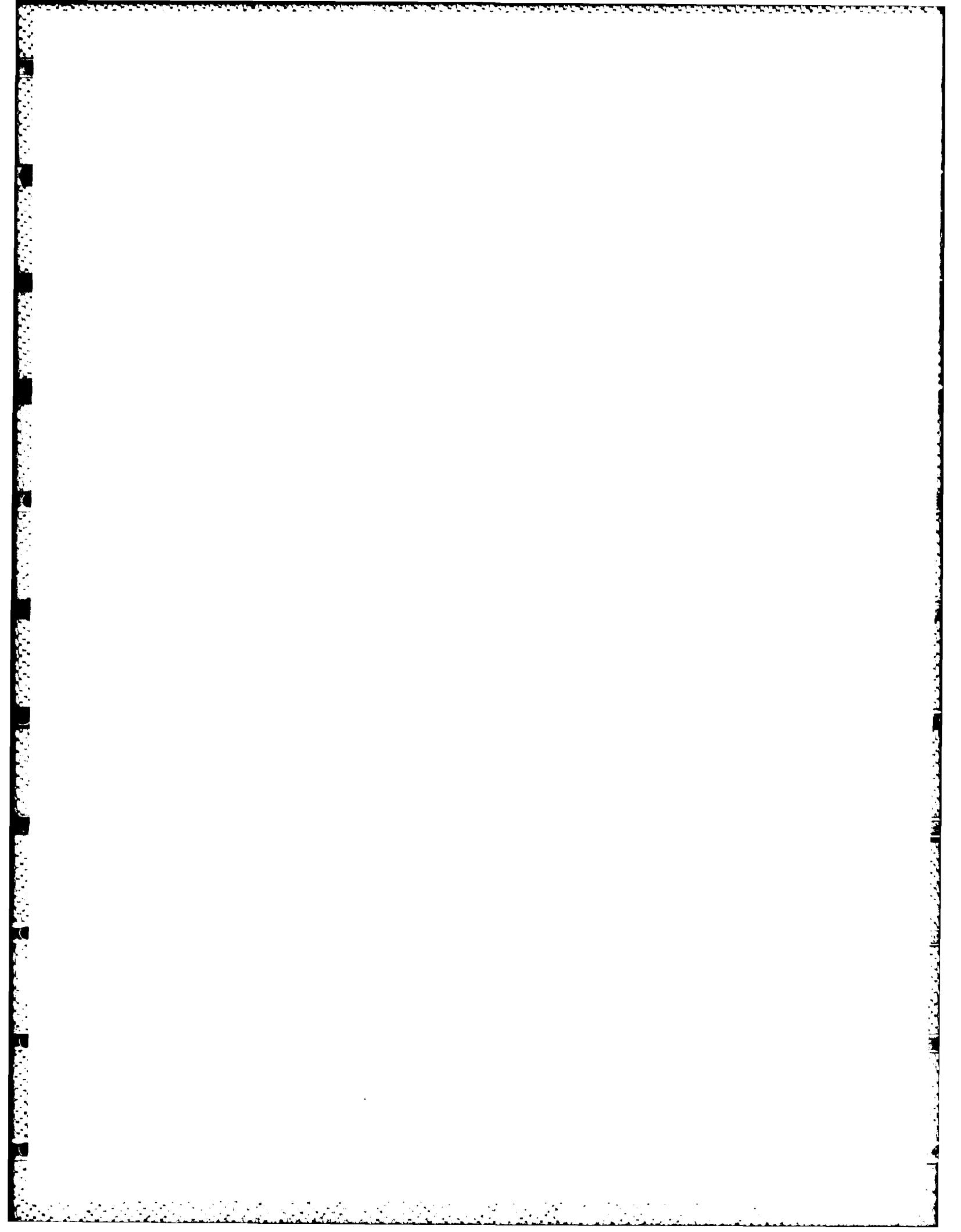
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## SYMBOLS

- C = Corrosion allowance
- D = Fillet weld size as originally welded
- D<sub>C</sub> = Fillet weld size when corroded
- D<sub>i</sub> = Continuous fillet weld size equivalent of an intermittent fillet weld with no corrosion
- D<sub>ic</sub> = Continuous fillet weld size equivalent of an intermittent fillet weld with a corrosion allowance
- E = Joint efficiency as originally welded
- E<sub>C</sub> = Joint efficiency when corroded
- L = Length of intermittent fillet welds
- RC = Relative cost of fillet welds in percent
- S = Spacing of intermittent fillet welds
- T = Original plate thickness
- T<sub>C</sub> = Plate thickness when corroded
- T<sub>r</sub> = Plate thickness required for a given load
- HAZB = Boundary line between fillet weld heat affected zone and base material
- 
- $\sigma$  = Tensile stress (KSI)
- $\sigma_{uc}$  = Ultimate tensile stress of continuous material
- $\sigma_{ui}$  = Ultimate tensile stress of intercostal material
- $\sigma_{uw}$  = Ultimate tensile stress of weld metal
- 
- $\tau$  = Shear stress (KSI)
- $\tau_{uc}$  = Ultimate shear stress of continuous material
- $\tau_{ui}$  = Ultimate shear stress of intercostal material
- $\tau_{wl}$  = Weld metal ultimate longitudinal shear stress
- $\tau_{wt}$  = Weld metal ultimate transverse shear stress



## 1. INTRODUCTION

A recent Ship Structure Committee report [SSC-296, Reference 1] illustrates the variety of fillet weld sizes which can be obtained for ship structural connections by using various existing rules from:

- o the American Bureau of Shipping (ABS),
- o other classification societies,
- o the U.S. Navy,
- o the American Welding Society (AWS), and
- o the American Institute of Steel Construction (AISC).

However, the comparisons in Reference 1 are somewhat limited. For example, only ten weld locations are compared while the current ABS Rules list weld sizes for 96 different locations and Lloyd's Register lists about 93. A given structural connection can require different weld sizes depending on its location in the ship (e.g., in the peaks or flat of bottom forward versus amidships), location in the member (e.g., center versus ends of a span), or tightness (e.g., watertight versus nontight). In addition, the various rules specify their minimum requirements in different forms. Some means of weighting the importance of a given line item to the overall cost of all the fillet welds on a typical ship is also needed. Therefore, it is very difficult to make reasonable comparative judgments on the various rules without an extensive effort.

Reference 1 recommends an extensive analysis of fillet welds by finite element techniques to determine minimum sizes along with "photoelastic, or similar stress analysis, experiments . . . to check the validity of the mathematical modeling and computer results" [page 43, Reference 1]. Before such work is started, it would appear most desirable to first analyze the current ABS weld tables in detail using methods which have been verified by actual weld joint tests to better identify the potential candidates for weld size reduction. That is the objective of this report which uses a simple engineering design approach, verified by testing, to characterize ABS fillet weld sizes and to put them in a more useful form for comparison with other rules or everyday use in a design office. This approach should aid further research by allowing such research to concentrate on more important aspects of the problem such as the question of what joint efficiencies are appropriate to the many different joint configurations and locations in a typical merchant

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| By                 |                       |
| Distribution       |                       |
| Availability Codes |                       |
| A-1                | Available for Special |



ship. This simpler approach will also help ship designers by giving them a better "feel" for the joint strengths required than the current method of choosing sizes from an extensive welding table and by giving them better insight on how to handle unusual configurations. It should be kept in mind that the work in this report is a study proposed for the design and selection of ABS welds. It is not a fabrication document and the use of this report in sizing any fillet welds under ABS jurisdiction is subject to ABS approval prior to use in actual construction.

Since this report is a proposed design procedure, it, like all design procedures, assumes that proper fabrication procedures and techniques will be applied to produce the specified welds. Thus, it should not restrict those contractors who can meet the requirement - rather - it should provide the acceptable design limitations, minimum and maximum, of the procedure. Also, if consideration is to be given to producibility and cost-effective measures in an effort to be competitive with others, it is necessary to provide those in design and construction with the tools they need. For example, the proposed procedure indicates a minimum weld size of  $1/8"$ ; it also allows a  $3/16"$  maximum fit-up gap with a  $1/8"$  increase in the size of the weld. Thus, the required design weld size becomes  $1/4"$  which generally can be made with a single pass weld. If, on the other hand, the design process indicated a  $3/16"$  fillet as the minimum size, the same alignment condition would require a  $5/16"$  fillet which generally requires a double pass weld. This would result in an increase in weld metal deposited plus the expense of an additional weld pass. Where a  $3/16"$  or a  $1/4"$  weld is the smallest that can actually be deposited, then a built in allowance will exist for fit-up gaps that are equal to or less than  $1/8"$  and  $3/16"$ , respectively. Thus, the welder would not be required by a design procedure to deposit excessive weld metal. Minimum weld sizes are discussed further in Section 5.5 with recommendations at the end of the report.

Briefly, this report first resolves some of the differences between the ABS and U.S. Navy rules by sizing the welds for ABS steels with a method which is more rigorous than the current Navy method. It is well known that the strength of a given size double fillet weld varies with the direction of loading. The existing Navy fabrication documents recognize the effect of loading direction but do not take advantage of it in order to simplify the process of sizing fillet welds. This fillet weld sizing proposal will account for the effect of loading direction in a manner which is still sufficiently conservative to ensure that properly fabricated welds will uniformly develop the required design strength of the members being joined.

Fillet welds are generally sized based on the "weaker" member at a joint. However, the determination of which member is "weaker" is also a function of the loading direction. In addition, there are cases where the "weaker" member as so defined really has little impact on the required strength of the fillet welds. Therefore, a new criteria is presented wherein the weld for tee type joints will usually be sized based on the thickness of the intercostal or non-continuous member of the joint.

The base material properties used in this report are minimum specification values taken from Reference 2. Appropriately modified weld strength data from References 3 through 6 have been used because weld longitudinal shear strength data for commercial electrodes on ABS steels were not readily available. Thus, it is assumed that commercial electrodes will have essentially the same shear strengths as the comparable series military specification electrodes. The material and weld strength values used with the proposed procedure must be on the same basis: either minimum values or average values; not a combination of the two.

After considering the effects of corrosion and intermittent welding, the joint efficiencies of the welds in the current ABS rules are determined to provide guidance on efficiencies which have given successful performance in the past. Then the ABS weld groups are assigned proposed minimum efficiencies and the welds resized. This produces new weld size tables which are more consistent than some of the current ABS weld size tables. Also, since equations are now available, the weld sizes can be readily determined for thicknesses greater than those in the current ABS weld size tables.

Using three sample ships, weld sizes are determined from both the current ABS and the proposed weld size tables. In addition, calculations are performed using ABS rule loadings for typical highly loaded fillet welded connections. Weld lengths, weights, and weighted average sizes are determined to allow budgetary cost saving estimates to be made and to allow an assessment to be made of the potential for further reductions in ABS fillet weld sizes.

## 2. DEVELOPMENT OF PROPOSED DESIGN CRITERIA

In this section, formulas for calculating nominal stresses in fillet welds are developed and applied to typical ABS steel combinations. The resulting fillet weld sizes are compared to those which would be obtained from the existing Navy procedure. The effect of uniform corrosion on joint efficiencies is determined along with equivalent sizes for intermittent fillet welds.

### 2.1 Loadings on Fillet Welds

Double fillet welds can be loaded in either of two basic ways: in longitudinal shear as shown in Figure 1 or in transverse shear as shown in Figure 2. The basic concern in sizing critical fillet welds is to ensure that the welds will develop the full strength of the joined members. In the longitudinal shear case, the weld need only develop the ultimate shear strength of the intercostal member; whereas, in the transverse shear case, the weld must develop the ultimate tensile strength of the intercostal member. Fillet welds usually fail along a plane through the throat, as shown in Figure 3. However, there is sufficient variation in the strengths of the base metals for the cases at hand that it is also possible for failure to occur along the heat-affected-zone boundary (HAZB)<sup>1</sup> between the intercostal member and the weld, as shown in Figure 4. In addition, the strength along the HAZB between the continuous member and the weld should be checked, especially when higher strength steels are involved. Therefore, the strength of the weld along three failure planes for each of the two loading conditions must be checked. It is assumed in all cases that adequate fusion has occurred between the base metal and the weld metal.

It would appear that the primary problem with previous design equations for fillet welds is their attempt to account for six possible failure modes with a single equation. References 3 through 5 appear to make an attempt in a few cases to account for alternate failure modes by varying the allowed electrode strength with different material combinations. However, that method is difficult to use because it requires adequate test data for every possible combination of materials and electrodes. Therefore, the new design procedure uses a different equation for each of the six possible failure modes. Although it is a bit more laborious, the calculations need only be done once for each material and electrode combination.

### 2.2 Stresses in Welds Loaded in Longitudinal Shear

The failure planes for double fillet welds loaded in longitudinal shear are shown by dashed lines in Figure 5. For this loading it is required that the weld develop the full ultimate shear strength of the intercostal member (plane aa). For failure in the throat of the weld (planes ob), the minimum required double fillet weld size is:

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(1) Symbols used throughout this report are identified on page vi.

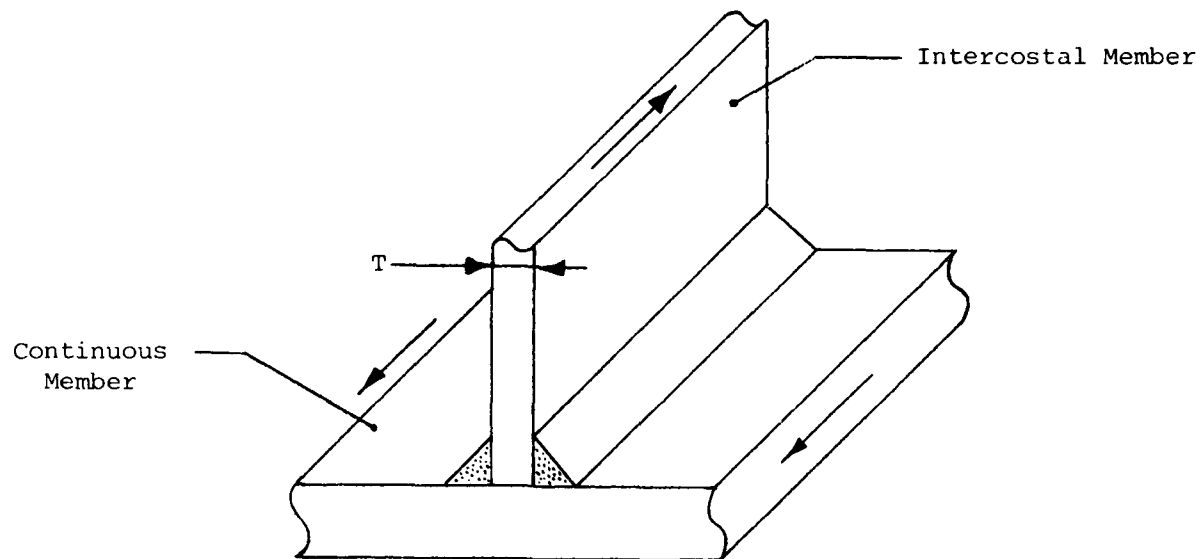


FIGURE 1

Double Fillet Weld Loaded  
in Longitudinal Shear

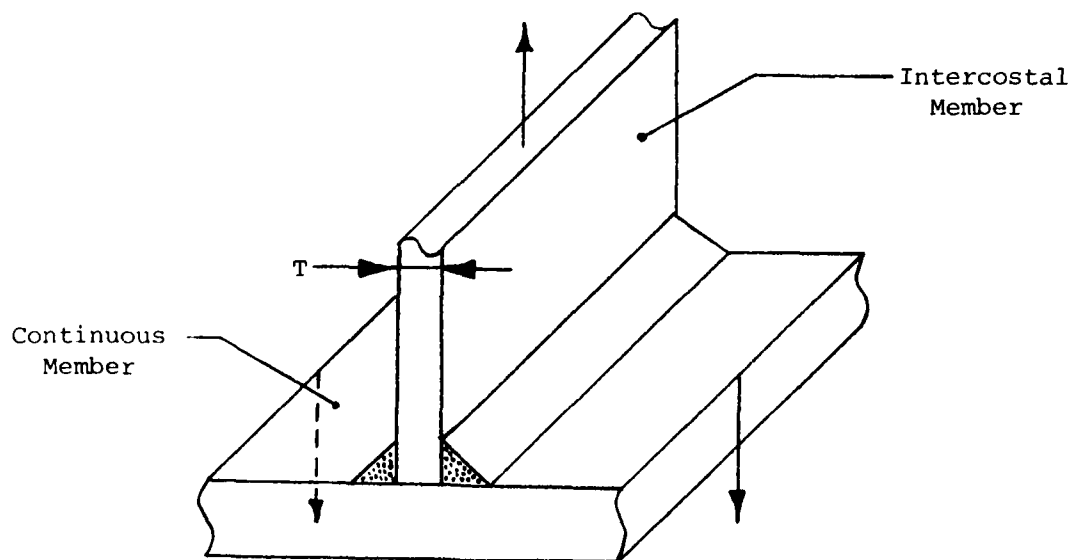


FIGURE 2

Double Fillet Weld Loaded  
in Transverse Shear

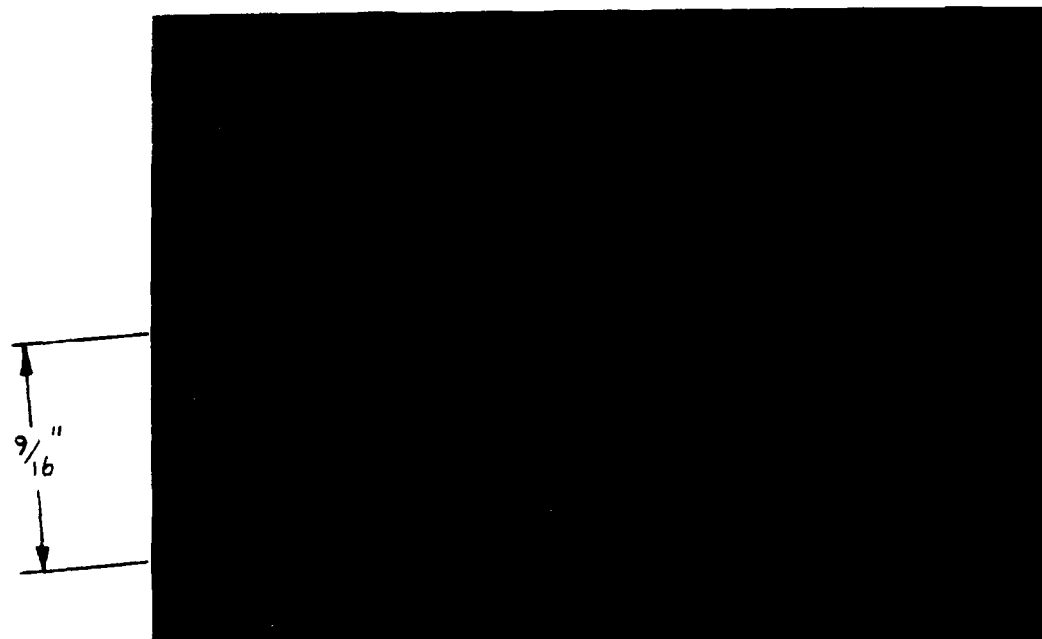


FIGURE 3

Throat Failure Plane - Transverse Shear Load

See planes cdo of Figure 6

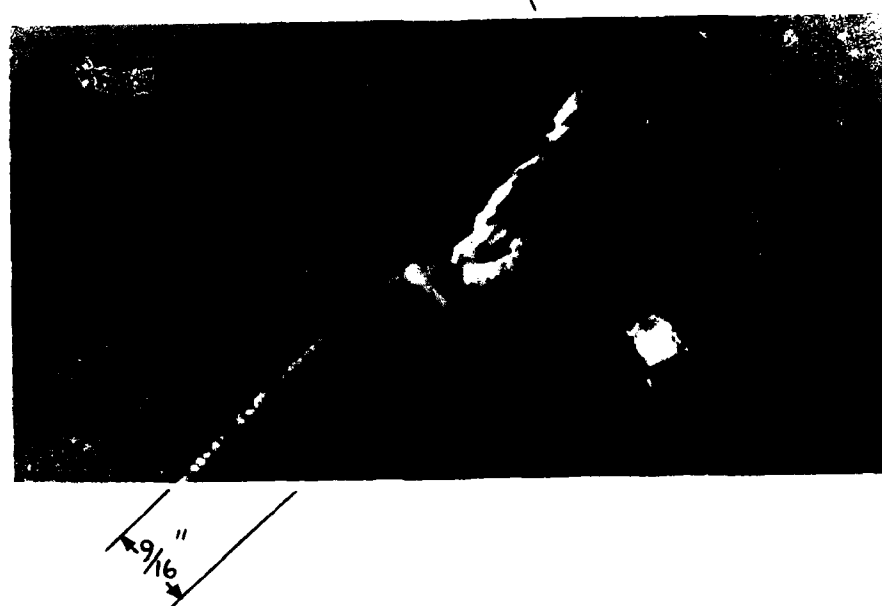


FIGURE 4

Intercostal Member HAZB Failure Plane - Transverse Shear Load

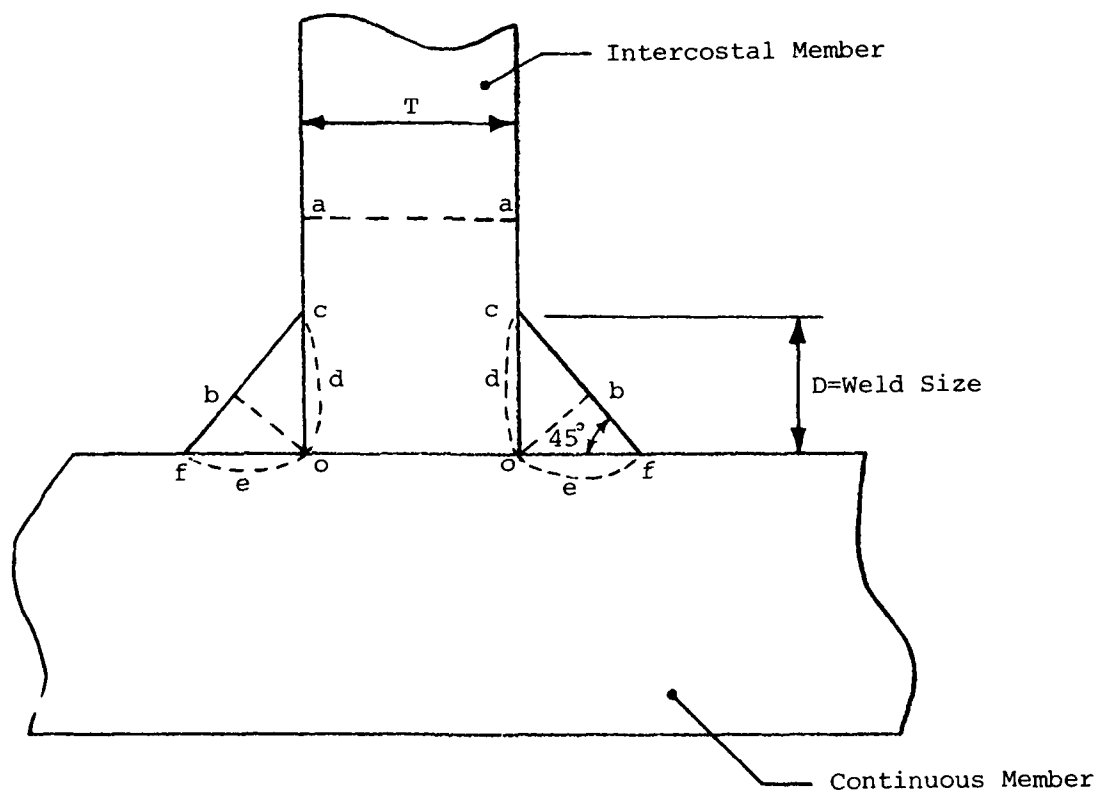


FIGURE 5

Failure Planes of a Double Fillet Weld  
Loaded in Longitudinal Shear

$$2 \times D \times \sin 45^\circ \times \tau_{wl} = T \times \tau_{ui}, \text{ or}$$

$$D/T = 0.707 \times \tau_{ui} / \tau_{wl}. \quad (1)$$

For failure along either HAZB, the length of the failure plane may be conservatively taken as  $1.1 \times D$  to account for a small amount of weld penetration into the base material [see Figure 4 and page 3-36 of Reference 9]. For failure along the intercostal member HAZB (planes cdo),

$$2 \times D \times 1.1 \times \tau_{ui} = T \times \tau_{ui}, \text{ or}$$

$$D/T = 0.455. \quad (2)$$

For failure along the continuous member HAZB (planes oef),

$$2 \times D \times 1.1 \times \tau_{uc} = T \times \tau_{ui}, \text{ or}$$

$$D/T = 0.455 \times \tau_{ui} / \tau_{uc}. \quad (3)$$

As long as a double fillet weld is equal to or larger than the greatest value of equations (1), (2), or (3), it will develop the full ultimate shear strength of the intercostal member.

### 2.3 Stresses in Welds Loaded in Transverse Shear

The transverse shear loading case is slightly more complex than the longitudinal shear loading case. Both theory and experiments show that the failure plane within the weld is located at  $22\frac{1}{2}$  degrees from the intercostal member (planes oh) rather than 45 degrees (planes ob) [see Figures 3 and 6 and Reference 7]. However, in order to simplify the calculations, transverse weld shear stresses are customarily made with reference to the 45 degree plane. Adhering to this practice and basing the weld size on the ultimate tensile strength of the intercostal member (plane aa), the minimum required double fillet weld size for failure in the throat of the weld is:

$$2 \times D \times \sin 45^\circ \times \tau_{wt} = T \times \sigma_{ui}, \text{ or}$$

$$D/T = 0.707 \times \sigma_{ui} / \tau_{wt}. \quad (4)$$

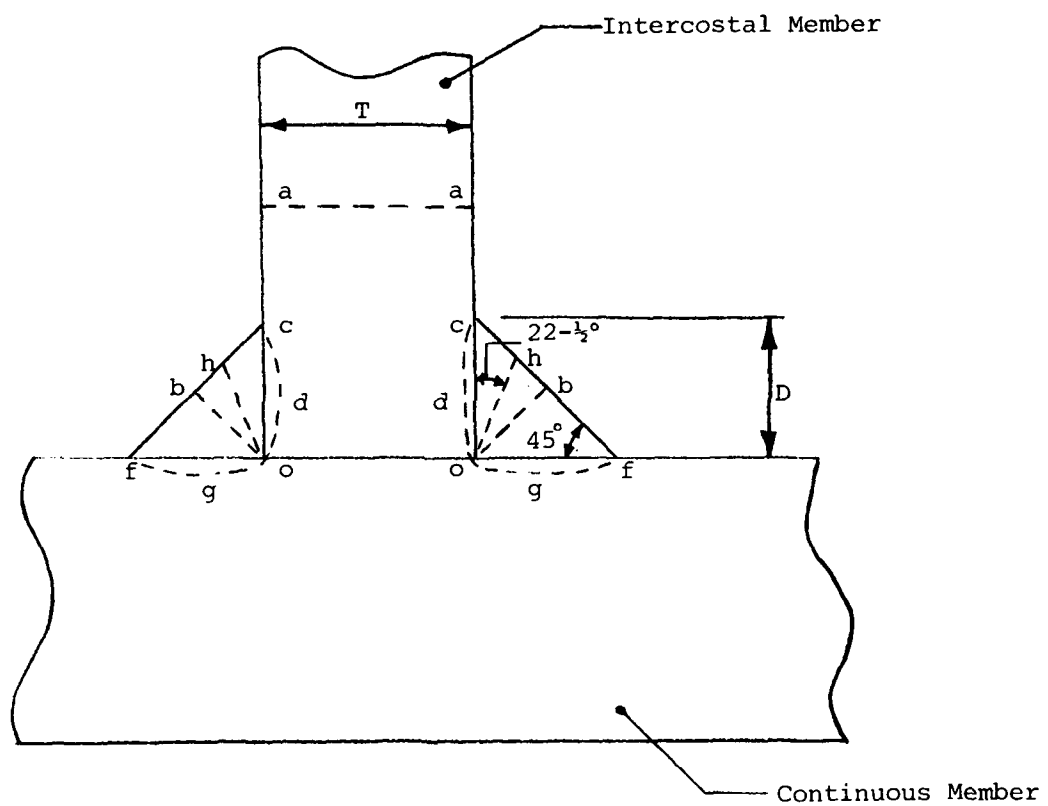


FIGURE 6

Failure Planes of a Double Fillet Weld  
Loaded in Transverse Shear

For failure along the intercostal member HAZB (planes cdo),

$$2 \times D \times 1.1 \times \tau_{ui} = T \times \sigma_{ui}, \text{ or}$$
$$D/T = 0.455 \times \sigma_{ui} / \tau_{ui}. \quad (5)$$

For this transverse loading, the continuous member HAZB (planes ogf) will be either in tension or compression. Therefore, the projected length of the HAZB (i.e., D) should be used rather than the 1.1 x D used previously. For failure along the continuous member HAZB,

$$2 \times D \times \sigma_{uc} = T \times \sigma_{ui}, \text{ or}$$
$$D/T = 0.5 \times \sigma_{ui} / \sigma_{uc}. \quad (6)$$

As long as a double fillet weld is equal to or larger than the greatest value of equations (4), (5), and (6), it will develop the full ultimate tensile strength of the intercostal member.

#### 2.4 Existing Navy Formula and Fillet Weld Sizes for ABS Steels

The formula which is currently used by the Navy for sizing double fillet welds is essentially a combination of the more rigorous equations (1) and (4) using the most conservative values from each equation. That is, the weld is sized using the ultimate tensile strength of the intercostal member and the longitudinal shear strength of the weld. This formula [see References 3 through 6] expressed in the symbols used in this report is:

$$2 \times D \times \sin 45^\circ \times \tau_{wl} = T \times \sigma_{ui}, \text{ or}$$
$$D/T = 0.707 \times \sigma_{ui} / \tau_{wl}. \quad (7)$$

It should be evident that this equation can only be defended on the basis that it is normally conservative because it is not possible to load the intercostal member in tension in a manner that will fail the weld in longitudinal shear in a typical ship structural connection.

Applying equation (7) to typical material combinations and electrodes for ABS steels results in double fillet weld sizes as shown in column 6 of Table 1.

#### 2.5 Fillet Weld Sizes Using Proposed Criteria

In order to utilize the more rigorous equations (1) through (6), only two additional properties are required: the ultimate shear strength of the base

TABLE 1

100 Percent Efficient Double Fillet Weld Sizes  
for ABS Steels Using Procedure of  
NAVSHIPS 0900-014-5010 [Reference 3]

| 1                                   | 2         | 3                             | 4                    | 5                             | 6                                           |
|-------------------------------------|-----------|-------------------------------|----------------------|-------------------------------|---------------------------------------------|
| Materials<br>Intercostal-Continuous | Electrode | $\sigma_{ui}$<br>(KSI)<br>(1) | $\tau_{wl}$<br>(KSI) | Figure No.<br>[Reference (3)] | $D/T = 0.707 \frac{\sigma_{ui}}{\tau_{wl}}$ |
| H36 - H36                           | MIL 8018  | 71                            | 60.7                 | 11-41                         | 0.827                                       |
| H36 - MS                            | MIL 8018  | 71                            | 60.7                 | SIM 11-45                     | 0.827                                       |
| H36 - H36                           | MIL 7018  | 71                            | 59.2                 | 11-39                         | 0.848                                       |
| H36 - MS                            | MIL 7018  | 71                            | 58.1                 | SIM 11-43                     | 0.864                                       |
| H32 - H32                           | MIL 8018  | 68                            | 60.7                 | 11-41                         | 0.792                                       |
| H32 - MS                            | MIL 8018  | 68                            | 60.7                 | SIM 11-45                     | 0.792                                       |
| H32 - H32                           | MIL 7018  | 68                            | 59.2                 | 11-39                         | 0.812                                       |
| H32 - MS                            | MIL 7018  | 68                            | 58.1                 | SIM 11-43                     | 0.827                                       |
| MS - H36                            | MIL 8018  | 58                            | 60.7                 | 11-45                         | 0.676                                       |
| MS - H32                            | MIL 8018  | 58                            | 60.7                 | 11-45                         | 0.676                                       |
| MS - H36                            | MIL 7018  | 58                            | 58.1                 | 11-43                         | 0.706                                       |
| MS - H32                            | MIL 7018  | 58                            | 58.1                 | 11-43                         | 0.706                                       |
| MS - MS                             | MIL 7018  | 58                            | 58.1                 | 11-51                         | 0.706                                       |
| MS - MS                             | MIL 60xx  | 58                            | 46.4                 | 11-49                         | 0.884                                       |

Note: (1) See Tables 43.1 and 43.2 of Reference 2 for other base material properties.

materials and the transverse shear strength of the weld metals. Experiments show that the ultimate shear strength of most steels varies from 2/3 to 3/4 of the ultimate tensile strength [page 10, Reference 10]. Since the fillet weld sizes for the longitudinal shear loading on the weld will be a direct function of the ultimate shear strength of the intercostal member, it will be conservative to use the higher value or:

$$\tau_{ui} = 0.75 \sigma_{ui}, \text{ and} \quad (8)$$

$$\tau_{uc} = 0.75 \sigma_{uc}. \quad (9)$$

With this assumption, it will be noted that equation (1) will always govern over equation (4) provided the weld transverse shear strength is greater than 1.33 times the weld longitudinal shear strength. Both theory and tests give ratios of 1.44 to 1.56 for transverse to longitudinal weld shear strength [References 7 and 8]. It will be conservative to use the smaller value or:

$$\tau_{wt} = 1.44 \times \tau_{wl}. \quad (10)$$

Weld shear strength values from References 3 and 6 are shown in Figure 7 for covered electrodes and in Figure 8 for bare electrodes. The shear strength values are plotted versus the ultimate tensile strength of the weld metal. It should be noted that there is a wide variation in the published values and many seem inconsistent. For example, the values from Reference 3 for MIL 9018 and 11018 electrodes vary with material combinations, whereas the values for MIL 8018 and 10018 electrodes do not. Also, the value from Reference 6 for MIL 11018 is greater than the value specified for MIL 12018 which clearly seems inconsistent. Based on these comparisons and other test results, it has been concluded that the maximum values acceptable for use with minimum specified material properties and the proposed design procedure are:

$$\tau_{wl} = 1.8 (\sigma_{uw})^{0.8} \text{ for covered electrodes, and} \quad (11)$$

$$\tau_{wl} = 2.5 (\sigma_{uw})^{0.75} \text{ for bare electrodes.} \quad (12)$$

For covered electrodes below the 9000 series, a simpler equation is sufficiently accurate:

$$\tau_{wl} = 10.25 + 0.625 \sigma_{uw}. \quad (11a)$$

With the assumptions of equations (8), (9), and (10), the double fillet weld sizes required by equations (1) through (6) for ABS steels using weld properties from equation (11a) are shown in Table 2 for longitudinal shear and in Table 3 for transverse shear. The weld size which governs is indicated with an asterisk. A comparison of these weld sizes with the sizes required by the Navy procedure is presented in Table 4 which shows that reductions of from

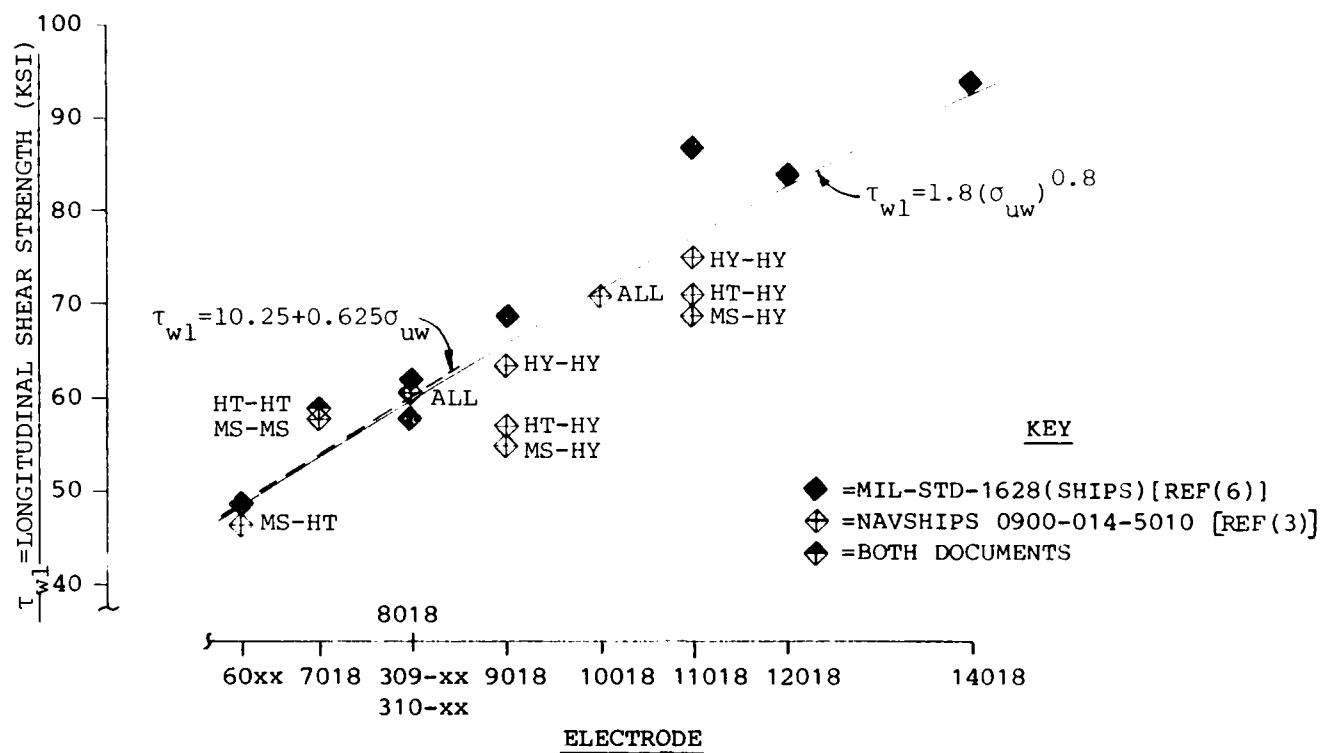


FIGURE 7  
COVERED ELECTRODE STRENGTH VALUES

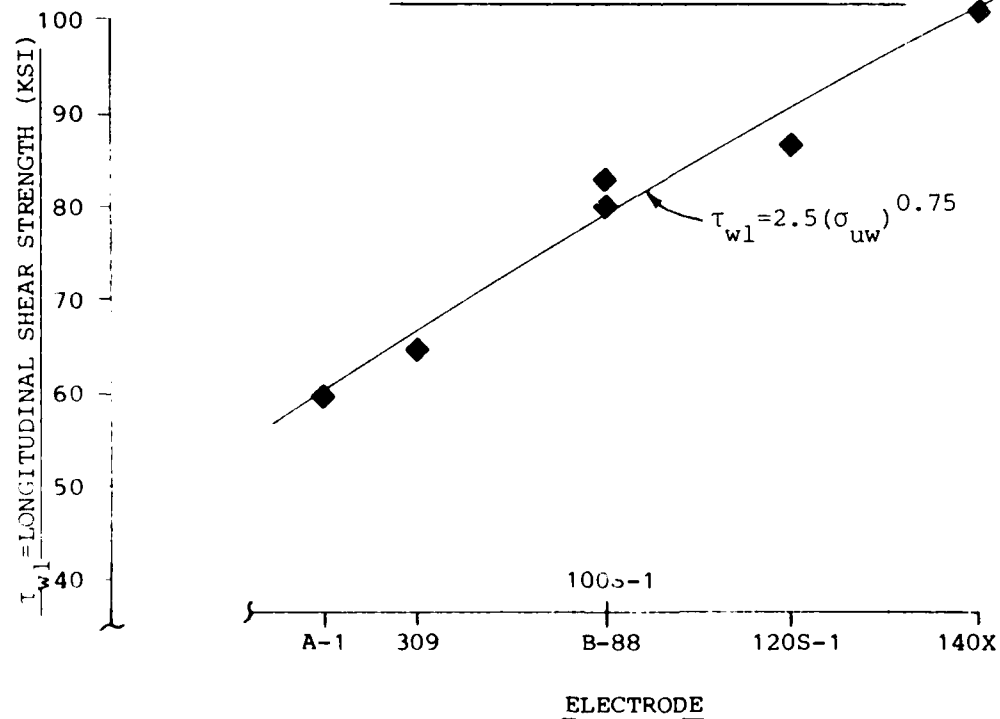


FIGURE 8  
BARE ELECTRODE STRENGTH VALUES

TABLE 2

100 Percent Efficient Double Fillet Weld Sizes For ABS Steels for Longitudinal Shear Loading Using Proposed Criteria

| 1         | 2         | 3                   | 4                                 | 5    | 6                 | 7                                 | 8                                                  | 9                                                             |
|-----------|-----------|---------------------|-----------------------------------|------|-------------------|-----------------------------------|----------------------------------------------------|---------------------------------------------------------------|
| Materials | Electrode | Intercoastal Member |                                   | Weld | Continuous Member | Required Minimum D/T              |                                                    |                                                               |
|           |           | $\sigma_{ui}$ (KSI) | $\tau_{ui}=0.75\sigma_{ui}$ (KSI) |      |                   | HAZB Shear @ Intercoastal = 0.455 | Throat Shear $\frac{\tau_{ui}}{\tau_{wl}}$ = 0.707 | HAZB Shear @ Continuous $\frac{\tau_{ui}}{\tau_{uc}}$ = 0.455 |
| H36 - H36 | MIL 8018  | 71                  | 53.3                              | 60.2 | 53.3              | 0.455                             | 0.626*                                             | 0.455                                                         |
| H36 - MS  | MIL 8018  | 71                  | 53.3                              | 60.2 | 43.5              | 0.455                             | 0.626*                                             | 0.558                                                         |
| H36 - H36 | MIL 7018  | 71                  | 53.3                              | 54   | 53.3              | 0.455                             | 0.698*                                             | 0.455                                                         |
| H36 - MS  | MIL 7018  | 71                  | 53.3                              | 54   | 43.5              | 0.455                             | 0.698*                                             | 0.558                                                         |
| H32 - H32 | MIL 8018  | 68                  | 51                                | 60.2 | 51                | 0.455                             | 0.599                                              | 0.455                                                         |
| H32 - MS  | MIL 8018  | 68                  | 51                                | 60.2 | 43.5              | 0.455                             | 0.599                                              | 0.533                                                         |
| H32 - H32 | MIL 7018  | 68                  | 51                                | 54   | 51                | 0.455                             | 0.668*                                             | 0.455                                                         |
| H32 - MS  | MIL 7018  | 68                  | 51                                | 54   | 43.5              | 0.455                             | 0.668*                                             | 0.533                                                         |
| MS - H36  | MIL 8018  | 58                  | 43.5                              | 60.2 | 53.3              | 0.455                             | 0.511                                              | 0.371                                                         |
| MS - H32  | MIL 8018  | 58                  | 43.5                              | 60.2 | 51                | 0.455                             | 0.511                                              | 0.388                                                         |
| MS - H36  | MIL 7018  | 58                  | 43.5                              | 54   | 53.3              | 0.455                             | 0.570                                              | 0.371                                                         |
| MS - H32  | MIL 7018  | 58                  | 43.5                              | 54   | 51                | 0.455                             | 0.570                                              | 0.388                                                         |
| MS - MS   | MIL 7018  | 58                  | 43.5                              | 54   | 43.5              | 0.455                             | 0.570                                              | 0.455                                                         |
| MS - MS   | MIL 60xx  | 58                  | 43.5                              | 49   | 43.5              | 0.455                             | 0.628*                                             | 0.455                                                         |

- NOTES: 1. The weld size in Table 2 or 3 which governs is indicated with an asterisk.  
 2. Column 7 uses equation (2).  
 3. Column 8 uses equation (1).  
 4. Column 9 uses equation (3).

TABLE 3  
100 Percent Efficient Double Fillet Weld Sizes for ABS Steels for Transverse  
Shear Loading for Using Proposed Criteria

| 1         | 2         | 3             | 4                 | 5                                              | 6                    | 7                                         | 8                                                    | 9                                                                          |
|-----------|-----------|---------------|-------------------|------------------------------------------------|----------------------|-------------------------------------------|------------------------------------------------------|----------------------------------------------------------------------------|
| Materials | Electrode | Instl<br>Mbr. | Weld              |                                                | Continuous<br>Member | Required Minimum D/T                      |                                                      |                                                                            |
|           |           |               | $t_{wl}$<br>(KSI) | Min.<br>$t_{wt} = 1.44 \times t_{wl}$<br>(KSI) |                      | HAZB<br>Shear @<br>Intercostal<br>= 0.607 | Throat Shear<br>$= 0.707 \frac{\sigma_{ui}}{t_{wt}}$ | HAZB<br>Tension @<br>Continuous<br>$= 0.5 \frac{\sigma_{ui}}{\sigma_{uc}}$ |
| H36 - H36 | MIL 8018  | 71            | 60.2              | 86.7                                           | 71                   | 0.607                                     | 0.579                                                | 0.500                                                                      |
| H36 - MS  | MIL 8018  | 71            | 60.2              | 86.7                                           | 58                   | 0.607                                     | 0.579                                                | 0.612                                                                      |
| H36 - H36 | MIL 7018  | 71            | 54                | 77.8                                           | 71                   | 0.607                                     | 0.645                                                | 0.500                                                                      |
| H36 - MS  | MIL 7018  | 71            | 54                | 77.8                                           | 58                   | 0.607                                     | 0.645                                                | 0.612                                                                      |
| H32 - H32 | MIL 8018  | 68            | 60.2              | 86.7                                           | 68                   | 0.607*                                    | 0.555                                                | 0.500                                                                      |
| H32 - MS  | MIL 8018  | 68            | 60.2              | 86.7                                           | 58                   | 0.607*                                    | 0.555                                                | 0.586                                                                      |
| H32 - H32 | MIL 7018  | 68            | 54                | 77.8                                           | 68                   | 0.607                                     | 0.618                                                | 0.500                                                                      |
| H32 - MS  | MIL 7018  | 68            | 54                | 77.8                                           | 58                   | 0.607                                     | 0.618                                                | 0.586                                                                      |
| MS - H36  | MIL 8018  | 58            | 60.2              | 86.7                                           | 71                   | 0.607*                                    | 0.473                                                | 0.408                                                                      |
| MS - H32  | MIL 8018  | 58            | 60.2              | 86.7                                           | 68                   | 0.607*                                    | 0.473                                                | 0.426                                                                      |
| MS - H36  | MIL 7018  | 58            | 54                | 77.8                                           | 71                   | 0.607*                                    | 0.527                                                | 0.408                                                                      |
| MS - H32  | MIL 7018  | 58            | 54                | 77.8                                           | 68                   | 0.607*                                    | 0.527                                                | 0.426                                                                      |
| MS - MS   | MIL 7018  | 58            | 54                | 77.8                                           | 58                   | 0.607*                                    | 0.527                                                | 0.500                                                                      |
| MS - MS   | MIL 60xx  | 58            | 49                | 70.6                                           | 58                   | 0.607                                     | 0.581                                                | 0.500                                                                      |

NOTES: 1. The weld size in Table 2 or 3 which governs is indicated with an asterisk.

2. Column 7 uses equations (5) and (8).

3. Column 8 uses equation (4).

4. Column 9 uses equation (6).

TABLE 4

Comparison of Weld Sizes for 100 Percent Efficient Double Fillet Welds for  
ABS Steels Using Navy Procedure [Reference 3 ] and Proposed Criteria

| 1                                    | 2         | 3                          | 4                                          | 5           |
|--------------------------------------|-----------|----------------------------|--------------------------------------------|-------------|
| Materials<br>Intercoastal-Continuous | Electrode | Weld Size<br>Ref. 3<br>D/T | Weld Size from<br>Proposed Criteria<br>D/T | % Reduction |
| H36 - H36                            | MIL 8018  | 0.827                      | 0.626                                      | 24%         |
| H36 - MS                             | MIL 8018  | 0.827                      | 0.626                                      | 24%         |
| H36 - H36                            | MIL 7018  | 0.848                      | 0.698                                      | 18%         |
| H36 - MS                             | MIL 7018  | 0.864                      | 0.698                                      | 19%         |
| H32 - H32                            | MIL 8018  | 0.792                      | 0.607                                      | 23%         |
| H32 - MS                             | MIL 8018  | 0.792                      | 0.607                                      | 23%         |
| H32 - H32                            | MIL 7018  | 0.812                      | 0.668                                      | 18%         |
| H32 - MS                             | MIL 7018  | 0.827                      | 0.668                                      | 19%         |
| MS - H36                             | MIL 8018  | 0.676                      | 0.607                                      | 10%         |
| MS - H32                             | MIL 8018  | 0.676                      | 0.607                                      | 10%         |
| MS - H36                             | MIL 7018  | 0.706                      | 0.607                                      | 14%         |
| MS - H32                             | MIL 7018  | 0.706                      | 0.607                                      | 14%         |
| MS - MS                              | MIL 7018  | 0.706                      | 0.607                                      | 14%         |
| MS - MS                              | MIL 60xx  | 0.884                      | 0.628                                      | 29%         |

10 to 29 percent are possible with this proposed criteria. This weld size variation of up to 29 percent is actually a hidden factor of safety in the current Navy procedure which should be eliminated precisely because it is hidden. It should also be eliminated because it is inconsistent in that it varies from 10 to 29 percent.

For longitudinal shear loading, the failure plane is the weld throat for all of the material and electrode combinations checked in Table 2. For transverse shear loading in Table 3, the failure plane is either the intercostal member HAZB or the weld throat. However, with a wider variation in material and electrode properties, each of the other three failure modes is still possible.

It should also be noted that significant weld size reductions are not obtained by using high-strength electrodes (i.e. 7018 and 8018) on mild steel intercostal members. The higher strength electrodes merely serve to shift the failure location from the throat of the weld to the intercostal member HAZB (compare column 8 of Table 2 with column 7 of Table 3).

Inspection of the proposed weld sizes (column 4 of Table 4) for the various ABS steels and welding electrode combinations shows remarkably small variations: from 0.607 to 0.698 times the intercostal member thickness. The required weld sizes could be conveniently grouped into two categories: one for mild steel intercostal members with a value of 0.628 and another for higher strength steel intercostal members with a value of 0.698. Then separate weld tables could be prepared for each group. Also, if higher strength steels than those shown in Table 4 are used, then additional calculations must be performed and additional weld size tables would probably be required.

The next step required is the determination of acceptable joint efficiencies. It is intended that a single set of joint efficiencies will be used for both mild steel and the current ABS higher strength steels. Since the current ABS weld tables have been used for both mild steel and ABS higher strength steels, the analysis of those tables will be based on the D/T value of 0.698. If the smaller D/T value of 0.628 were used, it would be equivalent to stating that the existing ABS weld tables are not acceptable for use with ABS higher strength steels.

Introducing a joint efficiency to account for locations which do not require the weld to develop the full shear or ultimate strength of the intercostal member gives the weld design equation:

$$D = 0.698 \times E \times T \quad (13)$$

A family of curves for various joint efficiencies is shown in Figure 9.

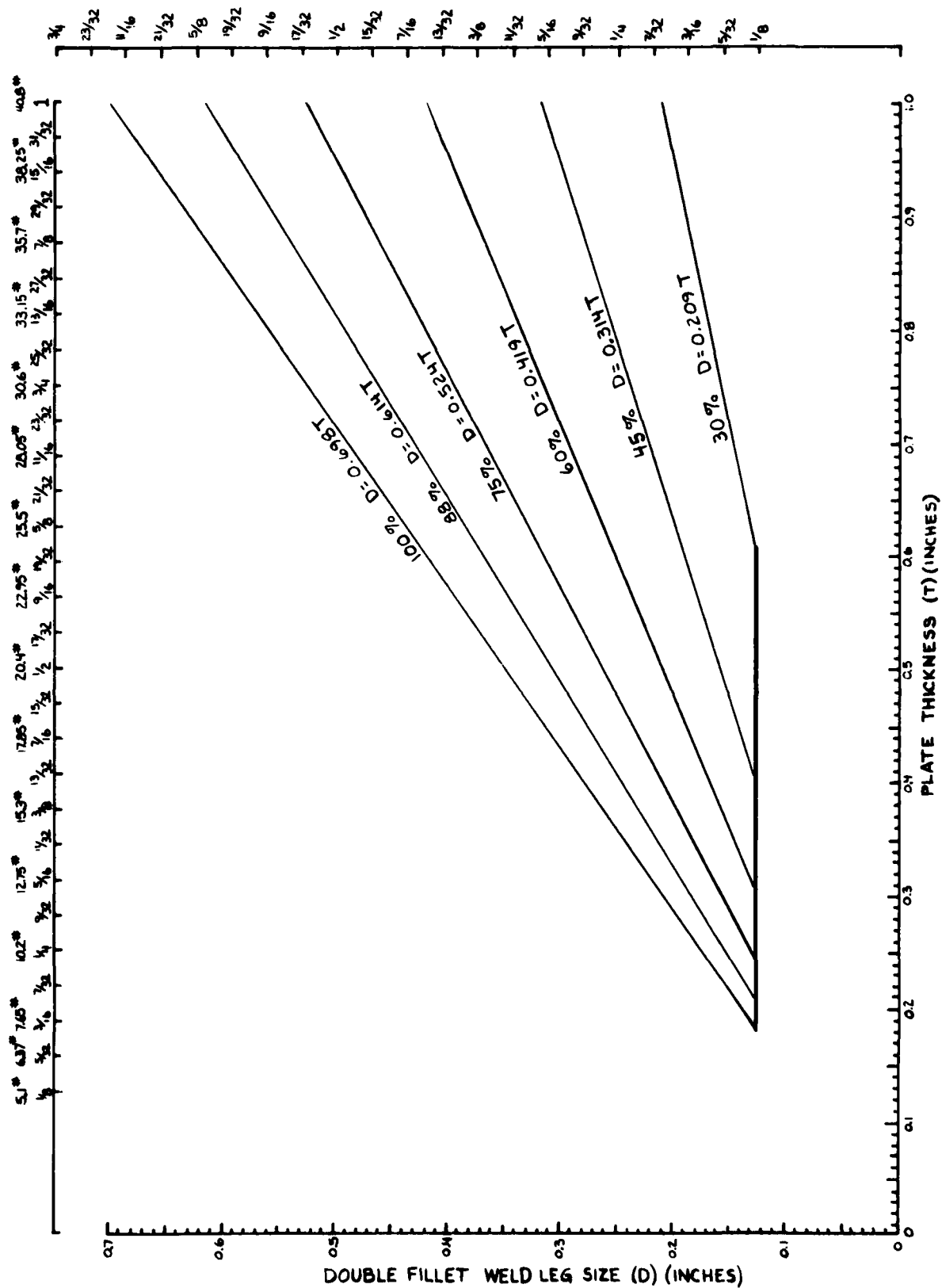


FIGURE 9

Weld Sizes Versus Plate Thickness for  
Constant Efficiency as Originally Welded

## 2.6 Effect of Uniform Corrosion

Since many of the required scantlings from the ABS rules contain allowances for uniform corrosion, the effect of such corrosion on joint strength must be determined. Figure 10 shows the geometry of such a condition. For a constant efficiency in the corroded condition ( $E_C$ ), the weld size equation [equation (13)] becomes:

$$D_C = 0.698 \times E_C \times T_C, \text{ or}$$

$$D - 1.414C = 0.698 \times E_C \times (T - 2C).$$

An appropriate corrosion allowance appears to be about 0.060 inch per surface [Reference 1, page 16; or Reference 2, Sections 7.13.2, 12.7.1, 13.3.1, 13.7.2, 15.15.2, and 16.9.1]. Using this value, the design equation for constant efficiencies in the corroded condition becomes:

$$D = 0.698 \times E_C \times (T - 0.12") + 0.085". \quad (14)$$

A family of curves for various joint efficiencies using this equation is shown in Figure 11. A comparison of Figure 11 with Figure 9 shows that this amount of corrosion has essentially no effect on the strength of 100% efficient joints. That is, the decrease in strength of the weld almost exactly matches the loss in strength of the intercostal member. However, the curves in the two figures become progressively further apart as the efficiency decreases. The determination of which family of curves is most appropriate for ABS fillet welds is discussed further in Section 3.

## 2.7 Equivalent Fillet Sizes for Intermittent Welds

The final element needed before proceeding to a study of the existing ABS fillet weld tables is a means to compare the strengths of intermittent fillet welds to the strengths of continuous fillet welds. For this comparison, a continuous fillet size,  $D_i$ , which is equivalent in strength to a given intermittent fillet size,  $D$ , of length,  $L$ , and spacing,  $S$ , is determined:

$$D_{ic} = (D - 1.414C) \times L/S + 1.414C.$$

With no corrosion, this equation is simply:

$$D_i = D \times L/S. \quad (15)$$

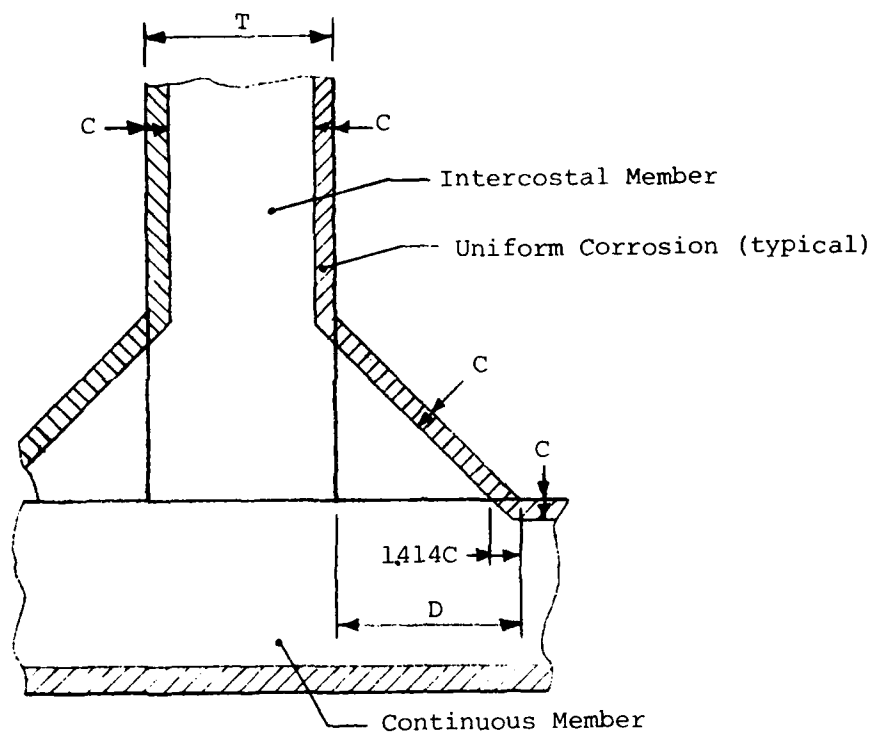


FIGURE 10

Uniform Corrosion on Fillet Welds

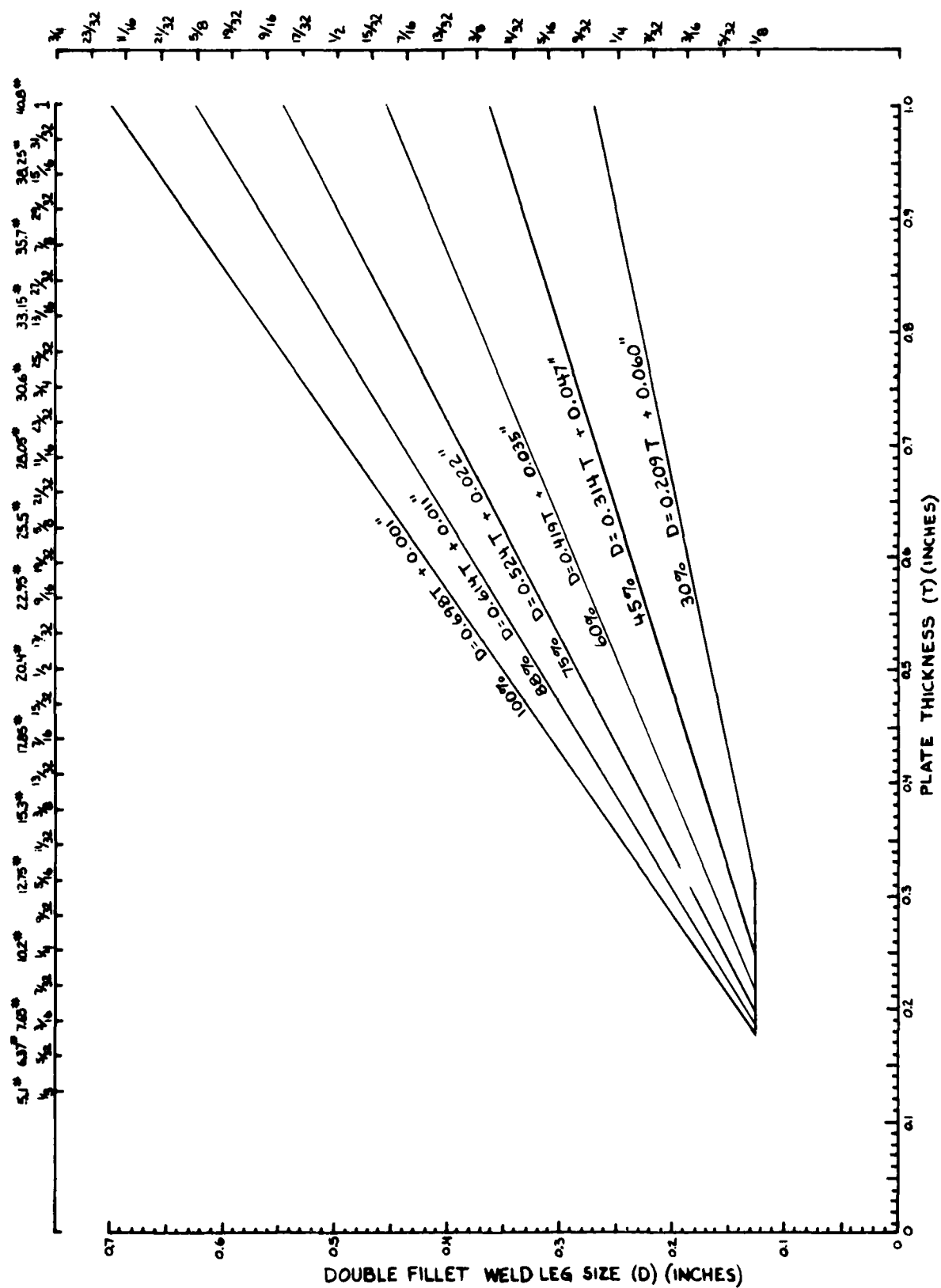


FIGURE 11  
 Weld Sizes Versus Plate Thickness for Constant L<sub>111</sub> (1000 LBS)  
 After 0.060 inch per Surface Corrosion  
 2-13

With 0.060 inch per surface corrosion allowance, the equivalent fillet size becomes:

$$D_{ic} = (D - 0.085") \times L/S + 0.085" \quad (16)$$

Calculations for typical intermittent fillet weld sizes are included in Table D-5 of Appendix D .

### 3. EFFICIENCIES OF ABS FILLET WELDS

Since the weld sizes required to develop the full strength of the connected members have now been determined, the next question to answer is what joint efficiencies are required for typical merchant ship structures. The Navy documents [References 3, 4, and 5] give tables of required efficiencies for naval ships which range from 50 to 100 percent with no corrosion allowance. In this section the joint efficiencies which exist in the current ABS rules are determined and used as a guide for specifying what efficiencies are appropriate to merchant ship structures.

#### 3.1 Grouping of ABS Fillet Welds

The current ABS Rules list the required fillet weld size as a function of plate thickness and location of the connection as shown in Appendix A. In the Table for continuous welds shown in Appendix A, each of the 96 locations with its associated weld sizes has been assigned a unique line number. This table was then inspected and the line items with similar weld sizes were assigned to 18 weld groups as shown in Table 5 and Appendix B. There are 13 weld groups (A through M) for all ships with an additional 5 weld groups for vessels classed as oil carriers (N through R). In this grouping process, five line items (Nos. 7, 8, 38, 51, and 88) have had one weld size altered 1/32 inch in order to eliminate five additional weld groups.

The intermittent fillet weld table was then examined in a similar manner. Except for two special cases in weld group C, intermittent fillet welds are only permitted for the eight lesser efficiency weld groups: F, G, H, J, K, L, M, and R although these groups account for almost half of the line items. Three line items in the continuous weld table (numbers 53, 56, and 72) have two variations in the intermittent weld table (designated 53A, 53B, etc.). There is a much wider variation in sizes for the intermittent welds than the continuous welds even when minor adjustments to spacings are made and minor differences in the smallest sizes are neglected. For example, weld group M has five different variations in the intermittent fillet weld sizes. Consequently, the intermittent fillet weld sizes have been assigned to 15 weld groups as shown in Table 6 and Appendix B giving a total of 33 weld groups.

#### 3.2 Efficiencies

The weld sizes for each of the 33 weld groups were then plotted versus plate thickness as shown in Appendix C. "Stepped" curves were used since the rules specify that intermediate plate thickness may use the weld size specified for the next lower plate thickness shown in the weld tables.

A decision then had to be made as to whether the proposed efficiencies should be based on the equations with a corrosion allowance [equations (14) and (16)] or those without a corrosion allowance [equations (13) and (15)]. Since the

TABLE 5

Efficiencies of ABS Double Continuous Fillet Welds  
When Corroded 0.060 Inch Per Surface

| ABS WELD GROUP | LINE NUMBERS                                                                                                    | NO.<br>OF<br>LINES | EXIST. EFFICIENCIES |                        |             | PROPOSED<br>MIN. EFF.<br>(%) |
|----------------|-----------------------------------------------------------------------------------------------------------------|--------------------|---------------------|------------------------|-------------|------------------------------|
|                |                                                                                                                 |                    | MAX.<br>(%)         | RANGE<br>(%<br>POINTS) | MIN.<br>(%) |                              |
| A              | 13, 51*                                                                                                         | 2                  | 118                 | 34                     | 84          | 100                          |
| B              | 39, 52, 62, 69, 74,<br>76, 79, 82                                                                               | 8                  | 98                  | 24                     | 74          | 75                           |
| C              | 1, 6, 11, 12, 14,<br>17, 20, 21, 23, 24,<br>30, 32, 34, 56, 57,<br>64, 65, 71, 72, 77                           | 20                 | 84                  | 18                     | 66          | 75                           |
| D              | 40, 42, 48, 63, 70,<br>75                                                                                       | 6                  | 74                  | 15                     | 59          | 60                           |
| E              | 66                                                                                                              | 1                  | 80                  | 29                     | 51          | 45                           |
| F              | 2, 7*, 22, 26, 28,<br>35, 78, 80, 81                                                                            | 9                  | 59                  | 18                     | 41          | 45                           |
| G              | 49                                                                                                              | 1                  | 64                  | 31                     | 33          | 30                           |
| H              | 50                                                                                                              | 1                  | 58                  | 28                     | 30          | 30                           |
| I              | 45                                                                                                              | 1                  | 66                  | 29                     | 37          | 45                           |
| J              | 54                                                                                                              | 1                  | 45                  | 22                     | 33          | 30                           |
| K              | 15, 16, 18, 19, 25                                                                                              | 5                  | 41                  | 11                     | 30          | 30                           |
| L              | 41                                                                                                              | 1                  | 40                  | 9                      | 31          | 30                           |
| M              | 3, 4, 5, 8*, 9, 10,<br>27, 29, 31, 33, 36,<br>37, 38*, 43, 44, 46,<br>47, 53, 55, 58, 59,<br>60, 61, 67, 68, 73 | 26                 | 40                  | 10                     | 30          | 30                           |
| N              | 83, 90, 91                                                                                                      | 3                  | 102                 | 20                     | 82          | 88                           |
| O              | 85, 87, 93, 94                                                                                                  | 4                  | 91                  | 17                     | 74          | 75                           |
| P              | 84, 92                                                                                                          | 2                  | 79                  | 15                     | 64          | 60                           |
| Q              | 86, 88*, 95                                                                                                     | 3                  | 68                  | 14                     | 54          | 60                           |
| R              | 89, 96                                                                                                          | 2                  | 59                  | 16                     | 43          | 45                           |
| TOTAL . . .    |                                                                                                                 | 96                 |                     |                        |             |                              |

\* One weld on each of these lines has been altered 1/32 inch in size to allow them to be classified in the weld groups shown.

**TABLE 6**

**Efficiencies of ABS Intermittent Fillet Welds  
When Corroded 0.060 Inch Per Surface**

| ABS WELD GROUP | LINE NUMBERS                           | NO.<br>OF<br>LINES | EXIST. EFFICIENCIES |                        |             | PROPOSED<br>MIN. EFF.<br>(%) |
|----------------|----------------------------------------|--------------------|---------------------|------------------------|-------------|------------------------------|
|                |                                        |                    | MAX.<br>(%)         | RANGE<br>(%<br>POINTS) | MIN.<br>(%) |                              |
| C1             | 56B                                    | 1                  | -                   | -                      | -           | Special Case                 |
| C2             | 72B                                    | 1                  | -                   | -                      | -           | Special Case                 |
| F1             | 78,80,81                               | 3                  | 74                  | 37                     | 37          | 45                           |
| F2             | 2,7,35*                                | 3                  | 74                  | 40                     | 34          | 45                           |
| F3             | 22,26,28                               | 3                  | 74                  | 36                     | 38          | 45                           |
| G1 & J1        | 49,54                                  | 2                  | 49                  | 20                     | 29          | 30                           |
| H1             | 50                                     | 1                  | 44                  | 19                     | 25          | 30                           |
| K1             | 19                                     | 1                  | 44                  | 21                     | 23          | 30                           |
| K2 & M3        | 15,27,29,31                            | 4                  | 40                  | 19                     | 21          | 30                           |
| K3 & L1        | 16,18,25,41                            | 4                  | 37                  | 18                     | 19          | 30                           |
| M1             | 10*,53B,55                             | 3                  | 44                  | 19                     | 25          | 30                           |
| M2             | 3,8,36,37,43,44                        | 6                  | 44                  | 21                     | 23          | 30                           |
| M4             | 4,5,9,33,38,46,47,<br>53A*,58,59,67,73 | 12                 | 37                  | 18                     | 19          | 30                           |
| M5             | 60,61                                  | 2                  | 37                  | 20                     | 17          | 30                           |
| R1             | 89,96                                  | 2                  | 58                  | 16                     | 42          | 45                           |
|                | TOTAL . . . .                          | 48                 |                     |                        |             |                              |

\* One spacing in each of these lines has been altered to allow them to be classified in the weld groups shown.

corrosion problem mainly affects the least efficient welds, weld groups M and M1 were plotted together in Figure 12. From this figure it can be seen that the equations with corrosion allowances fit the ABS table weld sizes significantly better than those without a corrosion allowance. Consequently, it was decided that all further work would include a corrosion allowance.

Neglecting the 3/16 inch welds, which are the minimum size specified, the maximum and minimum efficiency of each ABS continuous fillet weld group was calculated. The results, which are shown in Table 5 and Appendix C, show a wide variation in efficiency, from 30 to 118% overall and up to 34 percentage points within a given weld group. Similar calculations were performed for intermittent fillet welds neglecting some of the smaller welds. These calculations, which are summarized in Table 6, give a variation in efficiency of 17 to 74% overall and up to 40 percentage points within a given weld group.

### 3.3 Proposed Efficiencies and Weld Size Tables

After several trials, it was determined that the 33 ABS weld groups could be reasonably represented by just six efficiency categories as shown in Tables 5 and 6 using the equations which include corrosion allowances. The six efficiency categories selected are shown in Table 7 along with the approximate equivalent joint efficiency as originally welded (i.e., no corrosion). These equivalent joint efficiencies can be compared to the standard Navy efficiency groups shown in the last column of Table 7 since the Navy groups have no corrosion allowance. From this comparison it can be seen that Navy fillet welds are still more conservative than ABS fillet welds even when the conservatism of equation (7) is removed (see Section 2.4).

TABLE 7

Comparison of Weld Joint Efficiency Categories

| Proposed Efficiency Categories with Corrosion Allowance | Approximate Equivalent Efficiency as Originally Welded (see Figure 13) | Navy Efficiency Categories |
|---------------------------------------------------------|------------------------------------------------------------------------|----------------------------|
| 100                                                     | 100                                                                    | 100                        |
| 88                                                      | 90                                                                     |                            |
| 75                                                      | 80                                                                     |                            |
| 60                                                      | 67                                                                     | 75                         |
| 45                                                      | 54                                                                     | 60                         |
| 30                                                      | 41                                                                     | 50                         |

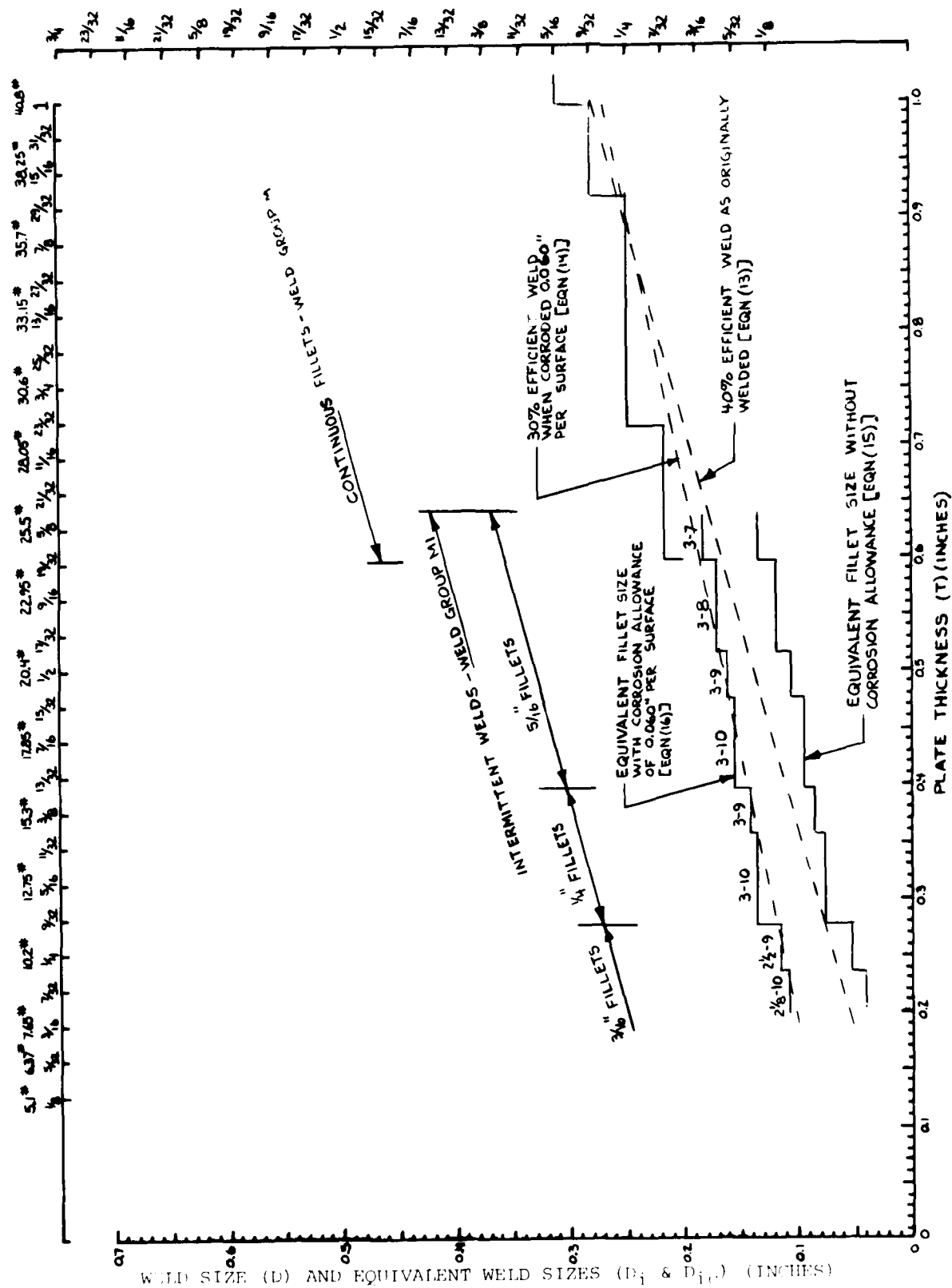


FIGURE 12

Comparison of Weld Sizes for Weld Groups M and M1  
With and Without Corrosion Allowance

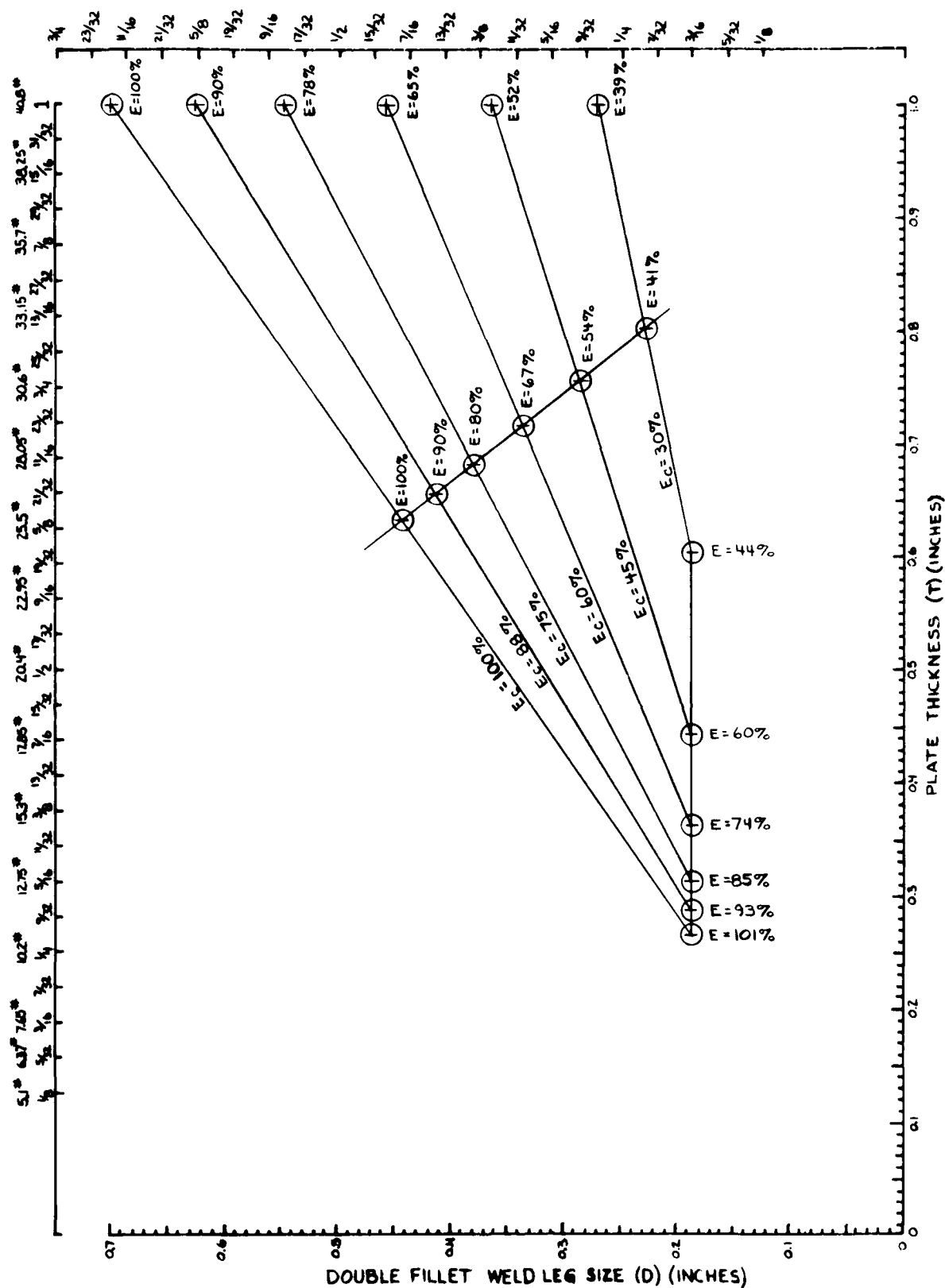


FIGURE 13

Efficiencies as Originally Welded of Proposed Efficiency Categories Which Include Corrosion Allowances

In addition to the comparison in Table 7, it should also be noted that the Navy generally requires a higher joint efficiency than ABS for many structural connections. For example, most unbracketed end connections must be 100% efficient by Navy requirements, whereas the ABS requirements are generally 80% efficient before corrosion. Also, most stiffening to plating supported joints must be 60% efficient by Navy requirements while the ABS requirements are generally 41% efficient before corrosion.

One other notable difference between ABS and Navy welding requirements is the lack of ABS guidelines for welding compensation for holes in structure. Navy requirements are 100% efficient joints for compensation in shell plating, stringer strakes of uppermost strength deck, and/or attached framing; 75% efficient joints for compensation in watertight, oiltight, or continuous bulkheads, decks, floors, and/or attached framing; and 50% efficient joints for compensation in non-tight structure.

The appropriate weld size equation is shown on each of the plots in Appendix C with the proposed increases or decreases in weld size crosshatched for emphasis. It should be noted that the proposed weld sizes are much more consistent than those in the current ABS weld tables. For example, most of the wide variations in weld sizes for weld groups G and H are eliminated. A further comparison of the proposed and ABS weld sizes versus standard plate thicknesses is given in Table 8.

The proposed weld sizes have been put in a more useful form in Appendix D. Line items which are essentially identical are combined as appropriate. This appendix contains essentially all the information required for everyday use in a design office. In Appendix D, Tables D-2 through D-5 along with Figures D-1 through D-4 have been based on the conservative D/T value of 0.698 so they can be used for either mild steel or current ABS higher strength steels. Table D-6 along with Figures D-5 and D-6 have been based on a D/T value of 0.628 so they can only be used for mild steel intercostal members. The size reduction for the latter table, neglecting round-off differences, is about 8%.

One additional comment on Table D-1 of Appendix D may be in order here. The line items for each structural item are arranged generally in descending order of required efficiency. The most critical joints (i.e., those with the highest required efficiency) then stand out rather distinctly. Although most inspectors probably have an excellent "feel" for which joints are most critical, perhaps this table will help identify to him which joints the designer considers most critical and thus the ones which should be given the closest inspection.

TABLE 8

Comparison of Proposed and ABS Fillet Weld Sizes Versus Plate Thickness

| Proposed Eff. (%)<br>or ABS Weld Group | Plate Thickness (t) |       |       |        |       |        |       |        |       |        |       |        |       |
|----------------------------------------|---------------------|-------|-------|--------|-------|--------|-------|--------|-------|--------|-------|--------|-------|
|                                        | 1/8                 | 3/16  | 1/4   | 5/16   | 3/8   | 7/16   | 1/2   | 9/16   | 5/8   | 11/16  | 3/4   | 13/16  | 15/16 |
| 100% (D=0.698 T +<br>0.001")           | 5.1#                | 7.65# | 10.2# | 12.75# | 15.3# | 17.85# | 20.4# | 22.95# | 25.5# | 28.05# | 30.6# | 33.15# | 35.7# |
| A                                      | 1/8                 | 5/32  | 3/16  | 1/4    | 9/32  | 5/16   | 3/8   | 13/31  | 7/16  | 1/2    | 17/32 | 19/32  | 5/8   |
| 75% (D=0.524 T +<br>0.022")            | 3/16                | 3/16  | 3/16  | 7/32   | 1/4   | 5/16   | 3/8   | 7/16   | 7/16  | 1/2    | 17/32 | 19/32  | 5/8   |
| B                                      | 1/8                 | 1/8   | 5/32  | 3/16   | 7/32  | 9/32   | 5/16  | 11/32  | 3/8   | 13/32  | 7/16  | 15/32  | 1/2   |
| C                                      | 3/16                | 3/16  | 3/16  | 3/16   | 7/32  | 1/4    | 9/32  | 5/16   | 11/32 | 13/32  | 13/32 | 7/16   | 15/32 |
| 60% (D=0.419 T +<br>0.035")            | 1/8                 | 1/8   | 5/32  | 3/16   | 7/32  | 7/32   | 1/4   | 9/32   | 5/16  | 11/32  | 3/8   | 13/32  | 13/32 |
| D                                      | 3/16                | 3/16  | 3/16  | 3/16   | 3/16  | 7/32   | 1/4   | 5/16   | 5/16  | 3/8    | 3/8   | 7/16   | 7/16  |
| 45% (D=0.314 T +<br>0.047")            | 1/8                 | 1/8   | 5/32  | 5/32   | 3/16  | 3/16   | 7/32  | 1/4    | 1/4   | 9/32   | 5/16  | 5/16   | 11/32 |
| E                                      | 3/16                | 3/16  | 3/16  | 3/16   | 7/32  | 7/32   | 1/4   | 9/32   | 9/32  | 5/16   | 5/16  | 11/32  | 3/8   |
| F                                      | 3/16                | 3/16  | 3/16  | 3/16   | 3/16  | 3/16   | 7/32  | 1/4    | 1/4   | 9/32   | 9/32  | 5/16   | 5/16  |
| I                                      | 3/16                | 3/16  | 3/16  | 3/16   | 3/16  | 3/16   | 1/4   | 1/4    | 1/4   | 1/4    | 9/32  | 9/32   | 5/16  |
| 30% (D=0.209 T +<br>0.060")            | 1/8                 | 1/8   | 1/8   | 5/32   | 5/32  | 5/32   | 3/16  | 3/16   | 7/32  | 7/32   | 7/32  | 1/4    | 1/4   |
| G                                      | 3/16                | 3/16  | 3/16  | 3/16   | 3/16  | 3/16   | 3/16  | 7/32   | 7/32  | 1/4    | 1/4   | 1/4    | 13/32 |
| H                                      | 3/16                | 3/16  | 3/16  | 3/16   | 3/16  | 3/16   | 3/16  | 7/32   | 7/32  | 7/32   | 1/4   | 1/4    | 13/32 |
| J                                      | 3/16                | 3/16  | 3/16  | 3/16   | 3/16  | 3/16   | 3/16  | 7/32   | 7/32  | 7/32   | 1/4   | 1/4    | 13/32 |
| K                                      | 3/16                | 3/16  | 3/16  | 3/16   | 3/16  | 3/16   | 3/16  | 7/32   | 7/32  | 7/32   | 1/4   | 1/4    | 9/32  |
| L                                      | 3/16                | 3/16  | 3/16  | 3/16   | 3/16  | 3/16   | 3/16  | 7/32   | 7/32  | 7/32   | 1/4   | 1/4    | 9/32  |
| M                                      | 3/16                | 3/16  | 3/16  | 3/16   | 3/16  | 3/16   | 3/16  | 7/32   | 7/32  | 7/32   | 1/4   | 1/4    | 9/32  |
| 88% (D=0.614 T +<br>0.011")            | 1/8                 | 1/8   | 1/8   | 7/32   | 1/4   | 9/32   | 11/32 | 3/8    | 13/32 | 7/16   | 1/2   | 17/32  | 9/16  |
| N                                      | 3/16                | 3/16  | 1/4   | 1/4    | 1/4   | 9/32   | 5/16  | 3/8    | 13/32 | 7/16   | 1/2   | 17/32  | 9/16  |
| 75% (D=0.524 T +<br>0.022")            | 1/8                 | 1/8   | 1/4   | 1/4    | 1/4   | 9/32   | 5/16  | 11/32  | 13/32 | 7/16   | 1/2   | 15/32  | 17/32 |
| O                                      | 3/16                | 3/16  | 1/4   | 1/4    | 1/4   | 9/32   | 5/16  | 11/32  | 13/32 | 7/16   | 1/2   | 15/32  | 17/32 |
| 60% (D=0.419 T +<br>0.035")            | 1/8                 | 1/8   | 1/4   | 1/4    | 1/4   | 7/32   | 1/4   | 9/32   | 5/16  | 11/32  | 3/8   | 13/32  | 13/32 |
| P                                      | 3/16                | 3/16  | 1/4   | 1/4    | 1/4   | 7/32   | 1/4   | 9/32   | 5/16  | 11/32  | 3/8   | 13/32  | 13/32 |
| Q                                      | 3/16                | 3/16  | 1/4   | 1/4    | 1/4   | 7/32   | 1/4   | 9/32   | 5/16  | 11/32  | 3/8   | 13/32  | 13/32 |
| 45% (D=0.314 T +<br>0.047")            | 1/8                 | 1/8   | 1/4   | 1/4    | 1/4   | 7/32   | 1/4   | 9/32   | 5/16  | 11/32  | 3/8   | 13/32  | 13/32 |
| R                                      | 3/16                | 3/16  | 1/4   | 1/4    | 1/4   | 7/32   | 1/4   | 9/32   | 5/16  | 11/32  | 3/8   | 13/32  | 13/32 |

#### 4. DIRECT CALCULATION OF WELD SIZES

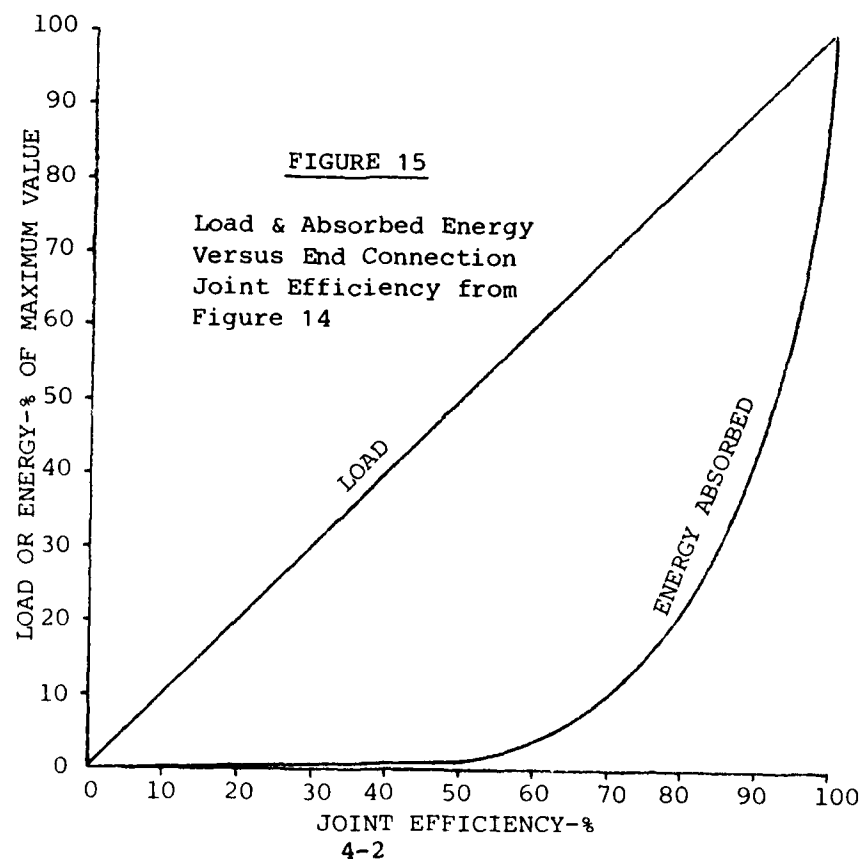
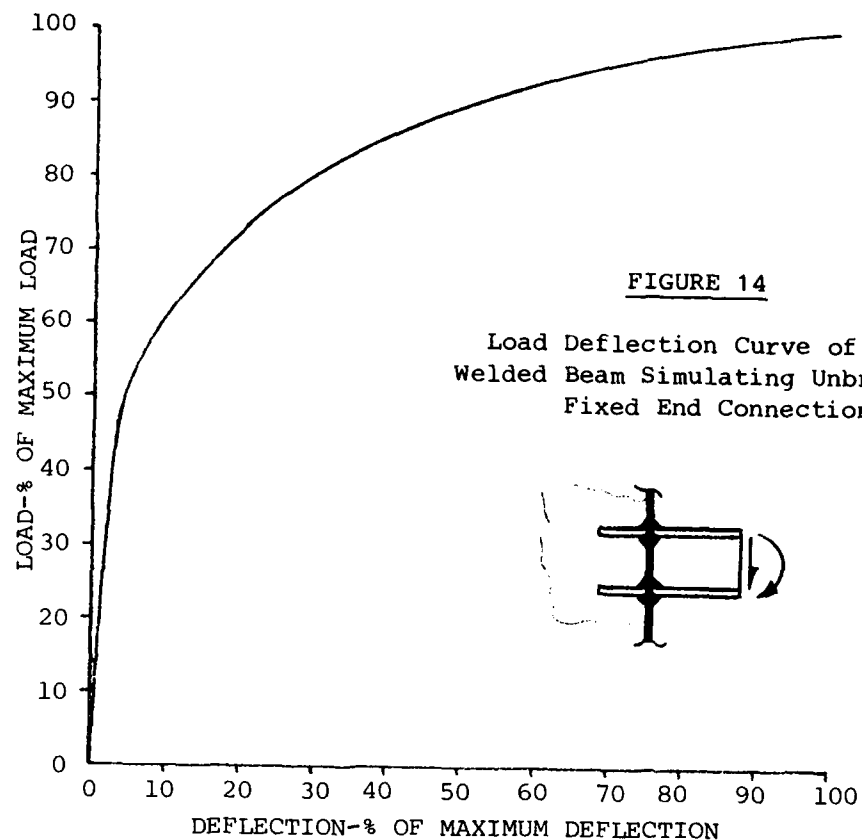
In Section 2 of this report, it has been shown that it is not possible to develop a single design strength equation which will uniformly handle the different combinations of ABS steels and electrodes. Therefore, it is not possible to use nominal design weld stresses unless such stresses are varied for each material and electrode combination or excessively large factors of safety are used. However, the calculations in Section 2 show that the ratio of 100% efficient weld sizes to plate thickness does not vary widely (only from 0.607 to 0.698) for typical ABS steels and electrodes. This ratio can form the basis of a procedure to base the weld sizes on direct calculations. Basically the procedure is to calculate a required local plate thickness at the joint which would sustain the nominal design stresses specified, multiply by 0.698 (or 0.628 for mild steel intercostal members, or one of the other values in column 4 of Table 4 if the electrode to be used is known) and add 1.414 times the corrosion allowance as appropriate:

$$D = 0.698 \times T_r + 0.085" \quad (17)$$

The main caution here is that the nominal design stresses specified must be based on strength and not on stiffness considerations such as buckling.

Another important caution is for end connections, particularly unbracketed end connections which are backed up as discussed in Section 5.1 or any member which is part of longitudinal strength structure or essentially continuous transverse structure. Nondimensionalized test results for a compact beam (i.e., no buckling imminent) simulating such a fillet welded, unbracketed, end connection are shown in Figure 14. If the test results of Figure 14 are plotted versus joint efficiency as shown in Figure 15, the load plots as a straight line because the joint efficiency is defined as a direct function of the load capacity. However, if the energy absorbed by the test beam (i.e., the area under the load deflection curve) is plotted versus joint efficiency as in Figure 15, the situation is drastically altered. For example, although a 75% efficient joint would develop 75% of the maximum load, it would develop only about 15% of the beam's energy capacity. Although there are probably very few merchant ship framing systems which need be designed to absorb significant amounts of energy in the plastic range, it would appear prudent not to reduce the strength of such end connections below the values specified in Appendix D.

If the joint in question must be designed for a combined loading, then the required thickness,  $T_r$ , must reflect the combined loading using an appropriate "failure theory". The assumption in this procedure is that the fillet welds will behave similar to the base material for intermediate combinations of say shear and tension. That is, the weld has been sized to develop the full tensile strength or the full shear strength of the base material so it should be adequate for any intermediate combination of tension and shear that the base material can sustain.



## 5. USE OF PROPOSED DESIGN CRITERIA

With any welding design procedure, several additional questions besides the required weld efficiency must be answered. These questions include what plate to base the weld on, how to handle unusual cases, how unbalanced the welds can be, what construction tolerances are appropriate, what minimum weld sizes to use, when to use intermittent welding, and how to handle special protective coatings? These questions will be discussed in this section.

### 5.1 Tee Type Joints

When applying this proposed double fillet weld design criteria, it is intended that the weld size for tee type joints will generally be based on the thickness of the intercostal or non-continuous member of the joint. This is to avoid the complex problem of determining which member is really the weaker. The current Navy procedure for determining the "weaker" member is to choose the member with the lowest product of thickness times ultimate tensile strength [see Section 11.3.4.1 of Reference 3] while the current ABS procedure is to use the "lesser thickness of members joined" (see column headings in Appendix A) except in special cases (see Note 1 to weld table in Appendix A). However, from the discussions in Section 2.1 of this report, it should be evident that neither procedure is entirely correct and that the determination of which member is the weaker is also a function of loading direction. For example, in Figure 1 the product of thickness and shear strength of the intercostal member should be compared to twice the product of thickness and shear strength of the continuous member, whereas in Figure 2 the product of thickness and tensile strength of the intercostal member should be compared to twice the product of thickness and shear strength of the continuous member. For most cases the intercostal member will thus be the weaker member.

Another case which should also be considered is the quite common joint shown in Figure 16. Here a relatively thin plate is continuous through a heavier one, for example a deck or longitudinal stiffener in way of a transverse bulkhead. In this case, the intercostal member is "backed up" and the weld should be based on the thickness of the intercostal member. The thickness of the continuous member has no influence on the required weld strength in this case.

Therefore, it appears that basing the weld sizes on the thickness of the intercostal member for tee type joints is more consistent and will generally result in a more optimally welded structure. It also has the advantage of being a simpler rule to use than the ABS or particularly the Navy procedure.

For cases where this procedure of using the intercostal member may give excessively large welds, several alternatives are available. First, if the continuous member is really the weak link in the connection, then an effective intercostal member thickness could be determined by considering the shear and

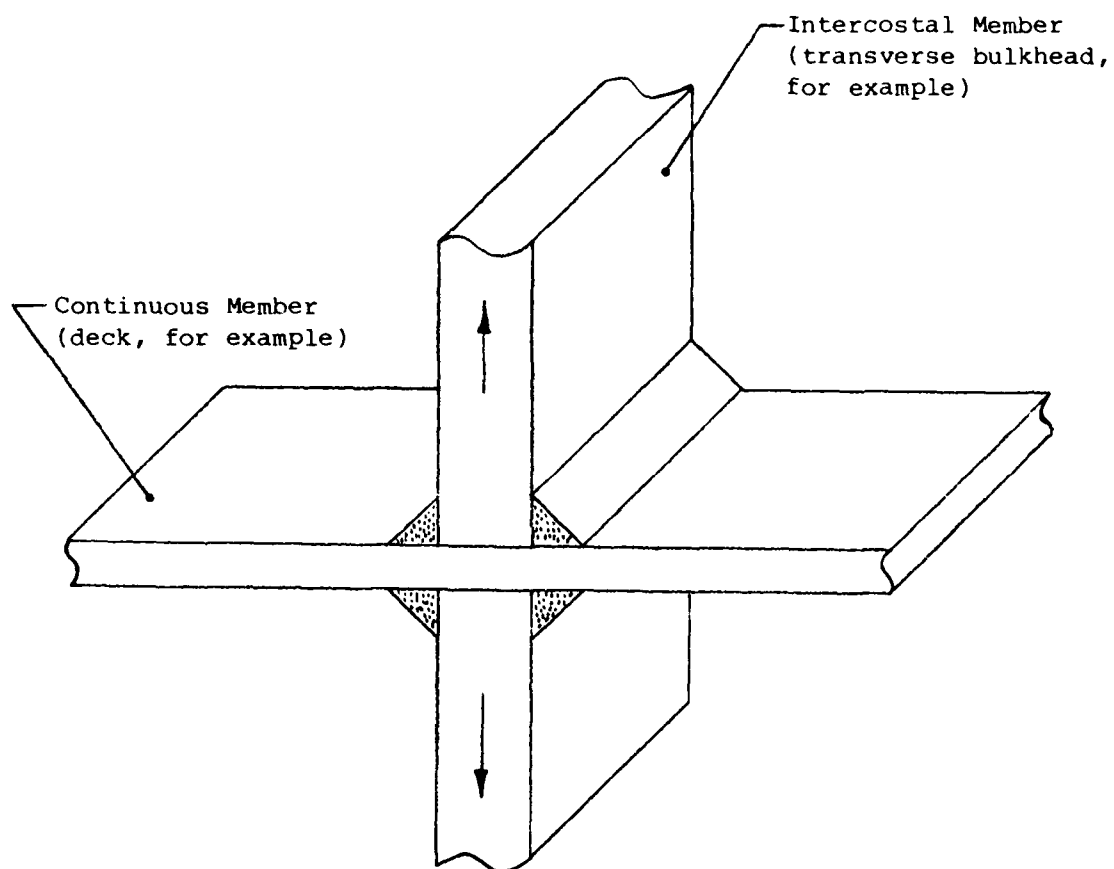


FIGURE 16

Double Fillet Weld In Way of a "Backed Up" Member

tensile strengths of the two members as described above and the weld based on that effective thickness. Second, the joint could be designed for the loads it must carry using the procedures described in Section 4.

### 5.2 Lap Joints and Corner Type Joints

For lap joints, the Navy procedure is clearly the best procedure to use. That is, the weld should be based on the thickness of the member with the lowest product of thickness times ultimate tensile strength since there is only a single failure plane in each of the joined members to be concerned with, although all six failure modes are still considered.

Corner type joints made with fillet welds are similar in principle to lap type joints: there is only a single failure plane in each of the joined members to be concerned with. Two corner type joints are shown in Figures 17 and 18. For longitudinal shear loading, which should cover the majority of corner joints, using the weaker member as defined by the Navy is clearly adequate. However, for transverse shear loading, the tensile strength of one member should be compared to the shear strength of the other when determining the weaker member. Although this is another complication, it could be considered if necessary.

### 5.3 Slightly Unbalanced Welds

In Table 8 both the existing and the proposed weld sizes are given in increments of 1/32 inch which is a bit finer than many shipyards work with. Increments of 1/16 inch are commonly used to reduce the number of fillet weld size gages and to simplify inspections. An alternate approach which has been used previously to reduce the amount of weld while still minimizing the number of weld sizes is shown in Figure 19. Whenever the tabular size is in 32nds, the fillet on one side of the weld is rounded up and the fillet on the other side is rounded down to the nearest 16th. This results in a slightly unbalanced joint as shown in Figure 19. For reasonably long joints loaded in longitudinal shear as shown in Figure 1, this slight unbalance should be completely insignificant. For welds loaded in transverse shear as shown in Figure 2, the slight unbalance would have a greater effect than the longitudinal shear case but it still should not be significant. It should be noted that two special cases in the current ABS rule tables, lines 56B and 72B, permit much larger variations in strengths on opposite sides of the connection. These two cases require continuous welds on one side of the connection with intermittent welds of much lower efficiency on the opposite side of the connection (see plots for ABS Weld Groups C1 and C2 in Appendix C). Therefore, it is felt that the current practice of allowing these slightly unbalanced joints should continue.

### 5.4 Construction Tolerances

This study is primarily concerned with minimum design weld sizes which are those commonly specified on working drawings. Construction tolerances are generally covered by other fabrication documents such as detail welding

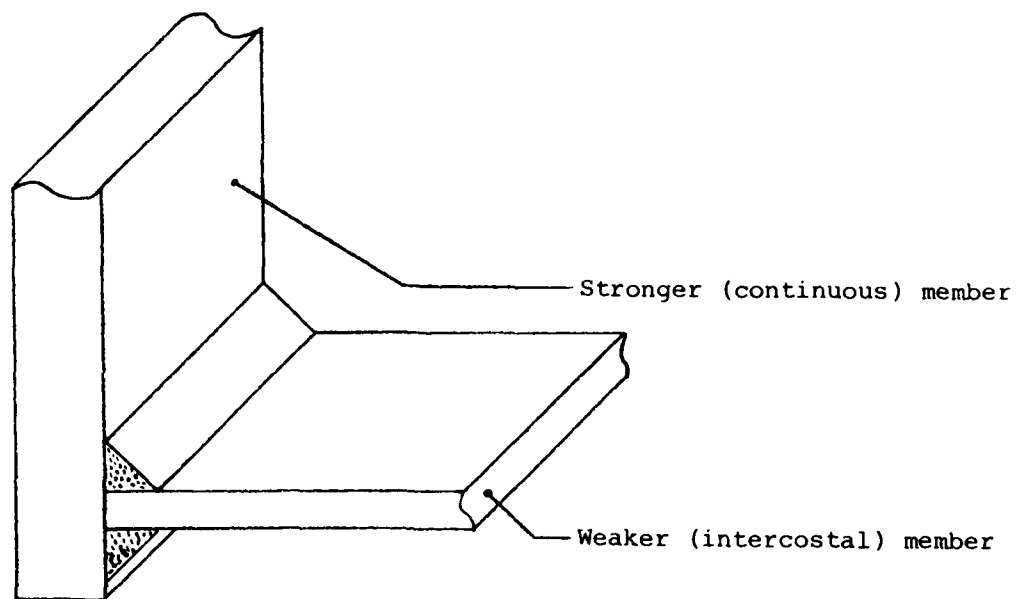


FIGURE 17

Double Fillet Weld In Way of a Corner Joint - Case 1

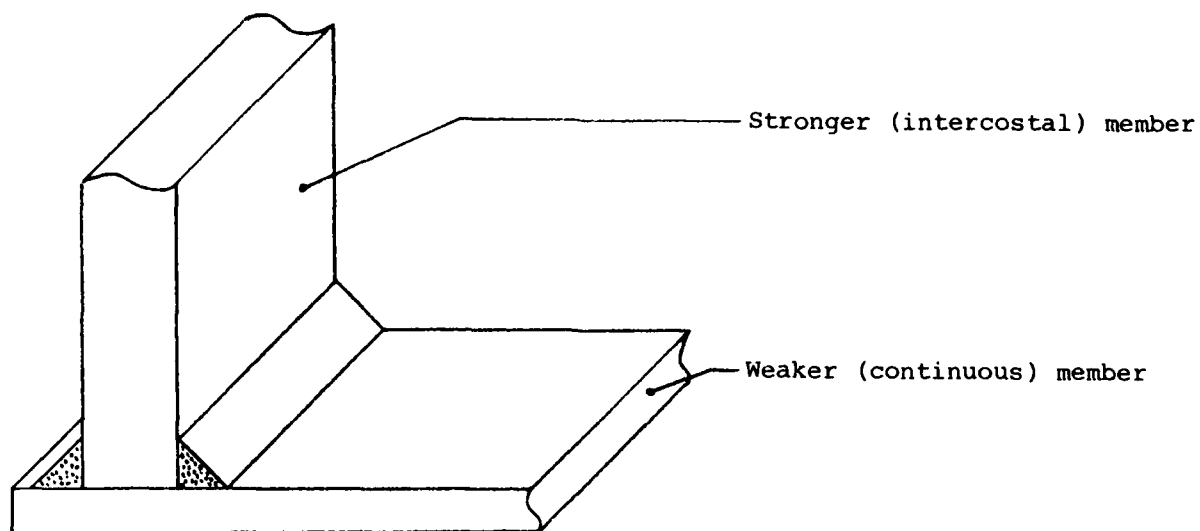
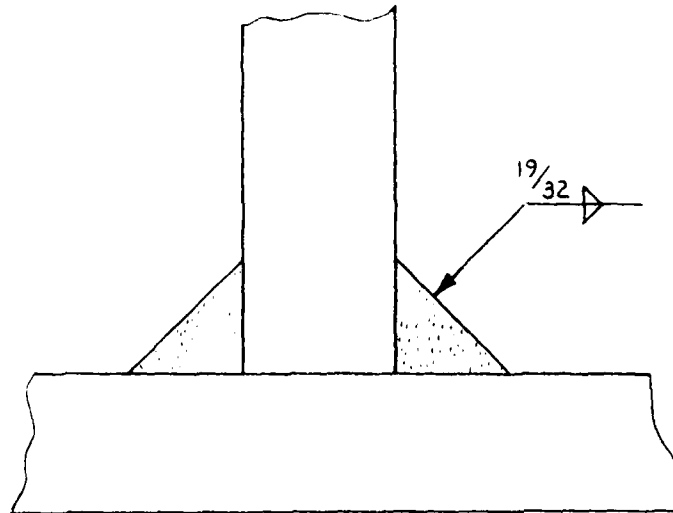
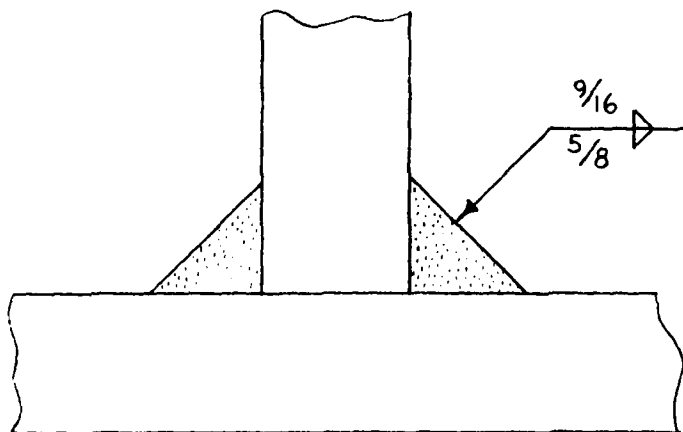


FIGURE 18

Double Fillet Weld In Way of a Corner Joint - Case 2



(a) Tabular Weld



(b) Actual Weld

FIGURE 19

Example of a Slightly Unbalanced Fillet Weld

procedures and are thus beyond the scope of the present study. However, one construction tolerance, the allowable opening between the plates before welding (i.e., the root gap), should be discussed here.

The current ABS allowance [Section 30.9.1 of Reference 2] for root gap is: "Where the gap between faying surfaces of members exceeds 2.0 mm or 1/16 in. and is not greater than 5 mm (3/16 in.) the weld leg size is to be increased by the amount of the opening." By comparison, the current military standard [Note 1 of Figure 22 of Reference 11] is: "Where (the root gap) is greater than 1/16 inch as a nominal condition, (the fillet size) shall be increased by an amount equal to the excess of the opening above 1/16 inch." The military standard also specifies the 3/16 inch maximum root opening. Some Japanese tests [see pages 9-126 and 9-127 of Reference 12] have indicated that root openings of up to 1/8 inch contribute to deeper penetration and consequently increase the strength of the weld. In view of these tests, it would appear appropriate to revise the current ABS root gap allowance to the slightly less conservative military standard.

### 5.5 Minimum Weld Sizes

When discussing minimum weld sizes it is important to distinguish between design values and as-built sizes. The minimum weld size generally produced by normal shipyard structural welding processes is about 3/16 inch. However, it is advantageous to specify design weld sizes on the working drawings as small as 1/8 inch where feasible for several reasons. First, as stated in Section 3.3 of Reference 1, "It is a common attitude for an inspector to reject . . . slightly undersized fillet welds." Unless the working drawings show the minimum weld size that is structurally acceptable rather than a somewhat arbitrary minimum value, the inspector has no practical alternative to rejecting all welds which fall below the arbitrary minimums. Second, the construction tolerances discussed in Section 5.4 require an increase in the weld sizes specified on the working drawings if the root opening is excessive. This increase will be applied to whatever weld size is specified on the working drawings which could result in excessive welding if arbitrary minimum values are used.

The existing ABS weld tables specify a minimum fillet weld size of 1/4 inch in the cargo tanks and ballast tanks in the cargo area for vessels classed as "oil carrier" and 3/16 inch (or 11/64) for other locations and vessels. For naval ships, 1/8 inch has generally been used as the minimum design fillet weld size [see Section 11 of References 3, 4, and 5 or Figures 1 through 40 of Reference 6]. It should be noted that this 1/8 inch minimum size has been used, apparently successfully, with the more liberal than ABS root opening allowance discussed in Section 5.4 and no corrosion allowance. Thus, it would appear that the ABS minimum fillet weld sizes can and should be reduced. As a concession to the "oil carrier" category, it is proposed that the ABS minimum weld sizes be reduced by 1/16 inch to 3/16 inch in the cargo tanks and ballast tanks in the cargo area for vessels classed as "oil carrier" and 1/8 inch for other locations and vessels. As can be readily determined from Figure D-6 for

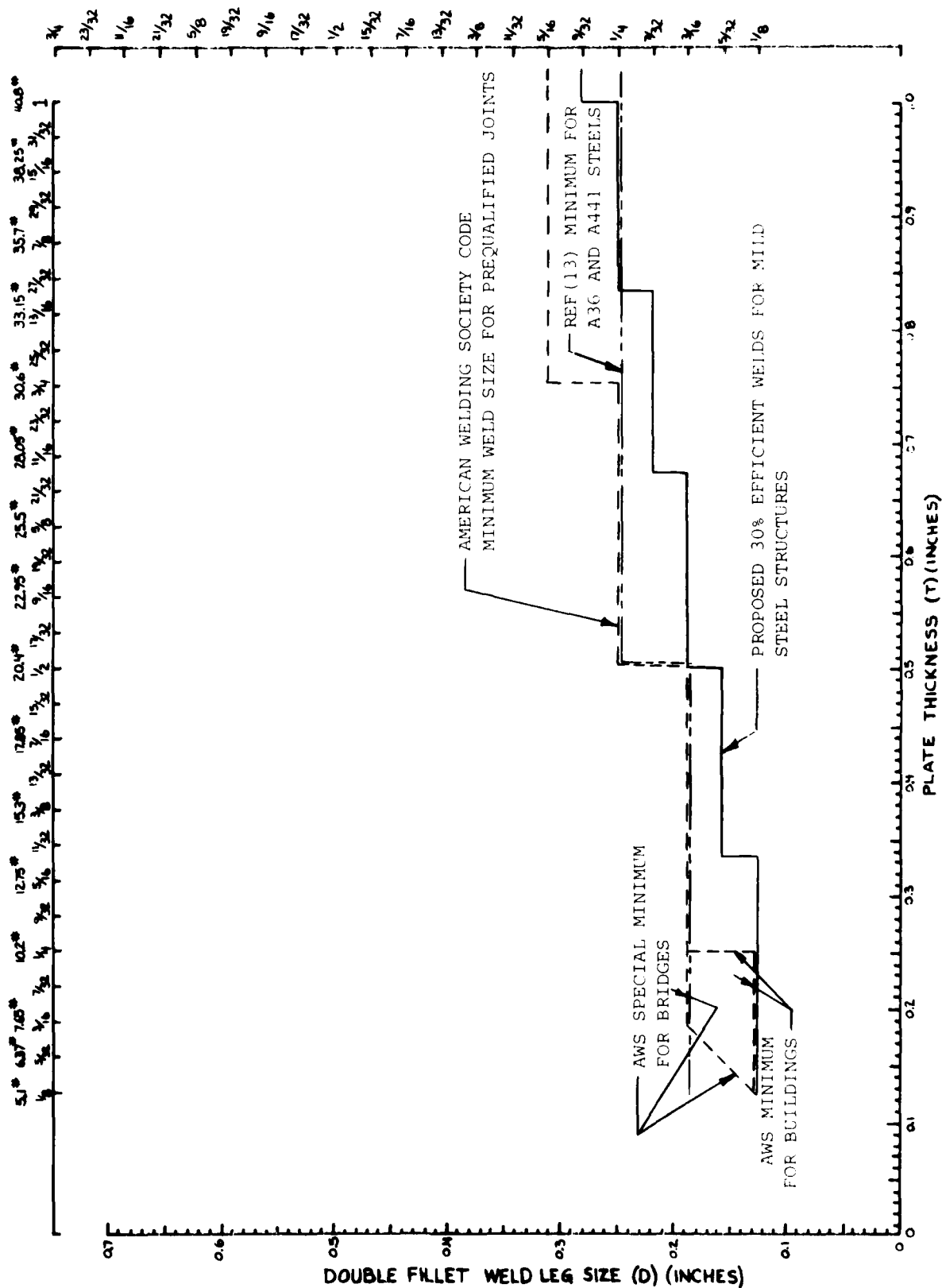


FIGURE 20

COMPARISON OF AWS, REFERENCE 13, AND PROPOSED MINIMUM WELD SIZES

mild steel structures, this proposed 1/16 inch reduction would generally involve only plates less than 0.84 inches thick for oil carriers and 0.51 inches thick for other vessels. For higher strength steel structures, Figure D-2 gives plates less than 0.76 inches thick for oil carriers and 0.47 inches thick for other vessels which would be affected by the proposed reduction.

The minimum weld size should also be a function of plate thickness to avoid the possibility of weld cracking due to insufficient heat input. In Section 30.9.1 of the ABS Rules, this problem is identified: "Special precautions such as the use of preheat or low-hydrogen electrodes or low-hydrogen welding processes may be required where small fillets are used to attach heavy plates or sections." As stated in Reference 13, "clearly any increase in preheat required by an increased chance of cracking could offset the economic benefits to be obtained from a reduction in fillet size." The weld sizes of the 30% efficiency category provide a reasonable approximation to the minimum weld sizes proposed in Reference 13 and Section 2.7.1.1 of the American Welding Society code [Reference 14], as shown in Figure 20. Consequently, if the weld sizes are based on direct calculations, no reductions below the 30% efficiency curve are proposed.

To further explore minimum weld sizes, design calculations have been prepared to check the required strength of the connection of bottom longitudinals to shell plate for the three sample ships. These connections should be among the most highly loaded fillet welded joints in the 30% efficiency category on the ships. The results of these calculations are summarized in Figure 21. As discussed in Appendix E, the calculation using von Mises combined stresses seems excessively conservative and, in fact, gives weld sizes greater than those required by ABS weld group M4. Modifying the von Mises equation to more accurately reflect experimental ultimate shear to ultimate tensile strength ratios (74.5% versus 57.7% in the original von Mises equation) produces more reasonable weld sizes. The simplified analyses are more in line with ABS nominal strength analysis procedures and give results which support the proposed reductions in ABS minimum weld sizes. All the calculations include a corrosion allowance. The end effects correction is due to a portion of the load acting on the shell plate being transferred directly to the floors rather than through the longitudinals and then into the floors. This correction is especially important on the containership and the O/B/O because their solid floors are spaced at intervals of less than two longitudinal frame spaces (i.e., bottom shell panel aspect ratios of 1.68 and 1.50 respectively).

#### 5.6 Intermittent Versus Continuous Welding

The use of continuous welding or intermittent welding where permitted by the ABS rules is essentially an economic trade-off because, with proper attention to details near the ends of the member, intermittent welds can be as strong as continuous welds. Intermittent welds do have an advantage on very thin structures where the minimum feasible continuous welds would give excessively strong joints. Chapter XIII of Reference 15 presents an analysis of essentially minimum size welds giving comparative costs of \$1.83 for

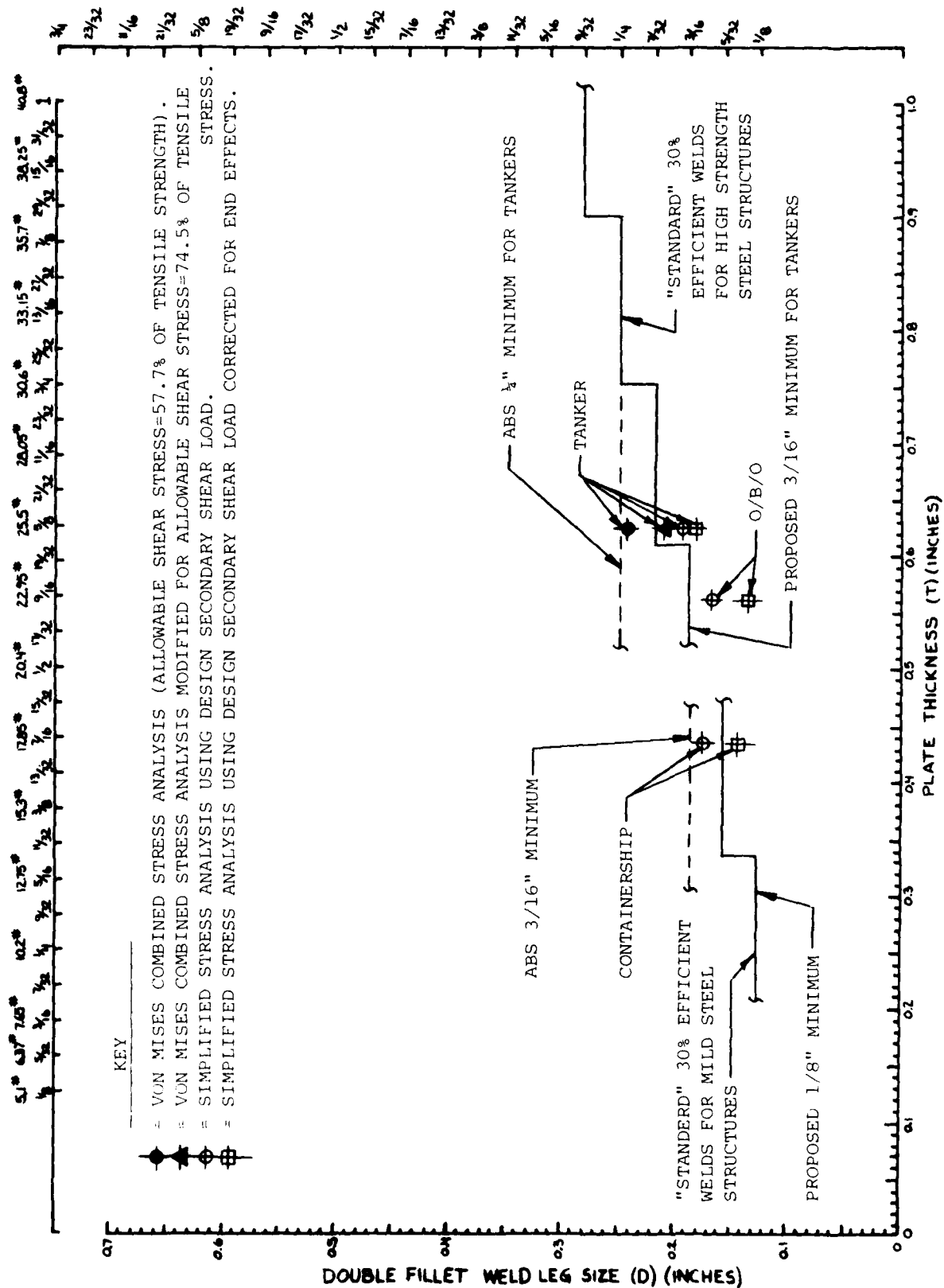


FIGURE 21

COMPARISON OF SAMPLE SHIP CALCULATED AND PROPOSED TABULAR WELD SIZES FOR CONNECTION OF BOTTOM LONGITUDINALS TO SHELL PLATE

continuous automatic welding, \$2.80 for intermittent manual welding, and \$6.43 for continuous manual welding. The continuous weld sizes were 5/32" while the intermittent welds were 3/16" 3-12. To compare equal strength joints the 5/32" continuous welds should be compared to 3/16" 10-12 intermittent welds if no corrosion allowance is involved or to 3/16" 8-3/8 - 12 intermittent welds if a corrosion allowance of 0.060" per surface is considered using equations (15) and (16) respectively. This should increase the cost of the intermittent welds considerably.

Since facilities will vary and the location of the joint when it is to be welded must be considered, this type of trade-off is best left to each individual shipyard.

#### 5.7 Special Protective Coatings

In various sections of the ABS rules, a reduction in scantlings is permitted if specially approved protective coatings are applied to the structure or other effective methods are adopted as a means of corrosion control. The required weld sizes are thus reduced because they are based on the reduced scantlings. However, this presents a slight inconsistency because the weld tables still include a corrosion allowance. It would appear more appropriate to use a different set of weld tables with the corrosion allowance removed for this case. This can easily be done using equation (13) rather than equation (14). The major question would be whether or not the joint efficiencies used with equation (14) would still be suitable for use with equation (13). It would seem hard to argue against using the same efficiencies. That is, if a joint efficiency of say 30% after the structure has been corroded in a severe environment is acceptable, then why shouldn't the same efficiency be acceptable in a protected environment. The amount of weld size reduction obtainable by this procedure (aside from that already obtained by the reduced scantlings) can be seen by comparing corresponding curves in Figures 9 and 11. Neglecting differences due to rounding off to standard weld sizes, the maximum reduction would vary from 0.001" for 100% efficient joints to 0.060" for 30% efficient joints. For the mild steel only case in Table D-6 of Appendix D, the maximum reduction would vary from 0.010" for 100% efficient joints to 0.062" for 30% efficient joints. However, some adjustment may be required for the smaller weld sizes to avoid the cracking problem from insufficient heat input mentioned in Section 5.5.

## 6. APPLICATION OF PROPOSED DESIGN CRITERIA TO SAMPLE SHIPS

The proposed fillet weld design criteria has been applied to three sample ships to give a practical comparison with the existing ABS Rules and to allow an economic assessment of the proposal to be made. The following sections summarize that work, much of which is included in Appendices E, F, and G.

### 6.1 General Procedure

The three sample commercial ships have been selected from the Maritime Administration CMX Designs [Reference 16]. Principal Characteristics of the three ships are given in Table 9. Arrangement drawings, scantling drawings, and characteristics at scantling drafts can be found in Appendices E, F, and G.

TABLE 9

Principal Characteristics of Sample Ships

| <u>Dimension</u>                 | <u>Voyager<br/>Class<br/>Tanker</u> | <u>Vanguard<br/>Class<br/>Containership</u> | <u>Crescent<br/>Class<br/>Ore/Bulk/Oil Carrier</u> | <u>Units</u> |
|----------------------------------|-------------------------------------|---------------------------------------------|----------------------------------------------------|--------------|
| Length overall                   | 950-0                               | 725-0                                       | 871-0                                              | ft-in.       |
| Length between<br>perpendiculars | 900-0                               | 685-0                                       | 827-0                                              | ft-in.       |
| Beam                             | 147-6                               | 103-0                                       | 106-0                                              | ft-in.       |
| Depth at side                    | 63-6                                | 60-0                                        | 60-0                                               | ft-in.       |
| Design draft                     | 48-6                                | 29-6                                        | 42-6                                               | ft-in.       |
| Displacement at<br>design draft  | 147,400                             | 32,200                                      | 86,700                                             | long tons    |
| Deadweight at<br>design draft    | 125,200                             | 19,700                                      | 69,300                                             | long tons    |
| Steel weight                     | 18,909                              | 9,125                                       | 14,378                                             | long tons    |
| Outfitting weight                | 1,467                               | 1,853                                       | 1,499                                              | long tons    |
| Machinery weight                 | 1,091                               | 1,112                                       | 932                                                | long tons    |
| Margin                           | 733                                 | 410                                         | 591                                                | long tons    |

The midship section of each ship was first checked for compliance with the 1981 ABS Rules. This allowed slight reductions in the existing scantlings which had been sized to the 1970 ABS Rules. Weld sizes required by the 1981 ABS Rules and the proposed design criteria were then determined. After additional calculations were performed for a few critical welds, tabulations of weld sizes, lengths, and weights were made including estimates for bow, stern, and deckhouse structures. These values were then used in the economic analysis.

## 6.2 Voyager Class Tanker

Table 10 summarizes the data developed for the tanker, a detail listing of which can be found in Appendix E. It should be noted that, as on the other two sample ships, the weighted average weld size is fairly small. About 2,700 feet (1%) of the altered weld length is increased rather than decreased in size by the proposed design procedure.

| <u>TABLE 10</u><br><u>Summary of Lengths, Sizes, and Weights of Welds</u><br><u>for Voyager Class Tanker</u> |                                                     |                                         |          |                                       |          |
|--------------------------------------------------------------------------------------------------------------|-----------------------------------------------------|-----------------------------------------|----------|---------------------------------------|----------|
|                                                                                                              | Total Length<br>of Double<br>Fillet Welds<br>(Feet) | Average Design<br>Weld Size<br>(Inches) |          | Weight of Design<br>Welds<br>(Pounds) |          |
|                                                                                                              |                                                     | Existing                                | Proposed | Existing                              | Proposed |
| Altered Welds                                                                                                | 342,210                                             | 0.268                                   | 0.225    | 83,500                                | 59,095   |
| Unaltered Welds                                                                                              | 48,918                                              | 0.338                                   | 0.338    | 18,998                                | 18,998   |
| TOTALS                                                                                                       | 391,128                                             | 0.278                                   | 0.242    | 102,498                               | 78,093   |

The bottom longitudinals of this ship were analyzed in some detail using ABS Rule loadings and the principles discussed in Section 4. Since these members are built up "T" beams, both the web to flange and the web to bottom shell plating connections were checked. Interestingly enough, an analysis using the von Mises yield criteria gives weld sizes greater than those required by the current ABS Rule weld Tables. Modifying the von Mises equation to more accurately reflect experimental ultimate shear to ultimate tensile strength ratios (74.5% versus 57.7% in the original von Mises equation) produces more reasonable weld sizes. Fortunately, the Bulk Oil Carrier Section of the ABS Rules gives sufficient data to allow calculation of nominal design stresses for the structural members and thus allow a nominal design stress analysis of the welds. The latter analysis gives reasonable weld sizes as shown in Figure E-5 of Appendix E.

Additional calculations were performed to check the strength of the connection of bottom longitudinals to bottom transverses and the connection of deck longitudinals to deck transverses.

### 6.3 Vanguard Class Containership

Table 11 summarizes the data developed for the containership. For this ship, additional calculations were made for the connection of longitudinals to bottom shell and for the connection of bottom longitudinals to web frames. About 1,400 feet (1%) of the altered weld length is increased rather than decreased in size by the proposed design procedure.

| <u>TABLE 11</u><br><u>SUMMARY OF LENGTHS SIZES AND WEIGHTS OF WELDS</u><br><u>FOR VANGUARD CLASS CONTAINERSHIP</u> |                                                     |                                         |          |                                       |          |
|--------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------|-----------------------------------------|----------|---------------------------------------|----------|
|                                                                                                                    | Total Length<br>of Double<br>Fillet Welds<br>(Feet) | Average Design<br>Weld Size<br>(Inches) |          | Weight of Design<br>Welds<br>(Pounds) |          |
|                                                                                                                    |                                                     | Existing                                | Proposed | Existing                              | Proposed |
| Altered Welds                                                                                                      | 191,667                                             | 0.232                                   | 0.204    | 35,116                                | 27,061   |
| Unaltered Welds                                                                                                    | 62,058                                              | 0.271                                   | 0.271    | 15,506                                | 15,506   |
| TOTALS                                                                                                             | 253,725                                             | 0.242                                   | 0.222    | 50,622                                | 42,567   |

### 6.4 Crescent Class Ore/Bulk/Oil Carrier

Table 12 summarizes the data developed for the Ore/Bulk/Oil Carrier. For this ship, the thickness of the deck slab longitudinals is slightly greater than the maximum value for which a weld size is specified in the ABS Rules. Hence, the next larger size is used. The appropriate equation for 30% efficient welds gives the same size. Additional calculations were prepared for the connection of longitudinals to the bottom shell. About 18,000 feet (8%) of the altered weld length is increased rather than decreased in size by the proposed design procedure. Most of these increases are in the bottom structure which apparently was not optimized to the same extent as the other two sample ships.

| <p style="text-align: center;"><u>TABLE 12</u></p> <p style="text-align: center;"><u>Summary of Lengths, Sizes, and Weights of</u><br/><u>Welds for Crescent Class Ore/Bulk/Oil Carrier</u></p> |                                                     |                                          |          |                                       |          |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------|------------------------------------------|----------|---------------------------------------|----------|
|                                                                                                                                                                                                 | Total Length<br>of Double<br>Fillet Welds<br>(Feet) | Average Design<br>Weld Sizes<br>(Inches) |          | Weight of Design<br>Welds<br>(Pounds) |          |
|                                                                                                                                                                                                 |                                                     | Existing                                 | Proposed | Existing                              | Proposed |
| Altered Welds                                                                                                                                                                                   | 213,909                                             | 0.277                                    | 0.239    | 55,784                                | 41,503   |
| Unaltered Welds                                                                                                                                                                                 | 66,793                                              | 0.336                                    | 0.336    | 25,631                                | 25,631   |
| TOTALS                                                                                                                                                                                          | 280,702                                             | 0.292                                    | 0.265    | 81,415                                | 67,134   |

#### 6.5 Fillet Weld Comparisons

Table 13 compares lengths, size reductions, and weight reductions for the three sample ships. Approximately 75 to 87 percent of the weld length on these ships could be reduced an average of 8 to 13 percent in size by using the proposed design criteria.

| <p style="text-align: center;"><u>TABLE 13</u></p> <p style="text-align: center;"><u>Double Fillet Weld Comparisons</u><br/><u>for Sample Ships</u></p> |                         |                                 |                                           |
|---------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------|---------------------------------|-------------------------------------------|
|                                                                                                                                                         | Voyager Class<br>Tanker | Vanguard Class<br>Containership | Crescent Class<br>Ore/Bulk/Oil<br>Carrier |
| Length of altered<br>welds (feet)                                                                                                                       | 342,210 (87.5%)         | 191,667 (75.5%)                 | 213,909 (76.2%)                           |
| Reduction in Average<br>weld size (inches)                                                                                                              | 0.036 (12.9%)           | 0.020 (8.3%)                    | 0.027 (9.2%)                              |
| Reduction in weight of<br>fillet welds (long tons)                                                                                                      | 10.9 (23.8%)            | 3.60 (15.9%)                    | 6.38 (17.5%)                              |
| Length of welds in<br>30% efficiency<br>category (feet)                                                                                                 | 262,145 (67.0%)         | 182,727 (72.0%)                 | 197,739 (70.4%)                           |

Figures 22 and 23 compare the lengths and weights of the proposed fillet welds versus weld efficiency category for the three sample ships. It should be noted that only a small percentage of fillet welds for typical commercial ships is required to develop the full strength of the joined members (i.e., 100% efficient welds). The majority of fillet welds (approximately 70% of weld length and 50% of weld weight) fall in the 30% efficiency category. As discussed in Section 5.5, the 30% efficiency category represents minimum practical weld sizes for a shipyard production environment. Thus it would appear that the proposed design criteria has accounted for most of the significant, practical ABS fillet weld size reductions.

The differences in lengths and weights of welds in the 45, 60, 75, and 88% efficiency categories are not significant. The 88% efficiency category is unique to single-hull bulk oil carriers. The amount of weld in the other categories will vary with the length of watertight boundaries and with the amount of bracketed versus unbracketed stiffener and girder end connections on a particular ship.

#### 6.6 Cost Saving Estimates

Cost estimates can be prepared to many different degrees of refinement depending on the resources available and the expected use of the estimates. For the purposes of this study, only an order of magnitude estimate of cost savings was specified. Consequently, very simple estimating procedures have been used. However, sufficient data on the three sample ships is provided in Tables 10 through 13 and Appendices E, F, and G to allow an independent investigator to prepare additional cost estimates to any degree of refinement desired.

For a simplified cost estimate, some relationship between weld size and cost is required which reflects the many different welding processes, steel combinations, and electrodes used in a typical shipyard. Intuitively, one would expect the cost of fillet welding to vary as a function somewhere between the weld size and the weld cross-sectional area (i.e., the deposited weld metal). A reasonable relationship for the purposes of this study is given in equation (18) where RC is the cost of a given fillet weld of size D in inches expressed as a percentage of the cost of 5/8 inch fillet welds.

$$RC = 15 + 223.45 (D - 0.1")^{1.5} \quad (18)$$

Figure 24 shows this curve along with the expected limits of any reasonable fillet weld cost curve. Also shown on Figure 24 are data points from a series of laboratory studies. Each data point represents an unweighted average of three weld positions (flat or horizontal, vertical, and overhead) for two combinations of material (HTS and HY80) with five electrodes for shielded metal arc welding (7015/7016, 7018, 8018, 9018, and 11018) and two electrodes for gas metal arc welding (70S-3 and 100S-1). Thus each data point is generally an average of 27 experimental points. These data are also plotted in Figure 25 in the form of the original test series with equation (18) modified to suit each test series. Equation (18) fits the experimental data very well

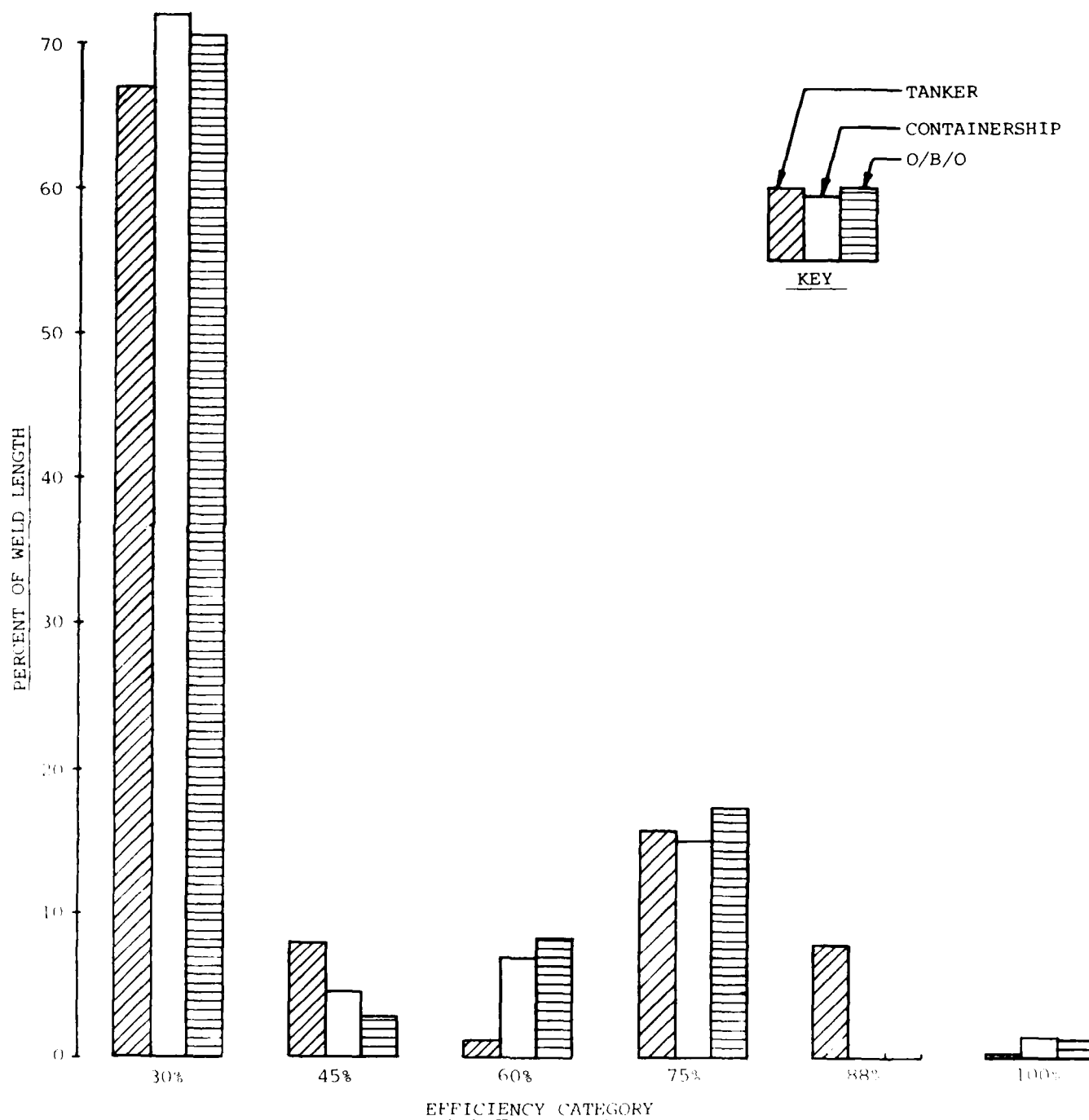


FIGURE 22

WELD LENGTH VERSUS EFFICIENCY CATEGORY FOR SAMPLE SHIPS

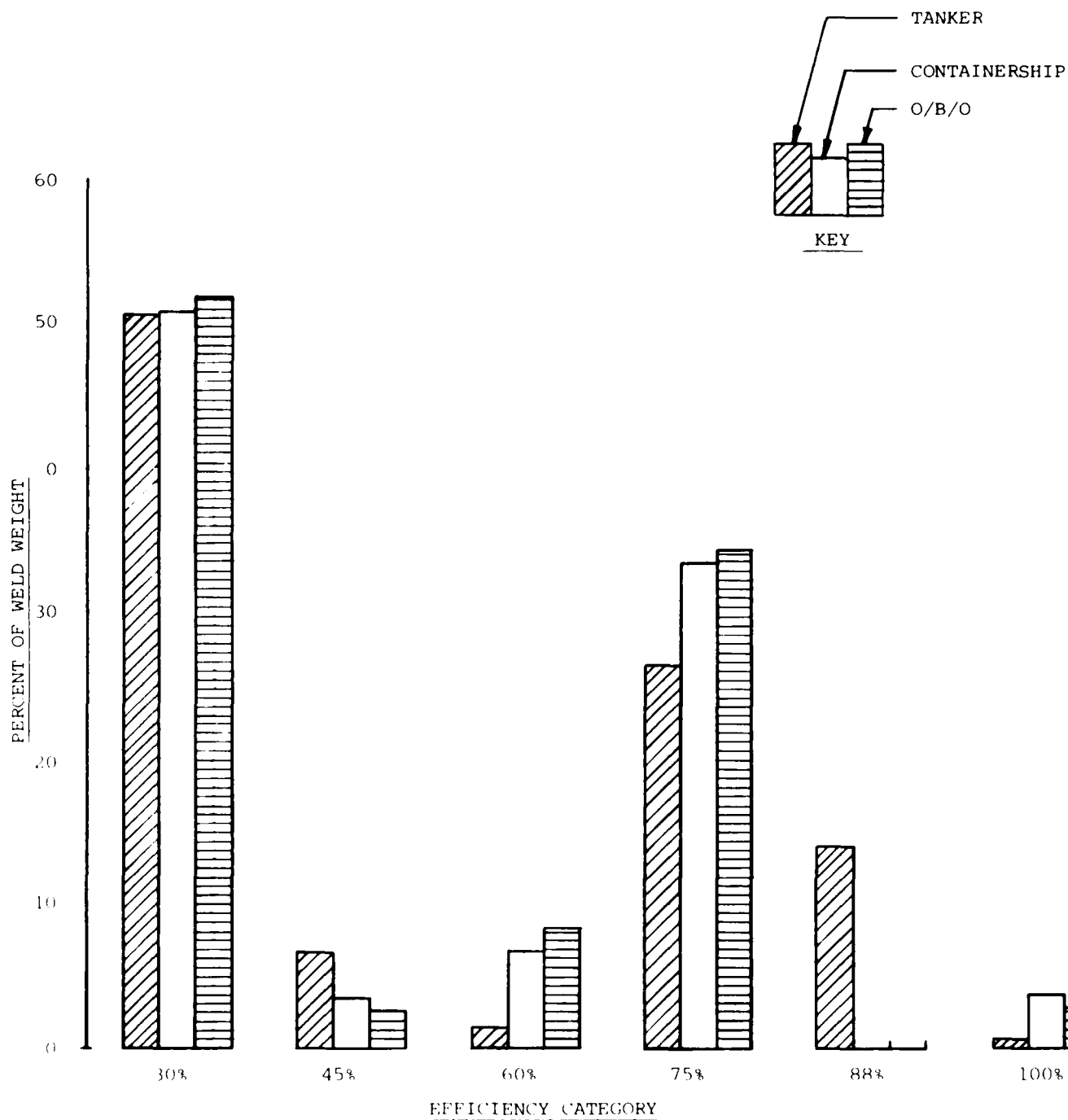


FIGURE 23

WELD WEIGHT VERSUS EFFICIENCY CATEGORY FOR SAMPLE SHIPS

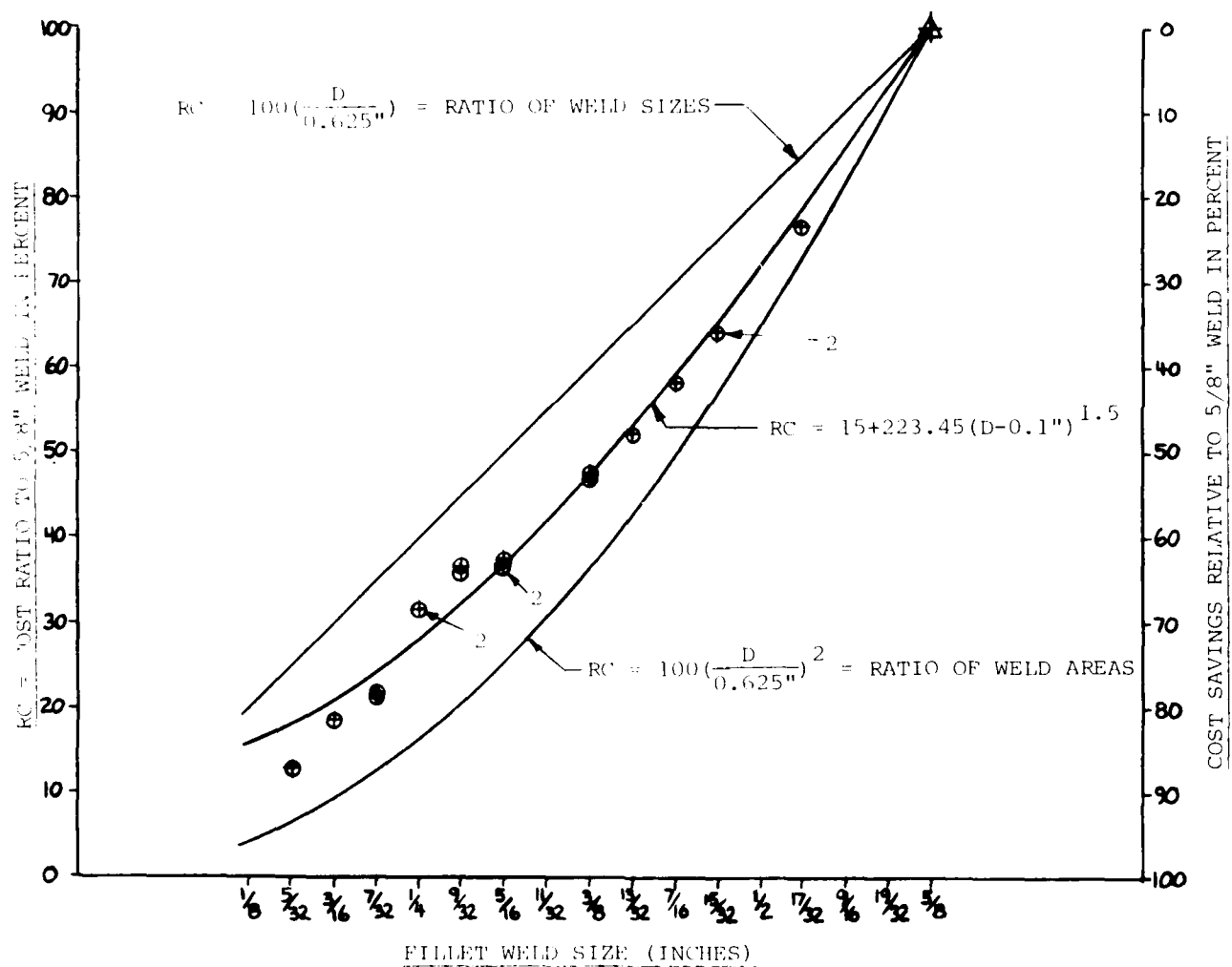


FIGURE 24  
 FILLET WELD RELATIVE COST CURVES

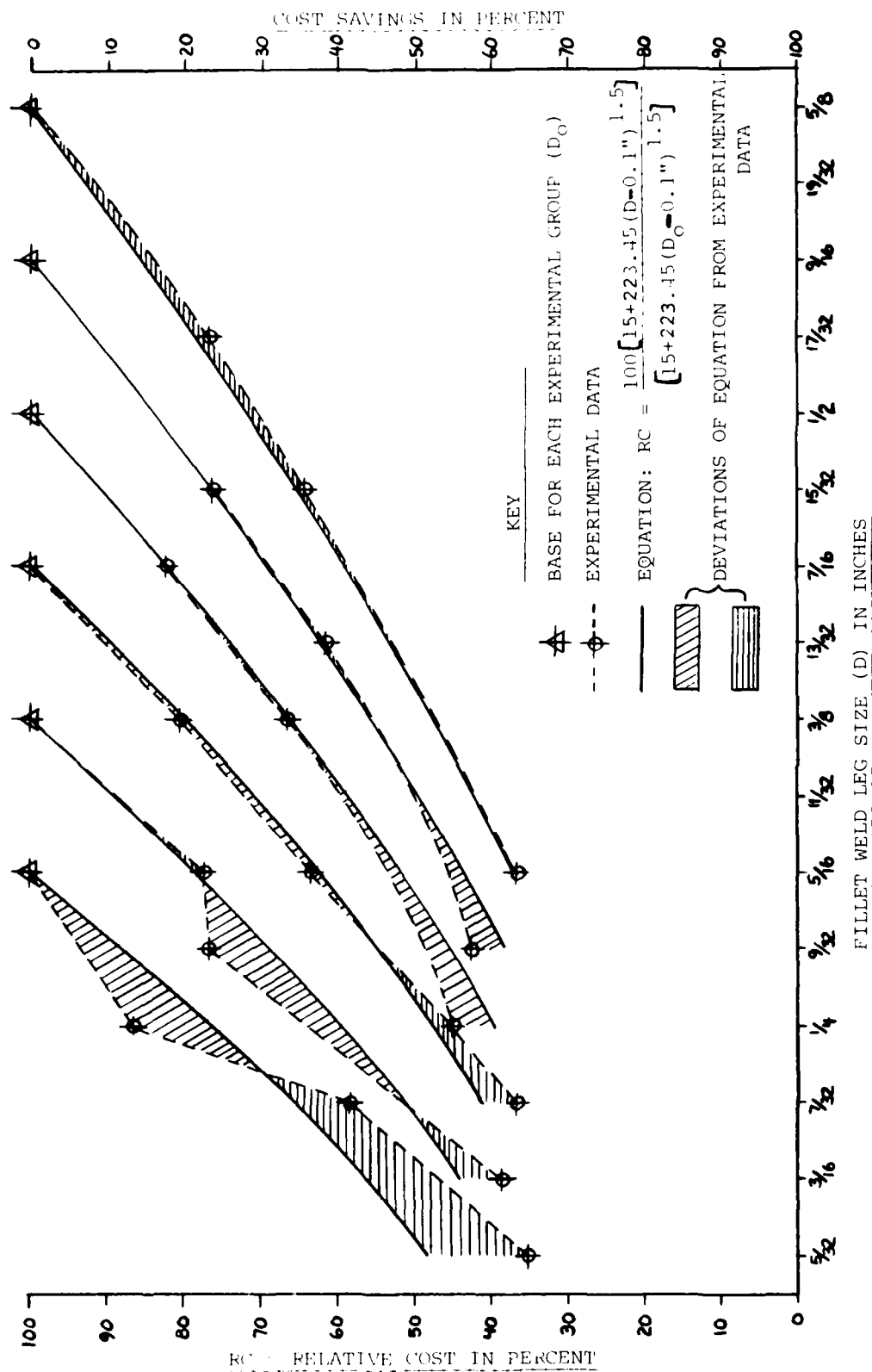


FIGURE 25

FILLET WELD RELATIVE COST CURVES FOR TEST SERIES

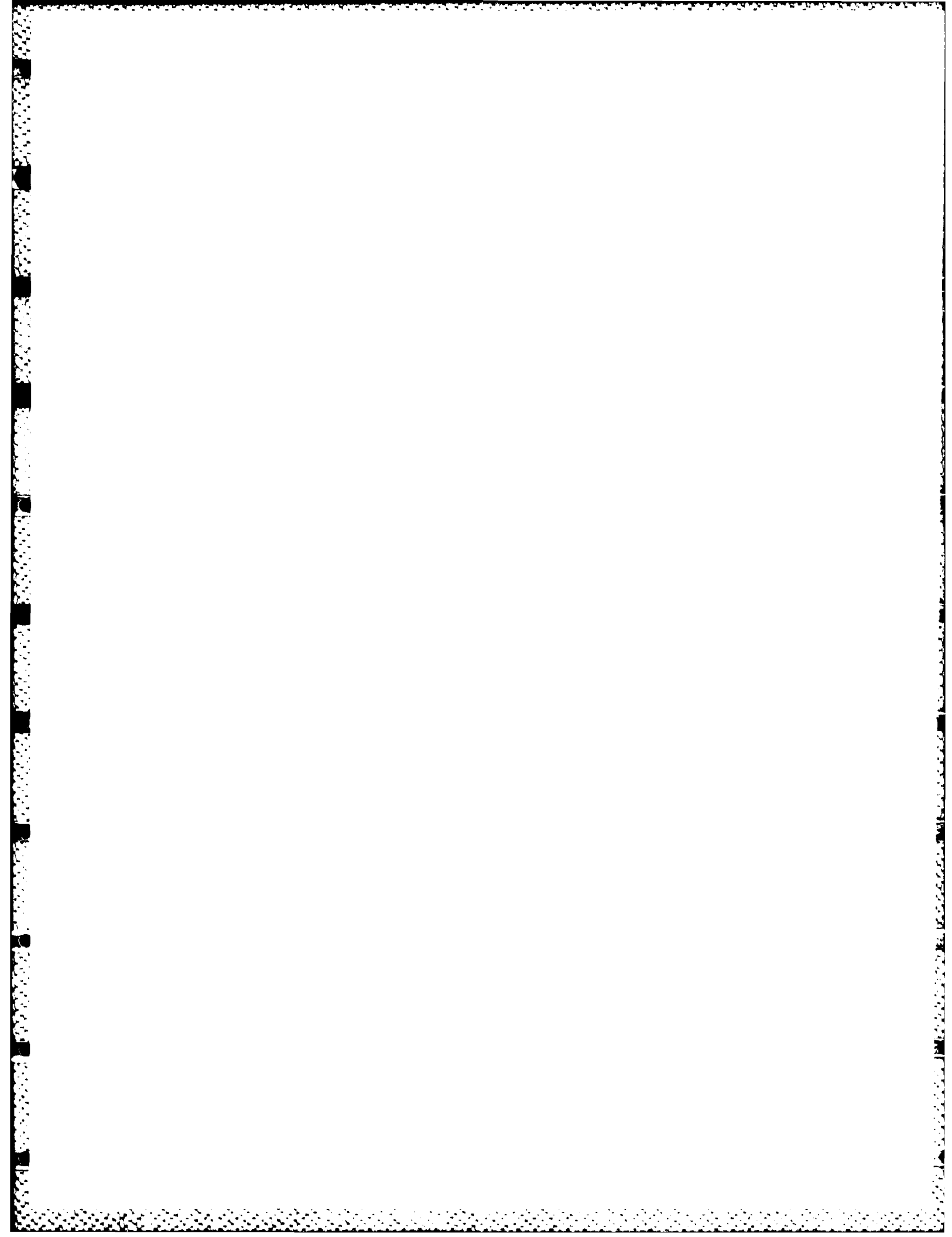
in the larger weld sizes and effectively averages the data for smaller weld sizes as required for this study.

The only additional data needed to make a reasonable cost estimate for the sample ships is a base weld cost. For this study it will be assumed that the average cost of 1/4 inch double fillet welds is \$3.00/foot in spring 1982 dollars. It is assumed that this value includes material, labor, and overhead. Equation (18) gives a relative cost of 27.98% for 1/4 inch fillets. Using these values the cost savings for each of three sample ships is shown in Table 14. The dollar amounts vary from 66,300 to 203,00 per ship while the percentage savings vary from 9.0 to 15.2.

| <p align="center"><b>TABLE 14</b><br/> <b>Fillet Weld Cost Savings for Sample Ships</b><br/> <b>Using Derived Cost Curve and \$3.00/Foot</b><br/> <b>for 1/4 Inch Double Fillet Welds</b></p> |                            |                                    |                                           |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------|------------------------------------|-------------------------------------------|
| Item                                                                                                                                                                                          | Voyager<br>Class<br>Tanker | Vanguard<br>Class<br>Containership | Crescent<br>Class<br>Ore/Bulk/Oil Carrier |
| A = Length of Double Fillet Welds (feet)                                                                                                                                                      | 391,128                    | 253,725                            | 280,702                                   |
| D <sub>1</sub> = Existing Average Fillet Weld Size (inches)                                                                                                                                   | 0.278                      | 0.242                              | 0.292                                     |
| F <sub>1</sub> = Cost/Ft of Existing Welds<br>$= \frac{\$3.00/\text{Ft}}{27.98\%} \times [15+223.45(D_1 - 0.1")^{1.5}]$                                                                       | 3.408                      | 2.890                              | 3.624                                     |
| K <sub>1</sub> = Cost of Existing Fillet welds = A x F <sub>1</sub>                                                                                                                           | \$1,333,000                | \$ 733,300                         | \$1,017,000                               |
| D <sub>2</sub> = Proposed Average Fillet Weld Size (inches)                                                                                                                                   | 0.242                      | 0.222                              | 0.265                                     |
| F <sub>2</sub> = Cost/Ft of Proposed Welds<br>$= \frac{\$3.00/\text{Ft}}{27.98\%} \times [15+223.45(D_2 - 0.1")^{1.5}]$                                                                       | 2.890                      | 2.629                              | 3.214                                     |
| K <sub>2</sub> = Cost of Proposed Fillet Welds = A x F <sub>2</sub>                                                                                                                           | \$1,130,000                | \$ 667,000                         | \$ 902,000                                |
| Cost Savings = K <sub>1</sub> - K <sub>2</sub>                                                                                                                                                | \$ 203,000                 | \$ 66,300                          | \$ 115,000                                |
| Cost Savings in Percent = $100(K_1 - K_2)/K_1$                                                                                                                                                | 15.2%                      | 9.0%                               | 11.3%                                     |

## 7. SUMMARY AND CONCLUSIONS

- 7.1 A new fillet weld design procedure has been developed for commercial ships which gives some modest reductions in weld size from the existing ABS Rule Tables along with some increases for consistency.
- 7.2 The weld size reductions are obtained by:
- o eliminating the inconsistencies in the current ABS Rule weld tables,
  - o varying the required weld size with material type, and
  - o reducing the minimum specified weld size.
- 7.3 The new weld size procedure has been put in a form suitable for design office use. It is much easier to use and to apply to unusual situations than the current ABS Rule tables.
- 7.4 The weighted average ABS fillet weld leg sizes for the three sample ships are already fairly small (0.242 to 0.292 inches). Thus the existing ABS fillet welds are, in general, not excessively conservative.
- 7.5 The majority of welds on the three sample ships (70% by length and 50% by weight) are minimum practical weld sizes for a shipyard production environment. Thus significant further reductions in ABS fillet weld sizes are not expected.
- 7.6 Weld cost savings in the order of 9 to 15 percent for three sample ships are obtainable with the proposed design procedure.
- 7.7 Additional fillet weld size reductions and cost savings could be obtained if a shipyard elected to use 8000 series in lieu of 7000 series electrodes on H32 and H36 material. Similar reductions could be obtained for the use of automatic welding processes on H32 and H36 material by using the bare electrode strength values of Figure 8 and the sizing procedure of Section 2. In both cases the resulting weld sizes would be equal to or slightly less than the values shown in Table D-6 which are designated for mild steel only.



## 8. RECOMMENDATIONS

- 8.1 The existing ABS Rules should be revised to incorporate the proposed design procedure (Appendix D of this report).
- 8.2 The existing ABS Rule allowance for excessive root gap should be revised to the current military standard value (see Section 5.4).
- 8.3 If further comparisons between ABS and other Rule weld sizes (such as Lloyds) are made, they should be extensive comparisons rather than sampling type comparisons such as those done in Reference 1. A major question would be the lack of an explicit corrosion allowance in some rules such as Lloyds or the U.S. Navy.
- 8.4 Consideration should be given to developing and incorporating into the existing ABS Rules weld tables without a corrosion allowance for use where specially approved protective coatings are applied to the structure or other effective methods are adopted as a means of corrosion control (see Section 5.7).
- 8.5 Future commercial ship fillet weld research should concentrate on verifying that the joint efficiencies shown in Appendix D are adequate for all commercial ship applications and on establishing additional line items for specific structural connections such as compensation for cuts in structure as mentioned in Section 3.3.
- 8.6 The weld sizing procedure of Section 2 should either be incorporated into the existing ABS Rules or referenced therein to help individual shipyards to readily determine appropriate weld sizes for the particular steels, electrodes, and welding processes they use.
- 8.7 Subsequent studies should include tests similar to those discussed in Section 5.4, where further verification is required to assess the strength of small fillet welds with various root openings. Additional studies on the damage frequency and durability of fillet welds could also be made.
- 8.8 Where 1/8 inch welds are not acceptable to ABS, an alternative to avoid excessive weld deposit increases for root gaps may be to change all 1/8 inch welds to 3/16\* and add the following footnote to the weld tables:

Footnote:

Where 3/16\* fillet welds are shown, the fillet size need only be increased by 1/16 inch for a 3/16 inch root gap (in lieu of the 1/8 inch required by the current military standard or 3/16 inch required by the current ABS procedure, see Section 5.4). For a 1/8-inch root gap, no weld size increase is required.

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APPENDIX A

ABS FILLET WELD SIZES

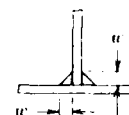
**TABLE 30.1**  
**Double Continuous Fillet Weld Sizes—Inches**

For leg requirements for thicknesses intermediate to those shown in the table, use the nearest lower thickness shown in the table.

For thickness less than  $\frac{3}{16}$  in. the leg size is not to be less than  $0.625t$  except for unbracketed end connections where the leg size is to be  $0.7t$ . The thickness  $t$  is the lesser thickness of members joined except where Note 1 at the end of the table applies. The leg size is not to be less than  $\frac{11}{64}$  in.

For vessels to be classed "Oil Carrier" the leg size in cargo tanks and in ballast tanks in the cargo area is not to be less than  $\frac{1}{4}$  in. except where approval has been given in accordance with 30.9.2a or b.

Where Type A or B appears in the *Structural Items* column, refer to 30.9.7 for weld description and arrangement.



$w$  = nominal leg size, in.

| Line No.                                 | Weld Gr. | Structural Items                                                                               | Leg size for lesser thickness of members joined, in. |                |                |                |                |                |                |                 |                |                |                 |                |                 |                 |                 |                 |                 |                |
|------------------------------------------|----------|------------------------------------------------------------------------------------------------|------------------------------------------------------|----------------|----------------|----------------|----------------|----------------|----------------|-----------------|----------------|----------------|-----------------|----------------|-----------------|-----------------|-----------------|-----------------|-----------------|----------------|
|                                          |          |                                                                                                | 0.32                                                 | 0.36           | 0.40           | 0.44           | 0.48           | 0.52           | 0.56           | 0.60            | 0.64           | 0.68           | 0.72            | 0.76           | 0.80            | 0.84            | 0.88            | 0.92            | 0.96            | 1.00           |
| Single Bottom Floors                     |          |                                                                                                |                                                      |                |                |                |                |                |                |                 |                |                |                 |                |                 |                 |                 |                 |                 |                |
| 1                                        | C        | To center vertical keel                                                                        | $\frac{3}{16}$                                       | $\frac{7}{32}$ | $\frac{1}{4}$  | $\frac{1}{4}$  | $\frac{9}{32}$ | $\frac{5}{16}$ | $\frac{5}{16}$ | $\frac{11}{32}$ | $\frac{3}{8}$  | $\frac{3}{8}$  | $\frac{13}{32}$ | $\frac{7}{16}$ | $\frac{7}{16}$  | $\frac{15}{32}$ | $\frac{1}{2}$   | $\frac{1}{2}$   | $\frac{17}{32}$ | $\frac{9}{16}$ |
| 2                                        | F        | To shell—aft peak of high power fine form vessels                                              | $\frac{3}{16}$                                       | $\frac{3}{16}$ | $\frac{3}{16}$ | $\frac{7}{32}$ | $\frac{7}{32}$ | $\frac{1}{4}$  | $\frac{1}{4}$  | $\frac{1}{4}$   | $\frac{1}{4}$  | $\frac{9}{32}$ | $\frac{9}{32}$  | $\frac{5}{16}$ | $\frac{5}{16}$  | $\frac{5}{16}$  | $\frac{5}{16}$  | $\frac{11}{32}$ | $\frac{11}{32}$ | $\frac{3}{8}$  |
| 3                                        | M        | To shell—flat of bottom forward and in peaks                                                   | $\frac{3}{16}$                                       | $\frac{3}{16}$ | $\frac{3}{16}$ | $\frac{3}{16}$ | $\frac{3}{16}$ | $\frac{3}{16}$ | $\frac{3}{16}$ | $\frac{7}{32}$  | $\frac{7}{32}$ | $\frac{7}{32}$ | $\frac{1}{4}$   | $\frac{1}{4}$  | $\frac{1}{4}$   | $\frac{1}{4}$   | $\frac{1}{4}$   | $\frac{9}{32}$  | $\frac{9}{32}$  | $\frac{5}{16}$ |
| 4                                        | M        | To shell—elsewhere                                                                             | $\frac{3}{16}$                                       | $\frac{3}{16}$ | $\frac{3}{16}$ | $\frac{3}{16}$ | $\frac{3}{16}$ | $\frac{3}{16}$ | $\frac{3}{16}$ | $\frac{7}{32}$  | $\frac{7}{32}$ | $\frac{7}{32}$ | $\frac{1}{4}$   | $\frac{1}{4}$  | $\frac{1}{4}$   | $\frac{1}{4}$   | $\frac{1}{4}$   | $\frac{9}{32}$  | $\frac{9}{32}$  | $\frac{5}{16}$ |
| 5                                        | M        | To face plate, Type B                                                                          | $\frac{3}{16}$                                       | $\frac{3}{16}$ | $\frac{3}{16}$ | $\frac{3}{16}$ | $\frac{3}{16}$ | $\frac{3}{16}$ | $\frac{3}{16}$ | $\frac{7}{32}$  | $\frac{7}{32}$ | $\frac{7}{32}$ | $\frac{1}{4}$   | $\frac{1}{4}$  | $\frac{1}{4}$   | $\frac{1}{4}$   | $\frac{1}{4}$   | $\frac{9}{32}$  | $\frac{9}{32}$  | $\frac{5}{16}$ |
| 6                                        | C        | To side shell, longitudinal bulkhead or other supporting member                                | $\frac{3}{16}$                                       | $\frac{7}{32}$ | $\frac{1}{4}$  | $\frac{1}{4}$  | $\frac{9}{32}$ | $\frac{5}{16}$ | $\frac{5}{16}$ | $\frac{11}{32}$ | $\frac{3}{8}$  | $\frac{3}{8}$  | $\frac{13}{32}$ | $\frac{7}{16}$ | $\frac{7}{16}$  | $\frac{15}{32}$ | $\frac{1}{2}$   | $\frac{1}{2}$   | $\frac{17}{32}$ | $\frac{9}{16}$ |
| Double Bottom Floors—Plate Floors        |          |                                                                                                |                                                      |                |                |                |                |                |                |                 |                |                |                 |                |                 |                 |                 |                 |                 |                |
| 7                                        | F        | To shell—aft peaks of high power fine form vessels                                             | $\frac{3}{16}$                                       | $\frac{3}{16}$ | $\frac{3}{16}$ | $\frac{7}{32}$ | $\frac{7}{32}$ | $\frac{1}{4}$  | $\frac{1}{4}$  | $\frac{1}{4}$   | $\frac{1}{4}$  | $\frac{9}{32}$ | $\frac{9}{32}$  | $\frac{5}{16}$ | $\frac{5}{16}$  | $\frac{11}{32}$ | $\frac{1}{2}$   | $\frac{1}{2}$   | $\frac{17}{32}$ | $\frac{9}{16}$ |
| 8                                        | M        | To shell—flat of bottom forward and in peaks                                                   | $\frac{3}{16}$                                       | $\frac{3}{16}$ | $\frac{3}{16}$ | $\frac{3}{16}$ | $\frac{3}{16}$ | $\frac{3}{16}$ | $\frac{3}{16}$ | $\frac{7}{32}$  | $\frac{7}{32}$ | $\frac{7}{32}$ | $\frac{1}{4}$   | $\frac{1}{4}$  | $\frac{1}{4}$   | $\frac{9}{32}$  | $\frac{1}{4}$   | $\frac{9}{32}$  | $\frac{9}{32}$  | $\frac{5}{16}$ |
| 9                                        | M        | To shell elsewhere (See Note 5)                                                                | $\frac{3}{16}$                                       | $\frac{3}{16}$ | $\frac{3}{16}$ | $\frac{3}{16}$ | $\frac{3}{16}$ | $\frac{3}{16}$ | $\frac{3}{16}$ | $\frac{7}{32}$  | $\frac{7}{32}$ | $\frac{7}{32}$ | $\frac{1}{4}$   | $\frac{1}{4}$  | $\frac{1}{4}$   | $\frac{1}{4}$   | $\frac{1}{4}$   | $\frac{9}{32}$  | $\frac{9}{32}$  | $\frac{5}{16}$ |
| 10                                       | M        | To center vertical keel and side girders where floor is continuous                             | $\frac{3}{16}$                                       | $\frac{3}{16}$ | $\frac{3}{16}$ | $\frac{3}{16}$ | $\frac{3}{16}$ | $\frac{3}{16}$ | $\frac{3}{16}$ | $\frac{7}{32}$  | $\frac{7}{32}$ | $\frac{7}{32}$ | $\frac{1}{4}$   | $\frac{1}{4}$  | $\frac{1}{4}$   | $\frac{1}{4}$   | $\frac{1}{4}$   | $\frac{9}{32}$  | $\frac{9}{32}$  | $\frac{5}{16}$ |
| 11                                       | C        | To center vertical keel and side girders where longitudinal girder is continuous               | $\frac{3}{16}$                                       | $\frac{7}{32}$ | $\frac{1}{4}$  | $\frac{1}{4}$  | $\frac{9}{32}$ | $\frac{5}{16}$ | $\frac{5}{16}$ | $\frac{11}{32}$ | $\frac{3}{8}$  | $\frac{3}{8}$  | $\frac{13}{32}$ | $\frac{7}{16}$ | $\frac{7}{16}$  | $\frac{15}{32}$ | $\frac{1}{2}$   | $\frac{1}{2}$   | $\frac{17}{32}$ | $\frac{9}{16}$ |
| 12                                       | C        | To sloping margin plate, side shell, and bulge                                                 | $\frac{3}{16}$                                       | $\frac{7}{32}$ | $\frac{1}{4}$  | $\frac{1}{4}$  | $\frac{9}{32}$ | $\frac{5}{16}$ | $\frac{5}{16}$ | $\frac{11}{32}$ | $\frac{3}{8}$  | $\frac{3}{8}$  | $\frac{13}{32}$ | $\frac{7}{16}$ | $\frac{7}{16}$  | $\frac{15}{32}$ | $\frac{1}{2}$   | $\frac{1}{2}$   | $\frac{17}{32}$ | $\frac{9}{16}$ |
| 13                                       | A        | To vertical margin plate, or side girder under longitudinal or wing tank bulkhead (See Note 1) | $\frac{1}{4}$                                        | $\frac{1}{4}$  | $\frac{5}{16}$ | $\frac{5}{16}$ | $\frac{3}{8}$  | $\frac{3}{8}$  | $\frac{7}{16}$ | $\frac{7}{16}$  | $\frac{1}{2}$  | $\frac{1}{2}$  | $\frac{17}{32}$ | $\frac{9}{16}$ | $\frac{19}{32}$ | $\frac{5}{8}$   | $\frac{21}{32}$ | $\frac{11}{16}$ | $\frac{21}{32}$ | $\frac{3}{4}$  |
| 14                                       | C        | To inner bottom in machinery space                                                             | $\frac{3}{16}$                                       | $\frac{7}{32}$ | $\frac{1}{4}$  | $\frac{1}{4}$  | $\frac{9}{32}$ | $\frac{5}{16}$ | $\frac{5}{16}$ | $\frac{11}{32}$ | $\frac{3}{8}$  | $\frac{3}{8}$  | $\frac{13}{32}$ | $\frac{7}{16}$ | $\frac{7}{16}$  | $\frac{15}{32}$ | $\frac{1}{2}$   | $\frac{1}{2}$   | $\frac{17}{32}$ | $\frac{9}{16}$ |
| 15                                       | K        | To inner bottom at forward end fore end strengthening, Type B                                  | $\frac{3}{16}$                                       | $\frac{3}{16}$ | $\frac{3}{16}$ | $\frac{3}{16}$ | $\frac{3}{16}$ | $\frac{3}{16}$ | $\frac{3}{16}$ | $\frac{7}{32}$  | $\frac{7}{32}$ | $\frac{7}{32}$ | $\frac{1}{4}$   | $\frac{1}{4}$  | $\frac{1}{4}$   | $\frac{1}{4}$   | $\frac{9}{32}$  | $\frac{9}{32}$  | $\frac{9}{32}$  | $\frac{5}{16}$ |
| 16                                       | K        | To inner bottom elsewhere Type B (See Note 5)                                                  | $\frac{3}{16}$                                       | $\frac{3}{16}$ | $\frac{3}{16}$ | $\frac{3}{16}$ | $\frac{3}{16}$ | $\frac{3}{16}$ | $\frac{3}{16}$ | $\frac{7}{32}$  | $\frac{7}{32}$ | $\frac{7}{32}$ | $\frac{1}{4}$   | $\frac{1}{4}$  | $\frac{1}{4}$   | $\frac{1}{4}$   | $\frac{9}{32}$  | $\frac{9}{32}$  | $\frac{9}{32}$  | $\frac{5}{16}$ |
| 17                                       | C        | At watertight and oiltight periphery connections                                               | $\frac{3}{16}$                                       | $\frac{7}{32}$ | $\frac{1}{4}$  | $\frac{1}{4}$  | $\frac{9}{32}$ | $\frac{5}{16}$ | $\frac{5}{16}$ | $\frac{11}{32}$ | $\frac{3}{8}$  | $\frac{3}{8}$  | $\frac{13}{32}$ | $\frac{7}{16}$ | $\frac{7}{16}$  | $\frac{15}{32}$ | $\frac{1}{2}$   | $\frac{1}{2}$   | $\frac{17}{32}$ | $\frac{9}{16}$ |
| 18                                       | K        | Stiffeners, Type B                                                                             | $\frac{3}{16}$                                       | $\frac{3}{16}$ | $\frac{3}{16}$ | $\frac{3}{16}$ | $\frac{3}{16}$ | $\frac{3}{16}$ | $\frac{3}{16}$ | $\frac{7}{32}$  | $\frac{7}{32}$ | $\frac{7}{32}$ | $\frac{1}{4}$   | $\frac{1}{4}$  | $\frac{1}{4}$   | $\frac{1}{4}$   | $\frac{9}{32}$  | $\frac{9}{32}$  | $\frac{9}{32}$  | $\frac{5}{16}$ |
| Double Bottom Floors—Open Floor Brackets |          |                                                                                                |                                                      |                |                |                |                |                |                |                 |                |                |                 |                |                 |                 |                 |                 |                 |                |
| 19                                       | K        | To center vertical keel, Type A                                                                | $\frac{1}{16}$                                       | $\frac{3}{16}$ | $\frac{3}{16}$ | $\frac{3}{16}$ | $\frac{3}{16}$ | $\frac{3}{16}$ | $\frac{3}{16}$ | $\frac{7}{32}$  | $\frac{7}{32}$ | $\frac{7}{32}$ | $\frac{1}{4}$   | $\frac{1}{4}$  | $\frac{1}{4}$   | $\frac{1}{4}$   | $\frac{9}{32}$  | $\frac{9}{32}$  | $\frac{9}{32}$  | $\frac{5}{16}$ |
| 20                                       | C        | To margin plate, Type A                                                                        |                                                      | $\frac{7}{32}$ | $\frac{1}{4}$  | $\frac{1}{4}$  | $\frac{9}{32}$ | $\frac{5}{16}$ | $\frac{5}{16}$ | $\frac{11}{32}$ | $\frac{3}{8}$  | $\frac{3}{8}$  | $\frac{13}{32}$ | $\frac{7}{16}$ | $\frac{7}{16}$  | $\frac{15}{32}$ | $\frac{1}{2}$   | $\frac{1}{2}$   | $\frac{17}{32}$ | $\frac{9}{16}$ |

TABLE 30.1 (continued)

Inches

| ABS                               |          |                                                          | Leg size for lesser thickness of members joined, in. |      |      |      |      |      |       |       |       |       |       |       |       |       |       |       |       |       |
|-----------------------------------|----------|----------------------------------------------------------|------------------------------------------------------|------|------|------|------|------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| Line No.                          | Weld Gr. | Structural Items                                         | 0.32                                                 | 0.36 | 0.40 | 0.44 | 0.48 | 0.52 | 0.56  | 0.60  | 0.64  | 0.68  | 0.72  | 0.76  | 0.80  | 0.84  | 0.88  | 0.92  | 0.96  | 1.00  |
| <b>Double Bottom</b>              |          |                                                          |                                                      |      |      |      |      |      |       |       |       |       |       |       |       |       |       |       |       |       |
| <b>—Center Girder</b>             |          |                                                          |                                                      |      |      |      |      |      |       |       |       |       |       |       |       |       |       |       |       |       |
| 21                                | C        | To inner bottom in way of engine                         | 3/16                                                 | 7/32 | 1/4  | 1/4  | 9/32 | 5/16 | 5/16  | 11/32 | 3/8   | 3/8   | 13/32 | 7/16  | 7/16  | 15/32 | 1/2   | 1/2   | 17/32 | 9/16  |
| 22                                | F        | To inner bottom clear of engine, Type B                  | 3/16                                                 | 3/16 | 3/16 | 7/32 | 7/32 | 1/4  | 1/4   | 1/4   | 1/4   | 9/32  | 9/32  | 5/16  | 5/16  | 5/16  | 5/16  | 11/32 | 11/32 | 3/8   |
| 23                                | C        | To shell or bar keel                                     | 3/16                                                 | 7/32 | 1/4  | 1/4  | 9/32 | 5/16 | 5/16  | 11/32 | 3/8   | 3/8   | 13/32 | 7/16  | 7/16  | 15/32 | 1/2   | 1/2   | 17/32 | 9/16  |
| 24                                | C        | At watertight and oiltight periphery connections         | 3/16                                                 | 7/32 | 1/4  | 1/4  | 9/32 | 5/16 | 5/16  | 11/32 | 3/8   | 3/8   | 13/32 | 7/16  | 7/16  | 15/32 | 1/2   | 1/2   | 17/32 | 9/16  |
| 25                                | K        | Stiffeners, Type B                                       | 3/16                                                 | 3/16 | 3/16 | 3/16 | 3/16 | 3/16 | 3/16  | 7/32  | 7/32  | 7/32  | 1/4   | 1/4   | 1/4   | 1/4   | 9/32  | 9/32  | 9/32  | 5/16  |
| <b>Double Bottom Side Girders</b> |          |                                                          |                                                      |      |      |      |      |      |       |       |       |       |       |       |       |       |       |       |       |       |
| 26                                | F        | To shell—flat of bottom forward (fore end strengthening) | 3/16                                                 | 3/16 | 3/16 | 7/32 | 7/32 | 1/4  | 1/4   | 1/4   | 1/4   | 9/32  | 9/32  | 5/16  | 5/16  | 5/16  | 5/16  | 11/32 | 11/32 | 3/8   |
| 27                                | M        | To shell elsewhere                                       | 3/16                                                 | 3/16 | 3/16 | 3/16 | 3/16 | 3/16 | 3/16  | 3/16  | 7/32  | 7/32  | 1/4   | 1/4   | 1/4   | 1/4   | 1/4   | 9/32  | 9/32  | 5/16  |
| 28                                | F        | To inner bottom in way of engines, Type B                | 3/16                                                 | 3/16 | 3/16 | 7/32 | 7/32 | 1/4  | 1/4   | 1/4   | 1/4   | 9/32  | 9/32  | 5/16  | 5/16  | 5/16  | 5/16  | 11/32 | 11/32 | 3/8   |
| 29                                | M        | To inner bottom elsewhere, Type B                        | 3/16                                                 | 3/16 | 3/16 | 3/16 | 3/16 | 3/16 | 3/16  | 7/32  | 7/32  | 7/32  | 1/4   | 1/4   | 1/4   | 1/4   | 1/4   | 9/32  | 9/32  | 5/16  |
| 30                                | C        | To floors in way of transverse bulkheads                 | 3/16                                                 | 7/32 | 1/4  | 1/4  | 9/32 | 5/16 | 5/16  | 11/32 | 3/8   | 3/8   | 13/32 | 7/16  | 7/16  | 15/32 | 1/2   | 1/2   | 17/32 | 9/16  |
| 31                                | M        | To floors elsewhere, Type B                              | 3/16                                                 | 3/16 | 3/16 | 3/16 | 3/16 | 3/16 | 3/16  | 7/32  | 7/32  | 7/32  | 1/4   | 1/4   | 1/4   | 1/4   | 1/4   | 9/32  | 9/32  | 5/16  |
| 32                                | C        | At oiltight and watertight periphery connections         | 3/16                                                 | 7/32 | 1/4  | 1/4  | 9/32 | 5/16 | 5/16  | 11/32 | 3/8   | 3/8   | 13/32 | 7/16  | 7/16  | 15/32 | 1/2   | 1/2   | 17/32 | 9/16  |
| 33                                | M        | Stiffeners, Type B                                       | 3/16                                                 | 3/16 | 3/16 | 3/16 | 3/16 | 3/16 | 3/16  | 7/32  | 7/32  | 7/32  | 1/4   | 1/4   | 1/4   | 1/4   | 1/4   | 9/32  | 9/32  | 5/16  |
| <b>Inner Bottom</b>               |          |                                                          |                                                      |      |      |      |      |      |       |       |       |       |       |       |       |       |       |       |       |       |
| <b>—Plating</b>                   |          |                                                          |                                                      |      |      |      |      |      |       |       |       |       |       |       |       |       |       |       |       |       |
| 34                                | C        | To shell and to other boundaries                         | 3/16                                                 | 7/32 | 1/4  | 1/4  | 9/32 | 5/16 | 5/16  | 11/32 | 3/8   | 3/8   | 13/32 | 7/16  | 7/16  | 15/32 | 1/2   | 1/2   | 17/32 | 9/16  |
| <b>Frames</b>                     |          |                                                          |                                                      |      |      |      |      |      |       |       |       |       |       |       |       |       |       |       |       |       |
| <b>—Transverse</b>                |          |                                                          |                                                      |      |      |      |      |      |       |       |       |       |       |       |       |       |       |       |       |       |
| 35                                | F        | To shell—aft peaks of high power, fine form vessels      | 3/16                                                 | 3/16 | 3/16 | 7/32 | 7/32 | 1/4  | 1/4   | 1/4   | 1/4   | 9/32  | 9/32  | 5/16  | 5/16  | 5/16  | 5/16  | 11/32 | 11/32 | 3/8   |
| 36                                | M        | To shell for 0.125L forward                              | 3/16                                                 | 3/16 | 3/16 | 3/16 | 3/16 | 3/16 | 3/16  | 7/32  | 7/32  | 7/32  | 1/4   | 1/4   | 1/4   | 1/4   | 1/4   | 9/32  | 9/32  | 5/16  |
| 37                                | M        | To shell in peaks                                        | 3/16                                                 | 3/16 | 3/16 | 3/16 | 3/16 | 3/16 | 3/16  | 7/32  | 7/32  | 7/32  | 1/4   | 1/4   | 1/4   | 1/4   | 1/4   | 9/32  | 9/32  | 5/16  |
| 38                                | M        | To shell elsewhere                                       | 3/16                                                 | 3/16 | 3/16 | 3/16 | 3/16 | 3/16 | 3/16  | 7/32  | 7/32  | 7/32  | 1/4   | 1/4   | 1/4   | 1/4   | 1/4   | 9/32  | 9/32  | 5/16  |
| 39                                | B        | Unbracketed, to inner bottom (See Note 1), Type A        | 7/32                                                 | 1/4  | 1/4  | 9/32 | 5/16 | 5/16 | 11/32 | 3/8   | 3/8   | 13/32 | 7/16  | 7/16  | 15/32 | 1/2   | 1/2   | 17/32 | 9/16  | 9/16  |
| 40                                | D        | Frame brackets to frames, decks and inner bottom, Type A | 3/16                                                 | 3/16 | 7/32 | 1/4  | 1/4  | 9/32 | 5/16  | 5/16  | 11/32 | 3/8   | 3/8   | 13/32 | 7/16  | 7/16  | 15/32 | 1/2   | 1/2   | 17/32 |
| <b>Frames</b>                     |          |                                                          |                                                      |      |      |      |      |      |       |       |       |       |       |       |       |       |       |       |       |       |
| <b>—Transverse, Reverse</b>       |          |                                                          |                                                      |      |      |      |      |      |       |       |       |       |       |       |       |       |       |       |       |       |
| 41                                | L        | To inner bottom, Type B                                  | 3/16                                                 | 3/16 | 3/16 | 3/16 | 3/16 | 3/16 | 3/16  | 7/32  | 7/32  | 7/32  | 1/4   | 1/4   | 1/4   | 1/4   | 1/4   | 9/32  | 9/32  | 5/16  |
| 42                                | D        | To brackets, Type A                                      | 1/16                                                 | 1/16 | 7/32 | 1/4  | 1/4  | 9/32 | 5/16  | 5/16  | 11/32 | 3/8   | 3/8   | 13/32 | 7/16  | 7/16  | 15/32 | 1/2   | 1/2   | 17/32 |
| <b>Frames</b>                     |          |                                                          |                                                      |      |      |      |      |      |       |       |       |       |       |       |       |       |       |       |       |       |
| <b>—Longitudinal</b>              |          |                                                          |                                                      |      |      |      |      |      |       |       |       |       |       |       |       |       |       |       |       |       |
| 43                                | M        | To shell for 0.125L forward                              | 1/16                                                 | 1/16 | 1/16 | 1/16 | 1/16 | 1/16 | 1/16  | 7/32  | 7/32  | 7/32  | 1/4   | 1/4   | 1/4   | 1/4   | 1/4   | 9/32  | 9/32  | 5/16  |
| 44                                | M        | To shell in peaks                                        | 1/16                                                 | 1/16 | 1/16 | 1/16 | 1/16 | 1/16 | 1/16  | 7/32  | 7/32  | 7/32  | 1/4   | 1/4   | 1/4   | 1/4   | 1/4   | 9/32  | 9/32  | 5/16  |
| 45                                | I        | To shell on flat of bottom forward                       | 3/16                                                 | 3/16 | 3/16 | 3/16 | 3/16 | 3/16 | 3/16  | 7/32  | 7/32  | 7/32  | 1/4   | 1/4   | 1/4   | 1/4   | 1/4   | 9/32  | 9/32  | 5/16  |

TABLE 30.1 (continued)

Inches

| Line No.                                                   | ABS Weld Gr. | Structural Items                                                                 | Leg size for lesser thickness of members joined. in. |      |      |      |      |      |       |       |       |       |       |       |       |       |       |       |       |       |      |
|------------------------------------------------------------|--------------|----------------------------------------------------------------------------------|------------------------------------------------------|------|------|------|------|------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|------|
|                                                            |              |                                                                                  | 0.32                                                 | 0.36 | 0.40 | 0.44 | 0.48 | 0.52 | 0.56  | 0.60  | 0.64  | 0.68  | 0.72  | 0.76  | 0.80  | 0.84  | 0.88  | 0.92  | 0.96  | 1.00  |      |
| <b>Frames</b>                                              |              |                                                                                  |                                                      |      |      |      |      |      |       |       |       |       |       |       |       |       |       |       |       |       |      |
| <b>—Longitudinal (cont'd)</b>                              |              |                                                                                  |                                                      |      |      |      |      |      |       |       |       |       |       |       |       |       |       |       |       |       |      |
| 46                                                         | M            | To shell elsewhere                                                               | 3/16                                                 | 3/16 | 3/16 | 3/16 | 3/16 | 3/16 | 3/16  | 7/32  | 7/32  | 7/32  | 1/4   | 1/4   | 1/4   | 1/4   | 1/4   | 9/32  | 9/32  | 5/16  |      |
| 47                                                         | M            | To inner bottom, Type B                                                          | 3/16                                                 | 3/16 | 3/16 | 3/16 | 3/16 | 3/16 | 3/16  | 7/32  | 7/32  | 7/32  | 1/4   | 1/4   | 1/4   | 1/4   | 1/4   | 9/32  | 9/32  | 5/16  |      |
| 48                                                         | D            | Brackets to longitudinals, floors, etc., Type A                                  | 3/16                                                 | 3/16 | 7/32 | 1/4  | 1/4  | 9/32 | 5/16  | 5/16  | 11/32 | 3/8   | 3/8   | 13/32 | 7/16  | 7/16  | 15/32 | 1/2   | 1/2   | 17/32 |      |
| <b>Girders, Web Frames, Stringers and Deck Transverses</b> |              |                                                                                  |                                                      |      |      |      |      |      |       |       |       |       |       |       |       |       |       |       |       |       |      |
| 49                                                         | G            | To shell and to bulkheads and decks in way of tanks                              | 3/16                                                 | 3/16 | 3/16 | 3/16 | 3/16 | 3/16 | 7/32  | 7/32  | 7/32  | 1/4   | 1/4   | 1/4   | 1/4   | 1/4   | 13/32 | 13/32 | 13/32 | 7/16  | 7/16 |
| 50                                                         | H            | To decks and bulkheads clear of tanks                                            | 3/16                                                 | 3/16 | 3/16 | 3/16 | 3/16 | 3/16 | 7/32  | 7/32  | 7/32  | 7/32  | 1/4   | 1/4   | 1/4   | 1/4   | 1/4   | 13/32 | 13/32 | 7/16  | 7/16 |
| 51                                                         | A            | End attachments, unbracketed (See Note 1), Type A                                | 1/4                                                  | 1/4  | 5/16 | 5/16 | 3/8  | 3/8  | 7/16  | 7/16  | 1/2   | 1/2   | 17/32 | 9/16  | 5/8   | 5/8   | 21/32 | 11/16 | 21/32 | 3/4   |      |
| 52                                                         | B            | End attachments, bracketed, Type A                                               | 7/32                                                 | 1/4  | 1/4  | 9/32 | 5/16 | 5/16 | 11/32 | 3/8   | 3/8   | 13/32 | 7/16  | 7/16  | 15/32 | 1/2   | 1/2   | 17/32 | 9/16  | 9/16  |      |
| 53                                                         | M            | To face plate                                                                    | 3/16                                                 | 3/16 | 3/16 | 3/16 | 3/16 | 3/16 | 3/16  | 7/32  | 7/32  | 7/32  | 1/4   | 1/4   | 1/4   | 1/4   | 1/4   | 9/32  | 9/32  | 5/16  |      |
| <b>Bulkheads</b>                                           |              |                                                                                  |                                                      |      |      |      |      |      |       |       |       |       |       |       |       |       |       |       |       |       |      |
| <b>—Plating</b>                                            |              |                                                                                  |                                                      |      |      |      |      |      |       |       |       |       |       |       |       |       |       |       |       |       |      |
| 54                                                         | J            | Swash bulkheads—periphery                                                        | 3/16                                                 | 3/16 | 3/16 | 3/16 | 3/16 | 3/16 | 7/32  | 7/32  | 1/4   | 1/4   | 1/4   | 1/4   | 1/4   | 1/4   | 9/32  | 9/32  | 9/32  | 5/16  | 5/16 |
| 55                                                         | M            | Non-tight bulkhead—periphery                                                     | 3/16                                                 | 3/16 | 3/16 | 3/16 | 3/16 | 3/16 | 3/16  | 7/32  | 7/32  | 7/32  | 1/4   | 1/4   | 1/4   | 1/4   | 1/4   | 9/32  | 9/32  | 5/16  | 5/16 |
| 56                                                         | C            | Oiltight or watertight bulkheads—periphery                                       | 3/16                                                 | 7/32 | 1/4  | 1/4  | 9/32 | 5/16 | 5/16  | 11/32 | 3/8   | 3/8   | 13/32 | 7/16  | 7/16  | 15/32 | 1/2   | 1/2   | 1/2   | 9/16  | 9/16 |
| 57                                                         | C            | Exposed bulkhead on freeboard or superstructure deck—periphery                   | 3/16                                                 | 7/32 | 1/4  | 1/4  | 9/32 | 5/16 | 5/16  | 11/32 | 3/8   | 3/8   | 13/32 | 7/16  | 7/16  | 15/32 | 1/2   | 1/2   | 1/2   | 9/16  | 9/16 |
| <b>Bulkheads</b>                                           |              |                                                                                  |                                                      |      |      |      |      |      |       |       |       |       |       |       |       |       |       |       |       |       |      |
| <b>—Stiffeners</b>                                         |              |                                                                                  |                                                      |      |      |      |      |      |       |       |       |       |       |       |       |       |       |       |       |       |      |
| 58                                                         | M            | To deep tank bulkheads, Type B                                                   | 3/16                                                 | 3/16 | 3/16 | 3/16 | 3/16 | 3/16 | 3/16  | 7/32  | 7/32  | 7/32  | 1/4   | 1/4   | 1/4   | 1/4   | 1/4   | 9/32  | 9/32  | 5/16  | 5/16 |
| 59                                                         | M            | To watertight bulkheads and superstructure or deck house front bulkheads, Type B | 3/16                                                 | 3/16 | 3/16 | 3/16 | 3/16 | 3/16 | 3/16  | 7/32  | 7/32  | 7/32  | 1/4   | 1/4   | 1/4   | 1/4   | 1/4   | 9/32  | 9/32  | 5/16  | 5/16 |
| 60                                                         | M            | To non-tight structural bulkheads, Type B                                        | 3/16                                                 | 3/16 | 3/16 | 3/16 | 3/16 | 3/16 | 3/16  | 7/32  | 7/32  | 7/32  | 1/4   | 1/4   | 1/4   | 1/4   | 1/4   | 9/32  | 9/32  | 5/16  | 5/16 |
| 61                                                         | M            | To deck house sides and deck house and superstructure end bulkheads, Type B      | 3/16                                                 | 3/16 | 3/16 | 3/16 | 3/16 | 3/16 | 3/16  | 7/32  | 7/32  | 7/32  | 1/4   | 1/4   | 1/4   | 1/4   | 1/4   | 9/32  | 9/32  | 5/16  | 5/16 |
| 62                                                         | B            | End attachments—unbracketed (See Note 1), Type A                                 | 7/32                                                 | 1/4  | 1/4  | 9/32 | 5/16 | 5/16 | 11/32 | 3/8   | 3/8   | 13/32 | 7/16  | 7/16  | 15/32 | 1/2   | 1/2   | 17/32 | 9/16  | 9/16  |      |
| 63                                                         | D            | Brackets to stiffeners, bulkhead, deck, inner bottom, etc., Type A               | 3/16                                                 | 3/16 | 7/32 | 1/4  | 1/4  | 9/32 | 5/16  | 5/16  | 11/32 | 3/8   | 3/8   | 13/32 | 7/16  | 7/16  | 15/32 | 1/2   | 1/2   | 17/32 |      |
| <b>Decks</b>                                               |              |                                                                                  |                                                      |      |      |      |      |      |       |       |       |       |       |       |       |       |       |       |       |       |      |
| <b>—Plating</b>                                            |              |                                                                                  |                                                      |      |      |      |      |      |       |       |       |       |       |       |       |       |       |       |       |       |      |
| 64                                                         | C            | Strength deck—periphery                                                          | 3/16                                                 | 7/32 | 1/4  | 1/4  | 9/32 | 5/16 | 5/16  | 11/32 | 3/8   | 3/8   | 13/32 | 7/16  | 7/16  | 15/32 | 1/2   | 1/2   | 17/32 | 9/16  | 9/16 |
| 65                                                         | C            | Exposed decks, water-tight and oil-tight decks—periphery                         | 3/16                                                 | 7/32 | 1/4  | 1/4  | 9/32 | 5/16 | 5/16  | 11/32 | 3/8   | 3/8   | 13/32 | 7/16  | 7/16  | 15/32 | 1/2   | 1/2   | 17/32 | 9/16  | 9/16 |
| 66                                                         | E            | Platform decks non-tight flats—periphery                                         | 3/16                                                 | 7/32 | 7/32 | 1/4  | 1/4  | 1/4  | 9/32  | 9/32  | 5/16  | 5/16  | 5/16  | 11/32 | 11/32 | 3/8   | 3/8   | 13/32 | 13/32 | 7/16  | 7/16 |

TABLE 30.1 (continued)

Inches

| ABS                                              |          |                                                                                  | Leg size for lesser thickness of members joined, in. |      |      |      |      |      |       |       |       |       |       |       |       |       |       |       |       |       |
|--------------------------------------------------|----------|----------------------------------------------------------------------------------|------------------------------------------------------|------|------|------|------|------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| Line No.                                         | Weld Gr. | Structural Items                                                                 | 0.32                                                 | 0.36 | 0.40 | 0.44 | 0.48 | 0.52 | 0.56  | 0.60  | 0.64  | 0.68  | 0.72  | 0.76  | 0.80  | 0.84  | 0.88  | 0.92  | 0.96  | 1.00  |
| <b>Decks</b>                                     |          |                                                                                  |                                                      |      |      |      |      |      |       |       |       |       |       |       |       |       |       |       |       |       |
| <b>—Beams and Longitudinals</b>                  |          |                                                                                  |                                                      |      |      |      |      |      |       |       |       |       |       |       |       |       |       |       |       |       |
| 67                                               | M        | To decks, except slab longitudinals, Type B                                      | 3/16                                                 | 3/16 | 3/16 | 3/16 | 3/16 | 3/16 | 3/16  | 7/32  | 7/32  | 7/32  | 1/4   | 1/4   | 1/4   | 1/4   | 1/4   | 9/32  | 9/32  | 5/16  |
| 68                                               | M        | To decks slab longitudinals (See Note 2), Type B                                 | 3/16                                                 | 3/16 | 3/16 | 3/16 | 3/16 | 3/16 | 3/16  | 7/32  | 7/32  | 7/32  | 1/4   | 1/4   | 1/4   | 1/4   | 1/4   | 9/32  | 9/32  | 5/16  |
| 69                                               | B        | End attachments, beams, unbracketed (See Note 1), Type A                         | 7/32                                                 | 1/4  | 1/4  | 9/32 | 5/16 | 5/16 | 11/32 | 3/8   | 3/8   | 13/32 | 7/16  | 7/16  | 15/32 | 1/2   | 1/2   | 17/32 | 9/16  | 9/16  |
| 70                                               | D        | Beam knees and brackets to beams, longitudinals, deck, bulkhead, etc., Type A    | 3/16                                                 | 3/16 | 7/32 | 1/4  | 1/4  | 9/32 | 5/16  | 5/16  | 11/32 | 3/8   | 3/8   | 13/32 | 7/16  | 7/16  | 15/32 | 1/2   | 1/2   | 17/32 |
| <b>Decks</b>                                     |          |                                                                                  |                                                      |      |      |      |      |      |       |       |       |       |       |       |       |       |       |       |       |       |
| <b>—Hatch Coamings and Ventilators</b>           |          |                                                                                  |                                                      |      |      |      |      |      |       |       |       |       |       |       |       |       |       |       |       |       |
| 71                                               | C        | To deck                                                                          | 3/16                                                 | 7/32 | 1/4  | 1/4  | 9/32 | 5/16 | 5/16  | 11/32 | 3/8   | 3/8   | 13/32 | 7/16  | 7/16  | 15/32 | 1/2   | 1/2   | 17/32 | 9/16  |
| <b>Hatch Covers</b>                              |          |                                                                                  |                                                      |      |      |      |      |      |       |       |       |       |       |       |       |       |       |       |       |       |
| <b>—Plating</b>                                  |          |                                                                                  |                                                      |      |      |      |      |      |       |       |       |       |       |       |       |       |       |       |       |       |
| 72                                               | C        | Watertight or oiltight periphery                                                 | 3/16                                                 | 7/32 | 1/4  | 1/4  | 9/32 | 5/16 | 5/16  | 11/32 | 3/8   | 3/8   | 13/32 | 7/16  | 7/16  | 15/32 | 1/2   | 1/2   | 17/32 | 9/16  |
| <b>Hatch Covers</b>                              |          |                                                                                  |                                                      |      |      |      |      |      |       |       |       |       |       |       |       |       |       |       |       |       |
| <b>—Stiffeners and Webs</b>                      |          |                                                                                  |                                                      |      |      |      |      |      |       |       |       |       |       |       |       |       |       |       |       |       |
| 73                                               | M        | To plating and to face plate                                                     | 3/16                                                 | 3/16 | 3/16 | 3/16 | 3/16 | 3/16 | 3/16  | 7/32  | 7/32  | 7/32  | 1/4   | 1/4   | 1/4   | 1/4   | 1/4   | 9/32  | 9/32  | 5/16  |
| 74                                               | B        | End attachment—unbracketed to side plate or other stiffener (See Note 1), Type A | 7/32                                                 | 1/4  | 1/4  | 9/32 | 5/16 | 5/16 | 11/32 | 3/8   | 3/8   | 13/32 | 7/16  | 7/16  | 15/32 | 1/2   | 1/2   | 17/32 | 9/16  | 9/16  |
| 75                                               | D        | Bracket to stiffener or side plate, Type A                                       | 3/16                                                 | 3/16 | 7/32 | 1/4  | 1/4  | 9/32 | 5/16  | 5/16  | 11/32 | 3/8   | 3/8   | 13/32 | 7/16  | 7/16  | 15/32 | 1/2   | 1/2   | 17/32 |
| <b>Foundations</b>                               |          |                                                                                  |                                                      |      |      |      |      |      |       |       |       |       |       |       |       |       |       |       |       |       |
| <b>—Main Engine, Major Auxiliaries</b>           |          |                                                                                  |                                                      |      |      |      |      |      |       |       |       |       |       |       |       |       |       |       |       |       |
| 76                                               | B        | To top plate, shell or inner bottom                                              | 7/32                                                 | 1/4  | 1/4  | 9/32 | 5/16 | 5/16 | 11/32 | 3/8   | 3/8   | 13/32 | 7/16  | 7/16  | 15/32 | 1/2   | 1/2   | 17/32 | 9/16  | 9/16  |
| <b>Foundations</b>                               |          |                                                                                  |                                                      |      |      |      |      |      |       |       |       |       |       |       |       |       |       |       |       |       |
| <b>—Boilers and Other Auxiliaries</b>            |          |                                                                                  |                                                      |      |      |      |      |      |       |       |       |       |       |       |       |       |       |       |       |       |
| 77                                               | C        | To top plate, shell or inner bottom                                              | 3/16                                                 | 7/32 | 1/4  | 1/4  | 9/32 | 5/16 | 5/16  | 11/32 | 3/8   | 3/8   | 13/32 | 7/16  | 7/16  | 15/32 | 1/2   | 1/2   | 17/32 | 9/16  |
| <b>Rudders</b>                                   |          |                                                                                  |                                                      |      |      |      |      |      |       |       |       |       |       |       |       |       |       |       |       |       |
| <b>—Horizontal Diaphragms</b>                    |          |                                                                                  |                                                      |      |      |      |      |      |       |       |       |       |       |       |       |       |       |       |       |       |
| 78                                               | F        | To side plating                                                                  | 3/16                                                 | 3/16 | 3/16 | 7/32 | 7/32 | 1/4  | 1/4   | 1/4   | 1/4   | 9/32  | 9/32  | 5/16  | 5/16  | 5/16  | 5/16  | 11/32 | 11/32 | 1/8   |
| 79                                               | B        | To vertical diaphragm in way of rudder axis                                      | 7/32                                                 | 1/4  | 1/4  | 9/32 | 5/16 | 5/16 | 11/32 | 3/8   | 3/8   | 13/32 | 7/16  | 7/16  | 15/32 | 1/2   | 1/2   | 17/32 | 9/16  | 9/16  |
| <b>—Vertical Diaphragms</b>                      |          |                                                                                  |                                                      |      |      |      |      |      |       |       |       |       |       |       |       |       |       |       |       |       |
| 80                                               | F        | To side plating                                                                  | 3/16                                                 | 3/16 | 3/16 | 7/32 | 7/32 | 1/4  | 1/4   | 1/4   | 1/4   | 9/32  | 9/32  | 5/16  | 5/16  | 5/16  | 5/16  | 11/32 | 11/32 | 1/8   |
| 81                                               | F        | To horizontal diaphragms                                                         | 3/16                                                 | 3/16 | 3/16 | 7/32 | 7/32 | 1/4  | 1/4   | 1/4   | 1/4   | 9/32  | 9/32  | 5/16  | 5/16  | 5/16  | 5/16  | 11/32 | 11/32 | 1/8   |
| In way of rudder axis to top and bottom castings |          |                                                                                  |                                                      |      |      |      |      |      |       |       |       |       |       |       |       |       |       |       |       |       |
| <b>Full penetration welds</b>                    |          |                                                                                  |                                                      |      |      |      |      |      |       |       |       |       |       |       |       |       |       |       |       |       |
| <b>—Side Plating</b>                             |          |                                                                                  |                                                      |      |      |      |      |      |       |       |       |       |       |       |       |       |       |       |       |       |
| 82                                               | B        | Slot welds (See Note 4)                                                          | 7/32                                                 | 1/4  | 1/4  | 9/32 | 5/16 | 5/16 | 11/32 | 3/8   | 3/8   | 13/32 | 7/16  | 7/16  | 15/32 | 1/2   | 1/2   | 17/32 | 9/16  | 9/16  |

TABLE 30.1 (continued)

Inches

| Line No.                                                          | Weld Gr. | ABS<br>Structural Items                                          | Leg size for lesser thickness of members joined, in |               |                |                |                |                 |                 |                 |                 |                 |                 |                |                 |                 |                 |                 |                 |                 |
|-------------------------------------------------------------------|----------|------------------------------------------------------------------|-----------------------------------------------------|---------------|----------------|----------------|----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|
|                                                                   |          |                                                                  | 0.32                                                | 0.36          | 0.40           | 0.44           | 0.45           | 0.52            | 0.56            | 0.60            | 0.64            | 0.68            | 0.72            | 0.76           | 0.80            | 0.84            | 0.88            | 0.92            | 0.96            | 1.00            |
| Additional Welding Requirements for Vessels Classed "Oil Carrier" |          |                                                                  |                                                     |               |                |                |                |                 |                 |                 |                 |                 |                 |                |                 |                 |                 |                 |                 |                 |
| Girders and Webs                                                  |          |                                                                  |                                                     |               |                |                |                |                 |                 |                 |                 |                 |                 |                |                 |                 |                 |                 |                 |                 |
| 83                                                                | N        | Centerline girder to shell                                       | $\frac{1}{4}$                                       | $\frac{1}{4}$ | $\frac{9}{32}$ | $\frac{5}{16}$ | $\frac{5}{16}$ | $\frac{11}{32}$ | $\frac{3}{8}$   | $\frac{13}{32}$ | $\frac{7}{16}$  | $\frac{7}{16}$  | $\frac{1}{2}$   | $\frac{1}{2}$  | $\frac{17}{32}$ | $\frac{9}{16}$  | $\frac{9}{16}$  | $\frac{19}{32}$ | $\frac{5}{8}$   | $\frac{21}{32}$ |
| 84                                                                | P        | Centerline girder to shell, mid 0.5 span (See Note 3)            | $\frac{1}{4}$                                       | $\frac{1}{4}$ | $\frac{1}{4}$  | $\frac{1}{4}$  | $\frac{1}{4}$  | $\frac{9}{32}$  | $\frac{5}{16}$  | $\frac{11}{32}$ | $\frac{11}{32}$ | $\frac{3}{8}$   | $\frac{13}{32}$ | $\frac{7}{16}$ | $\frac{7}{16}$  | $\frac{7}{16}$  | $\frac{15}{32}$ | $\frac{1}{2}$   | $\frac{17}{32}$ | $\frac{17}{32}$ |
| 85                                                                | O        | Centerline girder to deck                                        | $\frac{1}{4}$                                       | $\frac{1}{4}$ | $\frac{1}{4}$  | $\frac{9}{32}$ | $\frac{5}{16}$ | $\frac{5}{16}$  | $\frac{11}{32}$ | $\frac{3}{8}$   | $\frac{3}{8}$   | $\frac{13}{32}$ | $\frac{7}{16}$  | $\frac{7}{16}$ | $\frac{15}{32}$ | $\frac{1}{2}$   | $\frac{1}{2}$   | $\frac{17}{32}$ | $\frac{9}{16}$  | $\frac{9}{16}$  |
| 86                                                                | Q        | Centerline girder to deck, mid 0.5 span (See Note 3)             | $\frac{1}{4}$                                       | $\frac{1}{4}$ | $\frac{1}{4}$  | $\frac{1}{4}$  | $\frac{1}{4}$  | $\frac{9}{32}$  | $\frac{5}{16}$  | $\frac{5}{16}$  | $\frac{5}{16}$  | $\frac{11}{32}$ | $\frac{3}{8}$   | $\frac{3}{8}$  | $\frac{13}{32}$ | $\frac{13}{32}$ | $\frac{13}{32}$ | $\frac{7}{16}$  | $\frac{15}{32}$ | $\frac{15}{32}$ |
| 87                                                                | O        | Transverse bulkhead, webs to bulkhead                            | $\frac{1}{4}$                                       | $\frac{1}{4}$ | $\frac{1}{4}$  | $\frac{9}{32}$ | $\frac{5}{16}$ | $\frac{5}{16}$  | $\frac{11}{32}$ | $\frac{3}{8}$   | $\frac{3}{8}$   | $\frac{13}{32}$ | $\frac{7}{16}$  | $\frac{7}{16}$ | $\frac{15}{32}$ | $\frac{1}{2}$   | $\frac{1}{2}$   | $\frac{17}{32}$ | $\frac{9}{16}$  | $\frac{9}{16}$  |
| 88                                                                | Q        | Transverse bulkhead, webs to bulkhead, mid 0.5 span (See Note 3) | $\frac{1}{4}$                                       | $\frac{1}{4}$ | $\frac{1}{4}$  | $\frac{1}{4}$  | $\frac{1}{4}$  | $\frac{9}{32}$  | $\frac{5}{16}$  | $\frac{5}{16}$  | $\frac{5}{16}$  | $\frac{11}{32}$ | $\frac{3}{8}$   | $\frac{3}{8}$  | $\frac{13}{32}$ | $\frac{7}{16}$  | $\frac{7}{16}$  | $\frac{15}{32}$ | $\frac{15}{32}$ | $\frac{15}{32}$ |
| 89                                                                | R        | To face bars                                                     | $\frac{1}{4}$                                       | $\frac{1}{4}$ | $\frac{1}{4}$  | $\frac{1}{4}$  | $\frac{1}{4}$  | $\frac{1}{4}$   | $\frac{9}{32}$  | $\frac{9}{32}$  | $\frac{5}{16}$  | $\frac{5}{16}$  | $\frac{5}{16}$  | $\frac{5}{16}$ | $\frac{5}{16}$  | $\frac{5}{16}$  | $\frac{11}{32}$ | $\frac{11}{32}$ | $\frac{3}{8}$   | $\frac{3}{8}$   |
| End Attachments                                                   |          |                                                                  |                                                     |               |                |                |                |                 |                 |                 |                 |                 |                 |                |                 |                 |                 |                 |                 |                 |
| 90                                                                | N        | Bracketed, Type A                                                | $\frac{1}{4}$                                       | $\frac{1}{4}$ | $\frac{9}{32}$ | $\frac{5}{16}$ | $\frac{5}{16}$ | $\frac{11}{32}$ | $\frac{3}{8}$   | $\frac{13}{32}$ | $\frac{7}{16}$  | $\frac{7}{16}$  | $\frac{1}{2}$   | $\frac{1}{2}$  | $\frac{17}{32}$ | $\frac{9}{16}$  | $\frac{9}{16}$  | $\frac{19}{32}$ | $\frac{5}{8}$   | $\frac{21}{32}$ |
| Transverses                                                       |          |                                                                  |                                                     |               |                |                |                |                 |                 |                 |                 |                 |                 |                |                 |                 |                 |                 |                 |                 |
| 91                                                                | N        | Bottom transverse to shell                                       | $\frac{1}{4}$                                       | $\frac{1}{4}$ | $\frac{9}{32}$ | $\frac{5}{16}$ | $\frac{5}{16}$ | $\frac{11}{32}$ | $\frac{3}{8}$   | $\frac{13}{32}$ | $\frac{7}{16}$  | $\frac{7}{16}$  | $\frac{1}{2}$   | $\frac{1}{2}$  | $\frac{17}{32}$ | $\frac{9}{16}$  | $\frac{9}{16}$  | $\frac{19}{32}$ | $\frac{5}{8}$   | $\frac{21}{32}$ |
| 92                                                                | P        | Bottom transverse to shell mid 0.5 span (See Note 3)             | $\frac{1}{4}$                                       | $\frac{1}{4}$ | $\frac{1}{4}$  | $\frac{1}{4}$  | $\frac{1}{4}$  | $\frac{9}{32}$  | $\frac{5}{16}$  | $\frac{11}{32}$ | $\frac{11}{32}$ | $\frac{3}{8}$   | $\frac{13}{32}$ | $\frac{7}{16}$ | $\frac{7}{16}$  | $\frac{7}{16}$  | $\frac{15}{32}$ | $\frac{1}{2}$   | $\frac{17}{32}$ | $\frac{17}{32}$ |
| 93                                                                | O        | Side transverse and longitudinal bulkhead web to plating         | $\frac{1}{4}$                                       | $\frac{1}{4}$ | $\frac{1}{4}$  | $\frac{9}{32}$ | $\frac{5}{16}$ | $\frac{5}{16}$  | $\frac{11}{32}$ | $\frac{3}{8}$   | $\frac{3}{8}$   | $\frac{13}{32}$ | $\frac{7}{16}$  | $\frac{7}{16}$ | $\frac{15}{32}$ | $\frac{1}{2}$   | $\frac{1}{2}$   | $\frac{17}{32}$ | $\frac{9}{16}$  | $\frac{9}{16}$  |
| 94                                                                | O        | Deck transverse to deck                                          | $\frac{1}{4}$                                       | $\frac{1}{4}$ | $\frac{1}{4}$  | $\frac{9}{32}$ | $\frac{5}{16}$ | $\frac{5}{16}$  | $\frac{11}{32}$ | $\frac{3}{8}$   | $\frac{3}{8}$   | $\frac{13}{32}$ | $\frac{7}{16}$  | $\frac{7}{16}$ | $\frac{15}{32}$ | $\frac{1}{2}$   | $\frac{1}{2}$   | $\frac{17}{32}$ | $\frac{9}{16}$  | $\frac{9}{16}$  |
| 95                                                                | Q        | Deck transverse to deck, mid 0.5 span (See Note 3)               | $\frac{1}{4}$                                       | $\frac{1}{4}$ | $\frac{1}{4}$  | $\frac{1}{4}$  | $\frac{1}{4}$  | $\frac{9}{32}$  | $\frac{5}{16}$  | $\frac{5}{16}$  | $\frac{5}{16}$  | $\frac{11}{32}$ | $\frac{3}{8}$   | $\frac{3}{8}$  | $\frac{13}{32}$ | $\frac{13}{32}$ | $\frac{13}{32}$ | $\frac{7}{16}$  | $\frac{15}{32}$ | $\frac{15}{32}$ |
| 96                                                                | R        | To face bars                                                     | $\frac{1}{4}$                                       | $\frac{1}{4}$ | $\frac{1}{4}$  | $\frac{1}{4}$  | $\frac{1}{4}$  | $\frac{1}{4}$   | $\frac{9}{32}$  | $\frac{9}{32}$  | $\frac{5}{16}$  | $\frac{5}{16}$  | $\frac{5}{16}$  | $\frac{5}{16}$ | $\frac{5}{16}$  | $\frac{5}{16}$  | $\frac{11}{32}$ | $\frac{11}{32}$ | $\frac{3}{8}$   | $\frac{3}{8}$   |

SEE GENERAL NOTES AT BEGINNING OF TABLE

**Notes**

- 1 The weld size is to be determined from the thickness of the member being attached.
- 2 Slab longitudinals—where the thickness on which the weld size is based is greater than 1.0 in. the leg size is not to be less than 0.3 times that thickness but need not be greater than  $\frac{5}{16}$  in. provided the lesser thickness of members being joined is no greater than 1.34 in. Where the lesser thickness of members being joined is greater than 1.34 in. special consideration will be given to the weld size.
- 3 This may be applied only where the shearing forces over the mid half span are no greater than one half the maximum shearing force on

the member and where the web is of the same depth clear of end brackets and of the same thickness throughout the length of the member. The weld size is to be determined from the thickness of member being attached.

- 4 The weld size is to be determined from the thickness of the side plating.
- 5 With longitudinal framing the weld size is to be increased to give an equivalent weld area to that obtained without cut-outs for longitudinals.

**TABLE 30.2**  
**Intermittent Fillet Weld Sizes and Spacing—Inches**

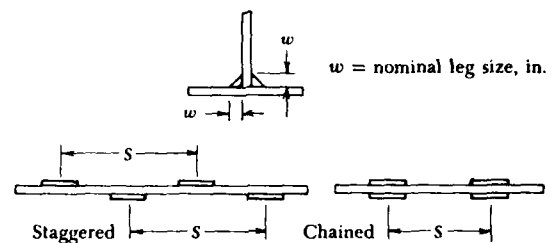
For weld requirements for thicknesses intermediate to those shown in the table use the nearest lower thickness shown in the table.

For vessels to be classed "Oil Carrier" the leg size in cargo tanks and in ballast tanks in the cargo area is not to be less than  $\frac{1}{4}$  in. except where approval has been given in accordance with 30.9.2a or b.

Where beams, stiffeners, frames, etc., are intermittently welded and pass through slotted girders, shelves or stringers, there is to be a pair of matched intermittent welds on each side of each such intersection and the beams, stiffeners and frames are to be efficiently attached to the girders, shelves and stringers.

Weld sizes other than given in the table may be used provided the spacing of welds is modified to give equivalent strength.

For double continuous weld sizes equivalent to the intermittent welds see Table 30.1



|                                |              | Leg size for lesser thickness of members joined, in.                             |                |               |               |               |                |                |                |                |                |                |                |
|--------------------------------|--------------|----------------------------------------------------------------------------------|----------------|---------------|---------------|---------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|
|                                |              | 0.20                                                                             | 0.24           | 0.28          | 0.32          | 0.36          | 0.40           | 0.44           | 0.48           | 0.52           | 0.56           | 0.60           | 0.64           |
| Nominal leg size of fillet $w$ |              | $\frac{3}{16}$                                                                   | $\frac{3}{16}$ | $\frac{1}{4}$ | $\frac{1}{4}$ | $\frac{1}{4}$ | $\frac{5}{16}$ | $\frac{5}{16}$ | $\frac{5}{16}$ | $\frac{5}{16}$ | $\frac{5}{16}$ | $\frac{5}{16}$ | $\frac{5}{16}$ |
| Length of fillet weld          |              | $2\frac{1}{8}$                                                                   | $2\frac{1}{2}$ | 3             | 3             | 3             | 3              | 3              | 3              | 3              | 3              | 3              | 3              |
| Line No.                       | ABS Weld Gr. | Structural Items                                                                 |                |               |               |               |                |                |                |                |                |                |                |
|                                |              | Spacing of Welds $S$ , in.                                                       |                |               |               |               |                |                |                |                |                |                |                |
| <b>Single-Bottom Floors</b>    |              |                                                                                  |                |               |               |               |                |                |                |                |                |                |                |
| 1                              |              | To center vertical keel                                                          |                |               |               |               |                |                |                |                |                |                |                |
|                                |              | See Table 30.1 for double continuous welds                                       |                |               |               |               |                |                |                |                |                |                |                |
| 2                              | F2           | To shell—aft peaks of high power, fine form vessels                              |                |               |               |               |                |                |                |                |                |                |                |
|                                |              | —                                                                                | —              | 6             | 6             | 5             | 6              | 6              | 6              | 6              | 6              | 5              | —              |
| 3                              | M2           | To shell—flat of bottom forward and in peaks                                     |                |               |               |               |                |                |                |                |                |                |                |
|                                |              | —                                                                                | —              | 10            | 10            | 9             | 10             | 10             | 10             | 9              | 9              | 8              | 8              |
| 4                              | M4           | To shell—elsewhere                                                               |                |               |               |               |                |                |                |                |                |                |                |
|                                |              | $\frac{1}{2}$                                                                    | $\frac{1}{2}$  | 12            | 12            | 11            | 12             | 12             | 11             | 10             | 10             | 10             | 10             |
| 5                              | M4           | To face plate                                                                    |                |               |               |               |                |                |                |                |                |                |                |
|                                |              | $\frac{1}{2}$                                                                    | $\frac{1}{2}$  | 12            | 12            | 11            | 12             | 12             | 11             | 10             | 10             | 10             | 10             |
| 6                              |              | To side shell, longitudinal bulkhead or other supporting member                  |                |               |               |               |                |                |                |                |                |                |                |
|                                |              | See Table 30.1 for double continuous welds                                       |                |               |               |               |                |                |                |                |                |                |                |
| <b>Double Bottom Floors</b>    |              |                                                                                  |                |               |               |               |                |                |                |                |                |                |                |
| <b>— Plate Floors</b>          |              |                                                                                  |                |               |               |               |                |                |                |                |                |                |                |
| 7                              | F2           | To shell—aft peaks of high power, fine form vessels                              |                |               |               |               |                |                |                |                |                |                |                |
|                                |              | —                                                                                | —              | 6             | 6             | 5             | 6              | 6              | 6              | 6              | 6              | 5              | —              |
| 8                              | M2           | To shell—flat of bottom forward and in peaks                                     |                |               |               |               |                |                |                |                |                |                |                |
|                                |              | —                                                                                | —              | 10            | 10            | 9             | 10             | 10             | 10             | 9              | 9              | 8              | 8              |
| 9                              | M4           | To shell elsewhere (See Note 5)                                                  |                |               |               |               |                |                |                |                |                |                |                |
|                                |              | $\frac{1}{2}$                                                                    | $\frac{1}{2}$  | 12            | 12            | 11            | 12             | 12             | 11             | 10             | 10             | 10             | 10             |
| 10                             | M1           | To center vertical keel and side girders where floor is continuous               |                |               |               |               |                |                |                |                |                |                |                |
|                                |              | $\frac{1}{2}$                                                                    | $\frac{1}{2}$  | 10            | 10            | 9             | 10             | 10             | 9              | 8              | 8              | 7              | 7              |
| 11                             |              | To center vertical keel and side girders where longitudinal girder is continuous |                |               |               |               |                |                |                |                |                |                |                |
|                                |              | See Table 30.1 for double continuous welds                                       |                |               |               |               |                |                |                |                |                |                |                |
| 12                             |              | To sloping margin plate, side shell, and bilge                                   |                |               |               |               |                |                |                |                |                |                |                |
|                                |              | See Table 30.1 for double continuous welds                                       |                |               |               |               |                |                |                |                |                |                |                |
| 13                             |              | To vertical margin plate or side girder under longitudinal or wing tank bulkhead |                |               |               |               |                |                |                |                |                |                |                |
|                                |              | See Table 30.1 for double continuous welds                                       |                |               |               |               |                |                |                |                |                |                |                |
| 14                             |              | To inner bottom in machinery space                                               |                |               |               |               |                |                |                |                |                |                |                |
|                                |              | See Table 30.1 for double continuous welds                                       |                |               |               |               |                |                |                |                |                |                |                |
| 15                             | K2           | To inner bottom at forward end (fore end strengthening)                          |                |               |               |               |                |                |                |                |                |                |                |
|                                |              | $\frac{1}{2}$                                                                    | $\frac{1}{2}$  | 11            | 11            | 10            | 11             | 11             | 10             | 9              | 9              | 8              | 8              |
| 16                             | K3           | To inner bottom—elsewhere (See Note 5)                                           |                |               |               |               |                |                |                |                |                |                |                |
|                                |              | $\frac{1}{2}$                                                                    | $\frac{1}{2}$  | 12            | 12            | 11            | 12             | 12             | 11             | 10             | 10             | 10             | 10             |
| 17                             |              | Oiltight and watertight periphery connections                                    |                |               |               |               |                |                |                |                |                |                |                |
|                                |              | See Table 30.1 for double continuous welds                                       |                |               |               |               |                |                |                |                |                |                |                |
| 18                             | K3           | Stiffeners                                                                       |                |               |               |               |                |                |                |                |                |                |                |
|                                |              | —                                                                                | 12             | 12            | 12            | 11            | 12             | 12             | 11             | 10             | 10             | 10             | 10             |
| <b>Double Bottom Floors</b>    |              |                                                                                  |                |               |               |               |                |                |                |                |                |                |                |
| <b>—Open Floor Brackets</b>    |              |                                                                                  |                |               |               |               |                |                |                |                |                |                |                |
| 19                             | K1           | To center vertical keel                                                          |                |               |               |               |                |                |                |                |                |                |                |
|                                |              | $\frac{1}{2}$                                                                    | $\frac{1}{2}$  | 10            | 10            | 9             | 10             | 10             | 9              | 8              | 8              | 7              | 7              |
| 20                             |              | To margin plate                                                                  |                |               |               |               |                |                |                |                |                |                |                |
|                                |              | See Table 30.1 for double continuous welds                                       |                |               |               |               |                |                |                |                |                |                |                |

TABLE 30.2 (continued)

Inches

| Line No.                   | ABS Weld Gr. |                                                          | Leg size for lesser thickness of members joined, in. |                |               |               |               |                |                |                |                |                |                |                |
|----------------------------|--------------|----------------------------------------------------------|------------------------------------------------------|----------------|---------------|---------------|---------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|
|                            |              |                                                          | 0.20                                                 | 0.24           | 0.28          | 0.32          | 0.36          | 0.40           | 0.44           | 0.48           | 0.52           | 0.56           | 0.60           | 0.64           |
|                            |              | Nominal leg size of fillet w                             | $\frac{3}{16}$                                       | $\frac{3}{16}$ | $\frac{1}{4}$ | $\frac{1}{4}$ | $\frac{1}{4}$ | $\frac{5}{16}$ | $\frac{5}{16}$ | $\frac{5}{16}$ | $\frac{5}{16}$ | $\frac{5}{16}$ | $\frac{5}{16}$ | $\frac{5}{16}$ |
|                            |              | Length of fillet weld                                    | $2\frac{1}{8}$                                       | $2\frac{1}{2}$ | 3             | 3             | 3             | 3              | 3              | 3              | 3              | 3              | 3              | 3              |
| Structural Items           |              |                                                          | Spacing of Welds S, in.                              |                |               |               |               |                |                |                |                |                |                |                |
| <b>Double Bottom</b>       |              |                                                          |                                                      |                |               |               |               |                |                |                |                |                |                |                |
| <b>—Center Girder</b>      |              |                                                          |                                                      |                |               |               |               |                |                |                |                |                |                |                |
| 21                         |              | To inner bottom in way of engine                         | See Table 30.1 for double continuous welds           |                |               |               |               |                |                |                |                |                |                |                |
| 22                         | F3           | To inner bottom—clear of engine—nontight                 | —                                                    | 6              | 6             | 6             | 5             | 6              | 6              | 5              | 5              | 5              | 5              | —              |
| 23                         |              | To shell or bar keel                                     | See Table 30.1 for double continuous welds           |                |               |               |               |                |                |                |                |                |                |                |
| 24                         |              | At oiltight and watertight periphery connections         | See Table 30.1 for double continuous welds           |                |               |               |               |                |                |                |                |                |                |                |
| 25                         | K3           | Stiffeners                                               | —                                                    | 12             | 12            | 12            | 11            | 12             | 12             | 11             | 10             | 10             | 10             | 10             |
| <b>Double Bottom</b>       |              |                                                          |                                                      |                |               |               |               |                |                |                |                |                |                |                |
| <b>—Side Girders</b>       |              |                                                          |                                                      |                |               |               |               |                |                |                |                |                |                |                |
| 26                         | F3           | To shell—flat of bottom forward (fore and strengthening) | —                                                    | 6              | 6             | 6             | 5             | 6              | 6              | 5              | 5              | 5              | 5              | —              |
| 27                         | M3           | To shell—elsewhere                                       | †11                                                  | †11            | 11            | 11            | 10            | 11             | 11             | 10             | 9              | 9              | 8              | 8              |
| 28                         | F3           | To inner bottom in way of engines                        | —                                                    | 6              | 6             | 6             | 5             | 6              | 6              | 5              | 5              | 5              | 5              | —              |
| 29                         | M3           | To inner bottom—elsewhere                                | †11                                                  | †11            | 11            | 11            | 10            | 11             | 11             | 10             | 9              | 9              | 8              | 8              |
| 30                         |              | To floors in way of transverse bulkheads                 | See Table 30.1 for double continuous welds           |                |               |               |               |                |                |                |                |                |                |                |
| 31                         | M3           | To floors—elsewhere                                      | †11                                                  | †11            | 11            | 11            | 10            | 11             | 11             | 10             | 9              | 9              | 8              | 8              |
| 32                         |              | At oiltight and watertight periphery connections         | See Table 30.1 for double continuous welds           |                |               |               |               |                |                |                |                |                |                |                |
| 33                         | M4           | Stiffeners                                               | 12                                                   | 12             | 12            | 12            | 11            | 12             | 12             | 11             | 10             | 10             | 10             | 10             |
| <b>Inner Bottom</b>        |              |                                                          |                                                      |                |               |               |               |                |                |                |                |                |                |                |
| <b>—Plating</b>            |              |                                                          |                                                      |                |               |               |               |                |                |                |                |                |                |                |
|                            |              | To shell and to other boundaries                         | See Table 30.1 for double continuous welds           |                |               |               |               |                |                |                |                |                |                |                |
| <b>Frames</b>              |              |                                                          |                                                      |                |               |               |               |                |                |                |                |                |                |                |
| <b>—Transverse</b>         |              |                                                          |                                                      |                |               |               |               |                |                |                |                |                |                |                |
| 35                         | F2           | To shell—aft peaks of high power, fine form vessels      | —                                                    | —              | 6             | 6             | 5             | 6              | 6              | 6              | 6              | 5              | 5              | —              |
| 36                         | M2           | To shell for 0.125L forward                              | —                                                    | —              | 10            | 10            | 9             | 10             | 10             | 10             | 9              | 9              | 8              | 8              |
| 37                         | M2           | To shell in peaks                                        | —                                                    | —              | 10            | 10            | 9             | 10             | 10             | 10             | 9              | 9              | 8              | 8              |
| 38                         | M4           | To shell—elsewhere (See Note 1)                          | †12                                                  | †12            | 12            | 12            | 11            | 12             | 12             | 11             | 10             | 10             | 10             | 10             |
| 39                         |              | Unbracketed to inner bottom                              | See Table 30.1 for double continuous welds           |                |               |               |               |                |                |                |                |                |                |                |
| 40                         |              | Frame brackets to frames, decks and inner bottom         | See Table 30.1 for double continuous welds           |                |               |               |               |                |                |                |                |                |                |                |
| <b>Frames</b>              |              |                                                          |                                                      |                |               |               |               |                |                |                |                |                |                |                |
| <b>—Transverse Reverse</b> |              |                                                          |                                                      |                |               |               |               |                |                |                |                |                |                |                |
| 41                         | L1           | To inner bottom                                          | †12                                                  | †12            | 12            | 12            | 11            | 12             | 12             | 11             | 10             | 10             | 10             | 10             |
| 42                         |              | To brackets                                              | See Table 30.1 for double continuous welds           |                |               |               |               |                |                |                |                |                |                |                |
| <b>Frames</b>              |              |                                                          |                                                      |                |               |               |               |                |                |                |                |                |                |                |
| <b>—Longitudinal</b>       |              |                                                          |                                                      |                |               |               |               |                |                |                |                |                |                |                |
| 43                         | M2           | To shell for 0.125L forward                              | —                                                    | —              | 10            | 10            | 9             | 10             | 10             | 10             | 9              | 9              | 8              | 8              |
| 44                         | M2           | To shell in peaks                                        | —                                                    | —              | 10            | 10            | 9             | 10             | 10             | 10             | 9              | 9              | 8              | 8              |
| 45                         |              | To shell on flat of bottom forward                       | See Table 30.1 for double continuous welds           |                |               |               |               |                |                |                |                |                |                |                |

TABLE 30.2 (continued)

Inches

|                                                     |              |                                                                                      | Leg size for lesser thickness of members joined, in.                   |                |               |               |               |                |                |                |                                           |                |                |                |
|-----------------------------------------------------|--------------|--------------------------------------------------------------------------------------|------------------------------------------------------------------------|----------------|---------------|---------------|---------------|----------------|----------------|----------------|-------------------------------------------|----------------|----------------|----------------|
|                                                     |              |                                                                                      | 0.20                                                                   | 0.24           | 0.28          | 0.32          | 0.36          | 0.40           | 0.44           | 0.48           | 0.52                                      | 0.56           | 0.60           | 0.64           |
| Line No.                                            | ABS Weld Gr. | Nominal leg size of fillet $w$                                                       | $\frac{3}{16}$                                                         | $\frac{3}{16}$ | $\frac{1}{4}$ | $\frac{1}{4}$ | $\frac{1}{4}$ | $\frac{5}{16}$ | $\frac{5}{16}$ | $\frac{5}{16}$ | $\frac{5}{16}$                            | $\frac{5}{16}$ | $\frac{5}{16}$ | $\frac{5}{16}$ |
|                                                     |              | Length of fillet weld                                                                | $2\frac{1}{8}$                                                         | $2\frac{1}{2}$ | 3             | 3             | 3             | 3              | 3              | 3              | 3                                         | 3              | 3              | 3              |
| Structural Items                                    |              |                                                                                      | Spacing of Welds $S$ , in.                                             |                |               |               |               |                |                |                |                                           |                |                |                |
| Frames                                              |              |                                                                                      |                                                                        |                |               |               |               |                |                |                |                                           |                |                |                |
| — Longitudinal (cont'd)                             |              |                                                                                      |                                                                        |                |               |               |               |                |                |                |                                           |                |                |                |
| 46                                                  | M4           | To shell elsewhere                                                                   | †12                                                                    | †12            | 12            | 12            | 11            | 12             | 12             | 11             | 10                                        | 10             | 10             | 10             |
| 47                                                  | M4           | To inner bottom                                                                      | †12                                                                    | 12             | 12            | 12            | 11            | 12             | 12             | 11             | 10                                        | 10             | 10             | 10             |
| 48                                                  |              | Brackets to longitudinals, floors, shell, etc.                                       | See Table 30.1 for double continuous welds                             |                |               |               |               |                |                |                |                                           |                |                |                |
| Girders, Web Frames, Stringers and Deck Transverses |              |                                                                                      |                                                                        |                |               |               |               |                |                |                |                                           |                |                |                |
| 49                                                  | G1           | To shell and to bulkheads and decks in way of tanks                                  | —                                                                      | 8              | 9             | 9             | 8             | 9              | 9              | 8              | 7                                         | 7              | 6              | 6              |
| 50                                                  | H1           | To decks and bulkheads clear of tanks                                                | —                                                                      | 9              | 10            | 10            | 9             | 10             | 10             | 9              | 8                                         | 8              | 7              | 7              |
| 51                                                  |              | End connections                                                                      | See Table 30.1 for double continuous welds                             |                |               |               |               |                |                |                |                                           |                |                |                |
| 53A                                                 | M4           | To face plate area $\leq 10$ in. <sup>2</sup>                                        | †10                                                                    | †10            | 12            | 12            | 11            | 12             | 12             | 11             | 10                                        | 10             | 10             | 10             |
| 53B                                                 | M1           | To face plate area $> 10$ in. <sup>2</sup>                                           | —                                                                      | —              | 10            | 10            | 9             | 10             | 10             | 9              | 8                                         | 8              | 7              | 7              |
| Bulkheads                                           |              |                                                                                      |                                                                        |                |               |               |               |                |                |                |                                           |                |                |                |
| — Plating                                           |              |                                                                                      |                                                                        |                |               |               |               |                |                |                |                                           |                |                |                |
| 54                                                  | J1           | Swash bulkhead—periphery                                                             | —                                                                      | 8              | 9             | 9             | 8             | 9              | 9              | 8              | 7                                         | 7              | 6              | 6              |
| 55                                                  | M1           | Non-tight structural bulkhead—periphery                                              | —                                                                      | 9              | 10            | 10            | 9             | 10             | 10             | 9              | 8                                         | 8              | 7              | 7              |
| 56A                                                 |              | Tank bulkheads—periphery                                                             | See Table 30.1 for double continuous welds                             |                |               |               |               |                |                |                |                                           |                |                |                |
| 56B                                                 | C1           | Watertight bulkheads—periphery                                                       |                                                                        |                |               |               |               |                |                |                |                                           |                |                |                |
|                                                     |              | One side                                                                             | Continuous weld of leg size of plate thickness less $\frac{1}{16}$ in. |                |               |               |               |                |                |                | See Table 30.1 for double continuous weld |                |                |                |
|                                                     |              | Other side                                                                           | —                                                                      | 12             | 12            | 12            | 11            | 12             | 12             | 11             | See Table 30.1 for double continuous weld |                |                |                |
| 57                                                  |              | Exposed bulkheads on freeboard and superstructure decks—periphery                    | See Table 30.1 for double continuous welds                             |                |               |               |               |                |                |                |                                           |                |                |                |
| Bulkheads                                           |              |                                                                                      |                                                                        |                |               |               |               |                |                |                |                                           |                |                |                |
| — Stiffeners                                        |              |                                                                                      |                                                                        |                |               |               |               |                |                |                |                                           |                |                |                |
| 58                                                  | M4           | To deep tank bulkheads (See Note 1)                                                  | —                                                                      | †12            | 12            | 12            | 11            | 12             | 12             | 11             | 10                                        | 10             | 10             | 10             |
| 59                                                  | M4           | To watertight bulkheads and superstructure or deckhouse front—bulkheads (See Note 1) | —                                                                      | †12            | 12            | 12            | 11            | 12             | 12             | 11             | 10                                        | 10             | 10             | 10             |
| 60                                                  | M5           | To non-tight structural bulkhead (See Note 2)                                        | †12                                                                    | †12            | 12            | 12            | 12            | 12             | 12             | 12             | 12                                        | 12             | 10             | 10             |
| 61                                                  | M5           | To deckhouse side and superstructure end bulkheads (See Note 2)                      | †12                                                                    | †12            | 12            | 12            | 12            | 12             | 12             | 12             | 12                                        | 12             | 10             | 10             |
| 62                                                  |              | End attachments                                                                      | See Table 30.1 for double continuous welds                             |                |               |               |               |                |                |                |                                           |                |                |                |
| 63                                                  |              | Brackets                                                                             | See Table 30.1 for double continuous welds                             |                |               |               |               |                |                |                |                                           |                |                |                |
| Decks                                               |              |                                                                                      |                                                                        |                |               |               |               |                |                |                |                                           |                |                |                |
| — Plating                                           |              |                                                                                      |                                                                        |                |               |               |               |                |                |                |                                           |                |                |                |
| 64                                                  |              | Strength deck—periphery                                                              | See Table 30.1 for double continuous welds                             |                |               |               |               |                |                |                |                                           |                |                |                |
| 65                                                  |              | Exposed deck, watertight and oiltight flat—periphery                                 | See Table 30.1 for double continuous welds                             |                |               |               |               |                |                |                |                                           |                |                |                |
| 66                                                  |              | Platform decks, non-tight flats—periphery                                            | See Table 30.1 for double continuous welds                             |                |               |               |               |                |                |                |                                           |                |                |                |

TABLE 30.2 (continued)

Inches

|                                         |              | Leg size for lesser thickness of members joined, in. |                                                                           |               |               |               |                |                         |                |                |                |                |                |
|-----------------------------------------|--------------|------------------------------------------------------|---------------------------------------------------------------------------|---------------|---------------|---------------|----------------|-------------------------|----------------|----------------|----------------|----------------|----------------|
|                                         |              | 0.20                                                 | 0.24                                                                      | 0.28          | 0.32          | 0.36          | 0.40           | 0.44                    | 0.48           | 0.52           | 0.56           | 0.60           | 0.64           |
| Nominal leg size of fillet w            |              | $\frac{3}{16}$                                       | $\frac{3}{16}$                                                            | $\frac{1}{4}$ | $\frac{1}{4}$ | $\frac{1}{4}$ | $\frac{5}{16}$ | $\frac{5}{16}$          | $\frac{5}{16}$ | $\frac{5}{16}$ | $\frac{5}{16}$ | $\frac{3}{16}$ | $\frac{5}{16}$ |
| Length of fillet weld                   |              | $2\frac{1}{8}$                                       | $2\frac{1}{2}$                                                            | 3             | 3             | 3             | 3              | 3                       | 3              | 3              | 3              | 3              | 3              |
| Line No.                                | ABS Weld Gr. | Structural Items                                     |                                                                           |               |               |               |                | Spacing of Welds S, in. |                |                |                |                |                |
| <b>Decks</b>                            |              |                                                      |                                                                           |               |               |               |                |                         |                |                |                |                |                |
| <b>—Beams and Longitudinals</b>         |              |                                                      |                                                                           |               |               |               |                |                         |                |                |                |                |                |
| 67                                      | M4           | T decks, except slab longitudinals                   | †12                                                                       | †12           | 12            | 12            | 11             | 12                      | 12             | 11             | 10             | 10             | 10             |
| 68                                      |              | To decks, slab longitudinals                         | See Table 30.1 for double continuous welds                                |               |               |               |                |                         |                |                |                |                |                |
| 69                                      |              | End attachments                                      | See Table 30.1 for double continuous welds                                |               |               |               |                |                         |                |                |                |                |                |
| 70                                      |              | Beam knees and brackets                              | See Table 30.1 for double continuous welds                                |               |               |               |                |                         |                |                |                |                |                |
| <b>Decks</b>                            |              |                                                      |                                                                           |               |               |               |                |                         |                |                |                |                |                |
| <b>—Hatch Coamings and Ventilators</b>  |              |                                                      |                                                                           |               |               |               |                |                         |                |                |                |                |                |
| 71                                      |              | To deck                                              | See Table 30.1 for double continuous welds                                |               |               |               |                |                         |                |                |                |                |                |
| <b>Hatch Covers</b>                     |              |                                                      |                                                                           |               |               |               |                |                         |                |                |                |                |                |
| <b>—Plating</b>                         |              |                                                      |                                                                           |               |               |               |                |                         |                |                |                |                |                |
| 72A                                     |              | Oiltight—periphery                                   | See Table 30.1 for double continuous welds                                |               |               |               |                |                         |                |                |                |                |                |
| 72B                                     | C2           | Weathertight—periphery                               | Continuous weld of same leg size as required for inside intermittent weld |               |               |               |                |                         |                |                |                |                |                |
|                                         |              | Outside                                              |                                                                           |               |               |               |                |                         |                |                |                |                |                |
|                                         |              | Inside                                               | —                                                                         | 12            | 12            | 12            | 11             | 12                      | 12             | 11             | 10             | 10             | 10             |
| <b>Hatch Covers</b>                     |              |                                                      |                                                                           |               |               |               |                |                         |                |                |                |                |                |
| <b>—Stiffeners and Webs</b>             |              |                                                      |                                                                           |               |               |               |                |                         |                |                |                |                |                |
| 73                                      | M4           | To plating and to face plate (see Note 4)            | †12                                                                       | †12           | 12            | 12            | 11             | 12                      | 12             | 11             | 10             | 10             | 10             |
| 74                                      |              | End attachment                                       | See Table 30.1 for double continuous welds                                |               |               |               |                |                         |                |                |                |                |                |
| 75                                      |              | Brackets                                             | See Table 30.1 for double continuous welds                                |               |               |               |                |                         |                |                |                |                |                |
| <b>Foundations</b>                      |              |                                                      |                                                                           |               |               |               |                |                         |                |                |                |                |                |
| <b>—Main Engine, Major Auxilliaries</b> |              |                                                      |                                                                           |               |               |               |                |                         |                |                |                |                |                |
| 76                                      |              | To top plate shell or inner bottom                   | See Table 30.1 for double continuous welds                                |               |               |               |                |                         |                |                |                |                |                |
| <b>Rudders</b>                          |              |                                                      |                                                                           |               |               |               |                |                         |                |                |                |                |                |
| <b>—Horizontal Diaphragms</b>           |              |                                                      |                                                                           |               |               |               |                |                         |                |                |                |                |                |
| 78                                      | F1           | To side plating                                      | 4                                                                         | 5             | 6             | 6             | 5              | 6                       | 6              | 6              | 6              | †6             | †6             |
| 79                                      |              | To vertical diaphragm in way of rudder axis          | See Table 30.1 for double continuous welds                                |               |               |               |                |                         |                |                |                |                |                |
| <b>—Vertical Diaphragms</b>             |              |                                                      |                                                                           |               |               |               |                |                         |                |                |                |                |                |
| 80                                      | F1           | To side plating                                      | 4                                                                         | 5             | 6             | 6             | 5              | 6                       | 6              | 6              | 6              | †6             | †6             |
| 81                                      | F1           | To horizontal diaphragms                             | 4                                                                         | 5             | 6             | 6             | 5              | 6                       | 6              | 6              | 6              | †6             | †6             |
|                                         |              | In way of rudder axis to top and bottom castings     | Full penetration welds                                                    |               |               |               |                |                         |                |                |                |                |                |
| <b>—Side Plating</b>                    |              |                                                      |                                                                           |               |               |               |                |                         |                |                |                |                |                |
| 82                                      |              | Slot welds                                           | See Table 30.1 for double continuous welds                                |               |               |               |                |                         |                |                |                |                |                |

TABLE 30.2 (continued)

Inches

|                                                                                 |      | Leg size for lesser thickness of members joined, in. |                |               |               |               |                |                |                |                |                |                |                |
|---------------------------------------------------------------------------------|------|------------------------------------------------------|----------------|---------------|---------------|---------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|
|                                                                                 |      | 0.20                                                 | 0.24           | 0.28          | 0.32          | 0.36          | 0.40           | 0.44           | 0.48           | 0.52           | 0.56           | 0.60           | 0.64           |
| Nominal leg size of fillet <i>w</i>                                             |      | $\frac{3}{16}$                                       | $\frac{3}{16}$ | $\frac{1}{4}$ | $\frac{1}{4}$ | $\frac{1}{4}$ | $\frac{5}{16}$ | $\frac{5}{16}$ | $\frac{5}{16}$ | $\frac{5}{16}$ | $\frac{5}{16}$ | $\frac{5}{16}$ | $\frac{5}{16}$ |
| Length of fillet weld                                                           |      | $2\frac{1}{8}$                                       | $2\frac{1}{2}$ | 3             | 3             | 3             | 3              | 3              | 3              | 3              | 3              | 3              | 3              |
| Line                                                                            | ABS  | Structural Items                                     |                |               |               |               |                |                |                |                |                |                |                |
| No.                                                                             | Weld | Spacing of Welds <i>S</i> , in.                      |                |               |               |               |                |                |                |                |                |                |                |
|                                                                                 | Gr.  |                                                      |                |               |               |               |                |                |                |                |                |                |                |
| Additional Welding Requirements for Vessels Classed "Oil Carriers" (See Note 3) |      |                                                      |                |               |               |               |                |                |                |                |                |                |                |
| Girders and Webs                                                                |      |                                                      |                |               |               |               |                |                |                |                |                |                |                |
| 89                                                                              | R1   | To face bars                                         | —              | —             | —             | 6             | 6              | 6              | 6              | 5              | 5              | 5              | —              |
| Transverses                                                                     |      |                                                      |                |               |               |               |                |                |                |                |                |                |                |
| 96                                                                              | R1   | To face bars                                         | —              | —             | —             | 6             | 6              | 6              | 6              | 5              | 5              | 5              | —              |

SEE GENERAL NOTES AT BEGINNING OF TABLE

## Notes

- 1 Unbracketed stiffeners of shell, watertight and oiltight bulkheads and house fronts are to have double continuous welds for one-tenth of their length at each end.
- 2 Unbracketed stiffeners of nontight structural bulkheads, deckhouse sides and after ends are to have a pair of matched intermittent welds at each end.
- 3 The welding of deck and shell longitudinals may be as required under decks or frames. In addition the shell longitudinals are to have double continuous welds at the ends and in way of transverses equal in length to the depth of the longitudinal. The deck longitudinals are also to have double continuous welds at the ends equal in length to the depth of the longitudinal, however at transverses a matched pair of welds will be acceptable.

4 Unbracketed stiffeners and webs of hatch covers are to be welded continuously to the plating and to the face plate for a length at ends equal to the end depth of the member.

5 With longitudinal framing the welds are to be arranged to give an equivalent weld area to that obtained without cut-outs for longitudinals.

† Fillet welds are to be staggered.

‡ Nominal size of fillet  $w$  is to be increased  $\frac{1}{16}$  in.

APPENDIX B

GROUPING OF ABS FILLET WELDS

APPENDIX B  
GROUPING OF ABS FILLET WELDS

| ABS<br>Weld<br>Grp. | Ln.<br>No.                                                                                  | Structural Items                                                                                        | Leg Size for Lesser Thickness of Members Joined, In. |      |      |      |      |       |       |      |       |       |       |       |                |      |       |       |       |      |
|---------------------|---------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------|------------------------------------------------------|------|------|------|------|-------|-------|------|-------|-------|-------|-------|----------------|------|-------|-------|-------|------|
|                     |                                                                                             |                                                                                                         | 0.32                                                 | 0.36 | 0.40 | 0.44 | 0.48 | 0.52  | 0.56  | 0.60 | 0.64  | 0.68  | 0.72  | 0.76  | 0.80           | 0.84 | 0.88  | 0.92  | 0.96  | 1.00 |
| A                   | 13                                                                                          | To vertical margin plate, or<br>side girder under longitudinal<br>or wing tank bulkhead (See<br>Note 1) | 1/4                                                  | 1/4  | 5/16 | 5/16 | 3/8  | 3/8   | 7/16  | 7/16 | 1/2   | 1/2   | 17/32 | 9/16  | 19/32          | 5/8  | 21/32 | 11/16 | 23/32 | 3/4  |
|                     | 51                                                                                          | End attachments, unbracketed<br>(See Note 1), Type A                                                    | 1/4                                                  | 1/4  | 5/16 | 5/16 | 3/8  | 3/8   | 7/16  | 7/16 | 1/2   | 1/2   | 17/32 | 9/16  | <del>5/8</del> | 5/8  | 21/32 | 11/16 | 23/32 | 3/4  |
| B                   | 39                                                                                          | Unbracketed to inner bottom<br>(See Note 1), Type A                                                     | 7/32                                                 | 1/4  | 1/4  | 9/32 | 5/16 | 5/16  | 11/32 | 3/8  | 3/8   | 13/32 | 7/16  | 7/16  | 15/32          | 1/2  | 1/2   | 17/32 | 9/16  | 9/16 |
|                     | 52                                                                                          | End attachments, bracketed,<br>Type A                                                                   | 7/32                                                 | 1/4  | 1/4  | 9/32 | 5/16 | 5/16  | 11/32 | 3/8  | 3/8   | 13/32 | 7/16  | 7/16  | 15/32          | 1/2  | 1/2   | 17/32 | 9/16  | 9/16 |
| 62                  | End attachments, unbracketed,<br>(See Note 1), Type A                                       | 7/32                                                                                                    | 1/4                                                  | 1/4  | 9/32 | 5/16 | 5/16 | 11/32 | 3/8   | 3/8  | 13/32 | 7/16  | 7/16  | 15/32 | 1/2            | 1/2  | 17/32 | 9/16  | 9/16  |      |
| 69                  | End attachments, beams<br>unbracketed (See Note 1),<br>Type A                               | 7/32                                                                                                    | 1/4                                                  | 1/4  | 9/32 | 5/16 | 5/16 | 11/32 | 3/8   | 3/8  | 13/32 | 7/16  | 7/16  | 15/32 | 1/2            | 1/2  | 17/32 | 9/16  | 9/16  |      |
| 74                  | End attachment - unbracketed<br>to side plate or other<br>stiffener (See Note 1),<br>Type A | 7/32                                                                                                    | 1/4                                                  | 1/4  | 9/32 | 5/16 | 5/16 | 11/32 | 3/8   | 3/8  | 13/32 | 7/16  | 7/16  | 15/32 | 1/2            | 1/2  | 17/32 | 9/16  | 9/16  |      |
| 76                  | To top plate, shell or inner<br>bottom                                                      | 7/32                                                                                                    | 1/4                                                  | 1/4  | 9/32 | 5/16 | 5/16 | 11/32 | 3/8   | 3/8  | 13/32 | 7/16  | 7/16  | 15/32 | 1/2            | 1/2  | 17/32 | 9/16  | 9/16  |      |
| 79                  | To vertical diaphragm in<br>way of rudder axis                                              | 7/32                                                                                                    | 1/4                                                  | 1/4  | 9/32 | 5/16 | 5/16 | 11/32 | 3/8   | 3/8  | 13/32 | 7/16  | 7/16  | 15/32 | 1/2            | 1/2  | 17/32 | 9/16  | 9/16  |      |
| 82                  | Slot welds (See Note 4)                                                                     | 7/32                                                                                                    | 1/4                                                  | 1/4  | 9/32 | 5/16 | 5/16 | 11/32 | 3/8   | 3/8  | 13/32 | 7/16  | 7/16  | 15/32 | 1/2            | 1/2  | 17/32 | 9/16  | 9/16  |      |

ABS

| Weld<br>Grp. | Ln.<br>No. | Structural Items                                                                 | Leg Size for Lesser Thickness of Members Joined, In. |      |      |      |      |      |      |       |      |      |       |      |      |       |      |      |       |      |
|--------------|------------|----------------------------------------------------------------------------------|------------------------------------------------------|------|------|------|------|------|------|-------|------|------|-------|------|------|-------|------|------|-------|------|
|              |            |                                                                                  | 0.32                                                 | 0.36 | 0.40 | 0.44 | 0.48 | 0.52 | 0.56 | 0.60  | 0.64 | 0.68 | 0.72  | 0.76 | 0.80 | 0.84  | 0.88 | 0.92 | 0.96  | 1.00 |
| C            | 1          | To center vertical keel                                                          | 3/16                                                 | 7/32 | 1/4  | 1/4  | 9/32 | 5/16 | 5/16 | 11/32 | 3/8  | 3/8  | 13/32 | 7/16 | 7/16 | 15/32 | 1/2  | 1/2  | 17/32 | 9/16 |
| 6            |            | To side shell, longitudinal bulkhead or other supporting member                  | 3/16                                                 | 7/32 | 1/4  | 1/4  | 9/32 | 5/16 | 5/16 | 11/32 | 3/8  | 3/8  | 13/32 | 7/16 | 7/16 | 15/32 | 1/2  | 1/2  | 17/32 | 9/16 |
| 11           |            | To center vertical keel and side girders where longitudinal girder is continuous | 3/16                                                 | 7/32 | 1/4  | 1/4  | 9/32 | 5/16 | 5/16 | 11/32 | 3/8  | 3/8  | 13/32 | 7/16 | 7/16 | 15/32 | 1/2  | 1/2  | 17/32 | 9/16 |
| 12           |            | To sloping margin plate, side shell, and bilge                                   | 3/16                                                 | 7/32 | 1/4  | 1/4  | 9/32 | 5/16 | 5/16 | 11/32 | 3/8  | 3/8  | 13/32 | 7/16 | 7/16 | 15/32 | 1/2  | 1/2  | 17/32 | 9/16 |
| 14           |            | To inner bottom in machinery space                                               | 3/16                                                 | 7/32 | 1/4  | 1/4  | 9/32 | 5/16 | 5/16 | 11/32 | 3/8  | 3/8  | 13/32 | 7/16 | 7/16 | 15/32 | 1/2  | 1/2  | 17/32 | 9/16 |
| 17           |            | At watertight and oiltight periphery connections                                 | 3/16                                                 | 7/32 | 1/4  | 1/4  | 9/32 | 5/16 | 5/16 | 11/32 | 3/8  | 3/8  | 13/32 | 7/16 | 7/16 | 15/32 | 1/2  | 1/2  | 17/32 | 9/16 |
| 20           |            | To margin plate, Type A                                                          | 7/32                                                 | 1/4  | 1/4  | 1/4  | 9/32 | 5/16 | 5/16 | 11/32 | 3/8  | 3/8  | 13/32 | 7/16 | 7/16 | 15/32 | 1/2  | 1/2  | 17/32 | 9/16 |
| 21           |            | To inner bottom in way of engine                                                 | 3/16                                                 | 7/32 | 1/4  | 1/4  | 9/32 | 5/16 | 5/16 | 11/32 | 3/8  | 3/8  | 13/32 | 7/16 | 7/16 | 15/32 | 1/2  | 1/2  | 17/32 | 9/16 |
| 23           |            | To shell or bar keel                                                             | 3/16                                                 | 7/32 | 1/4  | 1/4  | 9/32 | 5/16 | 5/16 | 11/32 | 3/8  | 3/8  | 13/32 | 7/16 | 7/16 | 15/32 | 1/2  | 1/2  | 17/32 | 9/16 |
| 24           |            | At watertight and oiltight periphery connections                                 | 3/16                                                 | 7/32 | 1/4  | 1/4  | 9/32 | 5/16 | 5/16 | 11/32 | 3/8  | 3/8  | 13/32 | 7/16 | 7/16 | 15/32 | 1/2  | 1/2  | 17/32 | 9/16 |
| 30           |            | To floors in way of transverse bulkheads                                         | 3/16                                                 | 7/32 | 1/4  | 1/4  | 9/32 | 5/16 | 5/16 | 11/32 | 3/8  | 3/8  | 13/32 | 7/16 | 7/16 | 15/32 | 1/2  | 1/2  | 17/32 | 9/16 |
| 32           |            | At oiltight and watertight periphery connections                                 | 3/16                                                 | 7/32 | 1/4  | 1/4  | 9/32 | 5/16 | 5/16 | 11/32 | 3/8  | 3/8  | 13/32 | 7/16 | 7/16 | 15/32 | 1/2  | 1/2  | 17/32 | 9/16 |

| ABS<br>Weld<br>Grp. | Ln.<br>No. | Structural Items                                                   | Leg Size for Lesser Thickness of Members Joined, In. |      |      |      |      |      |      |       |       |      |       |       |      |       |       |      |       |       |  |
|---------------------|------------|--------------------------------------------------------------------|------------------------------------------------------|------|------|------|------|------|------|-------|-------|------|-------|-------|------|-------|-------|------|-------|-------|--|
|                     |            |                                                                    | 0.32                                                 | 0.36 | 0.40 | 0.44 | 0.48 | 0.52 | 0.56 | 0.60  | 0.64  | 0.68 | 0.72  | 0.76  | 0.80 | 0.84  | 0.88  | 0.92 | 0.96  | 1.00  |  |
| C                   | 34         | To shell and to other boundaries                                   | 3/16                                                 | 7/32 | 1/4  | 1/4  | 9/32 | 5/16 | 5/16 | 11/32 | 3/8   | 3/8  | 13/32 | 7/16  | 7/16 | 15/32 | 1/2   | 1/2  | 17/32 | 9/16  |  |
|                     | 56         | Ollight or watertight bulkheads - periphery                        | 3/16                                                 | 7/32 | 1/4  | 1/4  | 9/32 | 5/16 | 5/16 | 11/32 | 3/8   | 3/8  | 13/32 | 7/16  | 7/16 | 15/32 | 1/2   | 1/2  | 17/32 | 9/16  |  |
|                     | 57         | Exposed bulkhead on freeboard or superstructure deck - periphery   | 3/16                                                 | 7/32 | 1/4  | 1/4  | 9/32 | 5/16 | 5/16 | 11/32 | 3/8   | 3/8  | 13/32 | 7/16  | 7/16 | 15/32 | 1/2   | 1/2  | 17/32 | 9/16  |  |
|                     | 64         | Strength deck - periphery                                          | 3/16                                                 | 7/32 | 1/4  | 1/4  | 9/32 | 5/16 | 5/16 | 11/32 | 3/8   | 3/8  | 13/32 | 7/16  | 7/16 | 15/32 | 1/2   | 1/2  | 17/32 | 9/16  |  |
|                     | 65         | Exposed decks, watertight and ollight decks - periphery            | 3/16                                                 | 7/32 | 1/4  | 1/4  | 9/32 | 5/16 | 5/16 | 11/32 | 3/8   | 3/8  | 13/32 | 7/16  | 7/16 | 15/32 | 1/2   | 1/2  | 17/32 | 9/16  |  |
|                     | 71         | To deck                                                            | 3/16                                                 | 7/32 | 1/4  | 1/4  | 9/32 | 5/16 | 5/16 | 11/32 | 3/8   | 3/8  | 13/32 | 7/16  | 7/16 | 15/32 | 1/2   | 1/2  | 17/32 | 9/16  |  |
| D                   | 72         | Watertight or ollight periphery                                    | 3/16                                                 | 7/32 | 1/4  | 1/4  | 9/32 | 5/16 | 5/16 | 11/32 | 3/8   | 3/8  | 13/32 | 7/16  | 7/16 | 15/32 | 1/2   | 1/2  | 17/32 | 9/16  |  |
|                     | 77         | To top plate, shell or inner bottom                                | 3/16                                                 | 7/32 | 1/4  | 1/4  | 9/32 | 5/16 | 5/16 | 11/32 | 3/8   | 3/8  | 13/32 | 7/16  | 7/16 | 15/32 | 1/2   | 1/2  | 17/32 | 9/16  |  |
|                     | 40         | Frame brackets to frames, decks and inner bottom Type A            | 3/16                                                 | 3/16 | 7/32 | 1/4  | 1/4  | 9/32 | 5/16 | 5/16  | 11/32 | 3/8  | 3/8   | 13/32 | 7/16 | 7/16  | 15/32 | 1/2  | 1/2   | 17/32 |  |
|                     | 42         | To brackets, Type A                                                | 3/16                                                 | 3/16 | 7/32 | 1/4  | 1/4  | 9/32 | 5/16 | 5/16  | 11/32 | 3/8  | 3/8   | 13/32 | 7/16 | 7/16  | 15/32 | 1/2  | 1/2   | 17/32 |  |
|                     | 48         | Brackets to longitudinal, floors, etc., Type A                     | 3/16                                                 | 3/16 | 7/32 | 1/4  | 1/4  | 9/32 | 5/16 | 5/16  | 11/32 | 3/8  | 3/8   | 13/32 | 7/16 | 7/16  | 15/32 | 1/2  | 1/2   | 17/32 |  |
|                     | 63         | Brackets to stiffeners, bulkhead, deck, inner bottom, etc., Type A | 3/16                                                 | 3/16 | 7/32 | 1/4  | 1/4  | 9/32 | 5/16 | 5/16  | 11/32 | 3/8  | 3/8   | 13/32 | 7/16 | 7/16  | 15/32 | 1/2  | 1/2   | 17/32 |  |

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Weld

Grp. No.

Leg Size for Lesser Thickness of Members Joined, In.

| Ln.<br>No. | Structural Items                                                                 | Leg Size for Lesser Thickness of Members Joined, In. |      |      |      |      |      |      |      |       |      |      |       |       |       |       |
|------------|----------------------------------------------------------------------------------|------------------------------------------------------|------|------|------|------|------|------|------|-------|------|------|-------|-------|-------|-------|
|            |                                                                                  | 0.32                                                 | 0.36 | 0.40 | 0.44 | 0.48 | 0.52 | 0.56 | 0.60 | 0.64  | 0.68 | 0.72 | 0.76  | 0.80  | 0.84  | 0.88  |
| D          | 70 Beam knees and brackets to beams, longitudinals, deck, bulkhead, etc., Type A | 3/16                                                 | 3/16 | 7/32 | 1/4  | 1/4  | 9/32 | 5/16 | 5/16 | 11/32 | 3/8  | 3/8  | 13/32 | 7/16  | 7/16  | 15/32 |
|            |                                                                                  |                                                      |      |      |      |      |      |      |      |       |      |      |       |       | 1/2   | 17/32 |
| 75         | Bracket to stiffener or side plate, Type A                                       | 3/16                                                 | 3/16 | 7/32 | 1/4  | 1/4  | 9/32 | 5/16 | 5/16 | 11/32 | 3/8  | 3/8  | 13/32 | 7/16  | 7/16  | 15/32 |
|            |                                                                                  |                                                      |      |      |      |      |      |      |      |       |      |      |       |       | 1/2   | 17/32 |
| E          | 66 Platform decks non-tight flats - periphery                                    | 3/16                                                 | 7/32 | 7/32 | 1/4  | 1/4  | 1/4  | 9/32 | 9/32 | 5/16  | 5/16 | 5/16 | 11/32 | 11/32 | 3/8   | 3/8   |
|            |                                                                                  |                                                      |      |      |      |      |      |      |      |       |      |      |       |       | 13/32 | 13/32 |
| F          | 2 To shell - aft peak of high power fine form vessels                            | 3/16                                                 | 3/16 | 3/16 | 7/32 | 7/32 | 1/4  | 1/4  | 1/4  | 1/4   | 9/32 | 9/32 | 5/16  | 5/16  | 5/16  | 11/32 |
|            |                                                                                  |                                                      |      |      |      |      |      |      |      |       |      |      |       |       | 5/16  | 11/32 |
| 7          | To shell - aft peaks of high power, fine form vessels                            | 3/16                                                 | 3/16 | 3/16 | 7/32 | 7/32 | 1/4  | 1/4  | 1/4  | 1/4   | 9/32 | 9/32 | 5/16  | 5/16  | 5/16  | 11/32 |
|            |                                                                                  |                                                      |      |      |      |      |      |      |      |       |      |      |       |       | 5/16  | 11/32 |
| 22         | To inner bottom clear of engine, Type B                                          | 3/16                                                 | 3/16 | 3/16 | 7/32 | 7/32 | 1/4  | 1/4  | 1/4  | 1/4   | 9/32 | 9/32 | 5/16  | 5/16  | 5/16  | 11/32 |
|            |                                                                                  |                                                      |      |      |      |      |      |      |      |       |      |      |       |       | 5/16  | 11/32 |
| 26         | To shell - flat of bottom forward (fore end strengthening)                       | 3/16                                                 | 3/16 | 3/16 | 7/32 | 7/32 | 1/4  | 1/4  | 1/4  | 1/4   | 9/32 | 9/32 | 5/16  | 5/16  | 5/16  | 11/32 |
|            |                                                                                  |                                                      |      |      |      |      |      |      |      |       |      |      |       |       | 5/16  | 11/32 |
| 28         | To inner bottom in way of engines, Type B                                        | 3/16                                                 | 3/16 | 3/16 | 7/32 | 7/32 | 1/4  | 1/4  | 1/4  | 1/4   | 9/32 | 9/32 | 5/16  | 5/16  | 5/16  | 11/32 |
|            |                                                                                  |                                                      |      |      |      |      |      |      |      |       |      |      |       |       | 5/16  | 11/32 |
| 35         | To shell - aft peaks of high power, fine form vessels                            | 3/16                                                 | 3/16 | 3/16 | 7/32 | 7/32 | 1/4  | 1/4  | 1/4  | 1/4   | 9/32 | 9/32 | 5/16  | 5/16  | 5/16  | 11/32 |
|            |                                                                                  |                                                      |      |      |      |      |      |      |      |       |      |      |       |       | 5/16  | 11/32 |
| 78         | To side plating                                                                  | 3/16                                                 | 3/16 | 3/16 | 7/32 | 7/32 | 1/4  | 1/4  | 1/4  | 1/4   | 9/32 | 9/32 | 5/16  | 5/16  | 5/16  | 11/32 |
|            |                                                                                  |                                                      |      |      |      |      |      |      |      |       |      |      |       |       | 5/16  | 11/32 |
| 80         | To side plating                                                                  | 3/16                                                 | 3/16 | 3/16 | 7/32 | 7/32 | 1/4  | 1/4  | 1/4  | 1/4   | 9/32 | 9/32 | 5/16  | 5/16  | 5/16  | 11/32 |
|            |                                                                                  |                                                      |      |      |      |      |      |      |      |       |      |      |       |       | 5/16  | 11/32 |
| 81         | To horizontal diaphragms                                                         | 3/16                                                 | 3/16 | 3/16 | 7/32 | 7/32 | 1/4  | 1/4  | 1/4  | 1/4   | 9/32 | 9/32 | 5/16  | 5/16  | 5/16  | 11/32 |
|            |                                                                                  |                                                      |      |      |      |      |      |      |      |       |      |      |       |       | 5/16  | 11/32 |

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| Weld<br>Grp. | Ln.<br>No. | Structural Items                                                      | Leg Size for Lesser Thickness of Members Joined, In. |      |      |      |      |      |      |      |      |      |      |      |      |      |       |       |       |       |      |
|--------------|------------|-----------------------------------------------------------------------|------------------------------------------------------|------|------|------|------|------|------|------|------|------|------|------|------|------|-------|-------|-------|-------|------|
|              |            |                                                                       | 0.32                                                 | 0.36 | 0.40 | 0.44 | 0.48 | 0.52 | 0.56 | 0.60 | 0.64 | 0.68 | 0.72 | 0.76 | 0.80 | 0.84 | 0.88  | 0.92  | 0.96  | 1.00  |      |
| G            | 49         | To shell and to bulkheads<br>and decks in way of tanks                | 3/16                                                 | 3/16 | 3/16 | 3/16 | 3/16 | 3/16 | 3/16 | 7/32 | 7/32 | 1/4  | 1/4  | 1/4  | 1/4  | 1/4  | 13/32 | 13/32 | 13/32 | 7/16  | 7/16 |
| H            | 50         | To decks and bulkheads clear<br>of tanks                              | 3/16                                                 | 3/16 | 3/16 | 3/16 | 3/16 | 3/16 | 3/16 | 7/32 | 7/32 | 7/32 | 1/4  | 1/4  | 1/4  | 1/4  | 1/4   | 13/32 | 13/32 | 13/32 | 7/16 |
| I            | 45         | To shell on flat of bottom<br>forward                                 | 3/16                                                 | 3/16 | 3/16 | 3/16 | 1/4  | 1/4  | 1/4  | 1/4  | 1/4  | 1/4  | 1/4  | 9/32 | 9/32 | 9/32 | 5/16  | 5/16  | 5/16  | 5/16  |      |
| J            | 54         | Swash bulkheads - periphery                                           | 3/16                                                 | 3/16 | 3/16 | 3/16 | 3/16 | 3/16 | 7/32 | 7/32 | 1/4  | 1/4  | 1/4  | 1/4  | 1/4  | 1/4  | 9/32  | 9/32  | 9/32  | 5/16  | 5/16 |
| K            | 15         | To inner bottom at forward end<br>(fore-end strengthening),<br>Type B | 3/16                                                 | 3/16 | 3/16 | 3/16 | 3/16 | 3/16 | 3/16 | 7/32 | 7/32 | 7/32 | 1/4  | 1/4  | 1/4  | 1/4  | 9/32  | 9/32  | 9/32  | 5/16  | 5/16 |
|              | 16         | To inner bottom elsewhere<br>Type B (See Note 5)                      | 3/16                                                 | 3/16 | 3/16 | 3/16 | 3/16 | 3/16 | 3/16 | 7/32 | 7/32 | 7/32 | 1/4  | 1/4  | 1/4  | 1/4  | 9/32  | 9/32  | 9/32  | 5/16  | 5/16 |
|              | 18         | Stiffeners, Type B                                                    | 3/16                                                 | 3/16 | 3/16 | 3/16 | 3/16 | 3/16 | 3/16 | 7/32 | 7/32 | 7/32 | 1/4  | 1/4  | 1/4  | 1/4  | 9/32  | 9/32  | 9/32  | 5/16  | 5/16 |
|              | 19         | To center vertical keel,<br>Type A                                    | 3/16                                                 | 3/16 | 3/16 | 3/16 | 3/16 | 3/16 | 3/16 | 7/32 | 7/32 | 7/32 | 1/4  | 1/4  | 1/4  | 1/4  | 9/32  | 9/32  | 9/32  | 5/16  | 5/16 |
|              | 25         | Stiffeners, Type B                                                    | 3/16                                                 | 3/16 | 3/16 | 3/16 | 3/16 | 3/16 | 3/16 | 7/32 | 7/32 | 7/32 | 1/4  | 1/4  | 1/4  | 1/4  | 9/32  | 9/32  | 9/32  | 5/16  | 5/16 |
| L            | 41         | To inner bottom, Type B                                               | 3/16                                                 | 3/16 | 3/16 | 3/16 | 3/16 | 3/16 | 3/16 | 7/32 | 7/32 | 7/32 | 1/4  | 1/4  | 1/4  | 1/4  | 5/16  | 5/16  | 5/16  | 5/16  | 5/16 |

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| Weld<br>Grp. | Ln.<br>No. | Structural Items                                                         | Leg Size for Lesser Thickness of Members Joined, In. |      |      |      |      |      |      |      |      |      |      |      |      |                 |      |      |      |      |      |
|--------------|------------|--------------------------------------------------------------------------|------------------------------------------------------|------|------|------|------|------|------|------|------|------|------|------|------|-----------------|------|------|------|------|------|
|              |            |                                                                          | 0.32                                                 | 0.36 | 0.40 | 0.44 | 0.48 | 0.52 | 0.56 | 0.60 | 0.64 | 0.68 | 0.72 | 0.76 | 0.80 | 0.84            | 0.88 | 0.92 | 0.96 | 1.00 |      |
| M            | 3          | To shell - flat of bottom<br>forward and in peaks                        | 3/16                                                 | 3/16 | 3/16 | 3/16 | 3/16 | 3/16 | 3/16 | 7/32 | 7/32 | 7/32 | 1/4  | 1/4  | 1/4  | 1/4             | 1/4  | 1/4  | 9/32 | 9/32 | 5/16 |
|              | 4          | To shell - elsewhere                                                     | 3/16                                                 | 3/16 | 3/16 | 3/16 | 3/16 | 3/16 | 3/16 | 7/32 | 7/32 | 7/32 | 1/4  | 1/4  | 1/4  | 1/4             | 1/4  | 1/4  | 9/32 | 9/32 | 5/16 |
|              | 5          | To face plate, Type B                                                    | 3/16                                                 | 3/16 | 3/16 | 3/16 | 3/16 | 3/16 | 3/16 | 7/32 | 7/32 | 7/32 | 1/4  | 1/4  | 1/4  | 1/4             | 1/4  | 1/4  | 9/32 | 9/32 | 5/16 |
|              | 8          | To shell - flat of bottom<br>forward and in peaks                        | 3/16                                                 | 3/16 | 3/16 | 3/16 | 3/16 | 3/16 | 3/16 | 7/32 | 7/32 | 7/32 | 1/4  | 1/4  | 1/4  | <del>9/32</del> | 1/4  | 9/32 | 9/32 | 5/16 |      |
|              | 9          | To shell elsewhere (See<br>Note 5)                                       | 3/16                                                 | 3/16 | 3/16 | 3/16 | 3/16 | 3/16 | 3/16 | 7/32 | 7/32 | 7/32 | 1/4  | 1/4  | 1/4  | 1/4             | 1/4  | 1/4  | 9/32 | 9/32 | 5/16 |
|              | 10         | To center vertical keel and<br>side girders where floor is<br>continuous | 3/16                                                 | 3/16 | 3/16 | 3/16 | 3/16 | 3/16 | 3/16 | 7/32 | 7/32 | 7/32 | 1/4  | 1/4  | 1/4  | 1/4             | 1/4  | 1/4  | 9/32 | 9/32 | 5/16 |
|              | 27         | To shell elsewhere                                                       | 3/16                                                 | 3/16 | 3/16 | 3/16 | 3/16 | 3/16 | 3/16 | 7/32 | 7/32 | 7/32 | 1/4  | 1/4  | 1/4  | 1/4             | 1/4  | 1/4  | 9/32 | 9/32 | 5/16 |
|              | 29         | To inner bottom elsewhere,<br>Type B                                     | 3/16                                                 | 3/16 | 3/16 | 3/16 | 3/16 | 3/16 | 3/16 | 7/32 | 7/32 | 7/32 | 1/4  | 1/4  | 1/4  | 1/4             | 1/4  | 1/4  | 9/32 | 9/32 | 5/16 |
|              | 31         | To floors elsewhere, Type B                                              | 3/16                                                 | 3/16 | 3/16 | 3/16 | 3/16 | 3/16 | 3/16 | 7/32 | 7/32 | 7/32 | 1/4  | 1/4  | 1/4  | 1/4             | 1/4  | 1/4  | 9/32 | 9/32 | 5/16 |
|              | 33         | Stiffeners, Type B                                                       | 3/16                                                 | 3/16 | 3/16 | 3/16 | 3/16 | 3/16 | 3/16 | 7/32 | 7/32 | 7/32 | 1/4  | 1/4  | 1/4  | 1/4             | 1/4  | 1/4  | 9/32 | 9/32 | 5/16 |
|              | 36         | To shell for 0.125L forward                                              | 3/16                                                 | 3/16 | 3/16 | 3/16 | 3/16 | 3/16 | 3/16 | 7/32 | 7/32 | 7/32 | 1/4  | 1/4  | 1/4  | 1/4             | 1/4  | 1/4  | 9/32 | 9/32 | 5/16 |
|              | 37         | To shell in peaks                                                        | 3/16                                                 | 3/16 | 3/16 | 3/16 | 3/16 | 3/16 | 3/16 | 7/32 | 7/32 | 7/32 | 1/4  | 1/4  | 1/4  | 1/4             | 1/4  | 1/4  | 9/32 | 9/32 | 5/16 |
|              | 38         | To shell elsewhere                                                       | 3/16                                                 | 3/16 | 3/16 | 3/16 | 3/16 | 3/16 | 3/16 | 7/32 | 7/32 | 7/32 | 1/4  | 1/4  | 1/4  | 1/4             | 1/4  | 1/4  | 9/32 | 9/32 | 5/16 |
|              | 43         | To shell for 0.125L forward                                              | 3/16                                                 | 3/16 | 3/16 | 3/16 | 3/16 | 3/16 | 3/16 | 7/32 | 7/32 | 7/32 | 1/4  | 1/4  | 1/4  | 1/4             | 1/4  | 1/4  | 9/32 | 9/32 | 5/16 |
|              | 44         | To shell in peaks                                                        | 3/16                                                 | 3/16 | 3/16 | 3/16 | 3/16 | 3/16 | 3/16 | 7/32 | 7/32 | 7/32 | 1/4  | 1/4  | 1/4  | 1/4             | 1/4  | 1/4  | 9/32 | 9/32 | 5/16 |
|              | 46         | To shell elsewhere                                                       | 3/16                                                 | 3/16 | 3/16 | 3/16 | 3/16 | 3/16 | 3/16 | 7/32 | 7/32 | 7/32 | 1/4  | 1/4  | 1/4  | 1/4             | 1/4  | 1/4  | 9/32 | 9/32 | 5/16 |

| ABS<br>Weld<br>Grp. | Ln.<br>No. | Structural Items                                                                       | Leg Size for Lesser Thickness of Members Joined, In. |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |
|---------------------|------------|----------------------------------------------------------------------------------------|------------------------------------------------------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|
|                     |            |                                                                                        | 0.32                                                 | 0.36 | 0.40 | 0.44 | 0.48 | 0.52 | 0.56 | 0.60 | 0.64 | 0.68 | 0.72 | 0.76 | 0.80 | 0.84 | 0.88 | 0.92 | 0.96 | 1.00 |      |
| M                   | 47         | To inner bottom, Type B                                                                | 3/16                                                 | 3/16 | 3/16 | 3/16 | 3/16 | 3/16 | 3/16 | 7/32 | 7/32 | 7/32 | 7/32 | 1/4  | 1/4  | 1/4  | 1/4  | 1/4  | 9/32 | 9/32 | 5/16 |
|                     | 53         | To face plate                                                                          | 3/16                                                 | 3/16 | 3/16 | 3/16 | 3/16 | 3/16 | 3/16 | 7/32 | 7/32 | 7/32 | 7/32 | 1/4  | 1/4  | 1/4  | 1/4  | 1/4  | 9/32 | 9/32 | 5/16 |
|                     | 55         | Non-tight bulkhead – peripheral                                                        | 3/16                                                 | 3/16 | 3/16 | 3/16 | 3/16 | 3/16 | 3/16 | 7/32 | 7/32 | 7/32 | 7/32 | 1/4  | 1/4  | 1/4  | 1/4  | 1/4  | 9/32 | 9/32 | 5/16 |
|                     | 58         | To deep tank bulkheads,<br>Type B                                                      | 3/16                                                 | 3/16 | 3/16 | 3/16 | 3/16 | 3/16 | 3/16 | 7/32 | 7/32 | 7/32 | 7/32 | 1/4  | 1/4  | 1/4  | 1/4  | 1/4  | 9/32 | 9/32 | 5/16 |
|                     | 59         | To watertight bulkheads and<br>superstructure or deck house<br>front bulkheads, Type B | 3/16                                                 | 3/16 | 3/16 | 3/16 | 3/16 | 3/16 | 3/16 | 7/32 | 7/32 | 7/32 | 7/32 | 1/4  | 1/4  | 1/4  | 1/4  | 1/4  | 9/32 | 9/32 | 5/16 |
|                     | 60         | To non-tight structural<br>bulkheads, Type B                                           | 3/16                                                 | 3/16 | 3/16 | 3/16 | 3/16 | 3/16 | 3/16 | 7/32 | 7/32 | 7/32 | 7/32 | 1/4  | 1/4  | 1/4  | 1/4  | 1/4  | 9/32 | 9/32 | 5/16 |
|                     | 61         | To deck house sides and deck<br>house and superstructure<br>end bulkheads, Type B      | 3/16                                                 | 3/16 | 3/16 | 3/16 | 3/16 | 3/16 | 3/16 | 7/32 | 7/32 | 7/32 | 7/32 | 1/4  | 1/4  | 1/4  | 1/4  | 1/4  | 9/32 | 9/32 | 5/16 |
|                     | 67         | To decks, except slab<br>longitudinals, Type B                                         | 3/16                                                 | 3/16 | 3/16 | 3/16 | 3/16 | 3/16 | 3/16 | 7/32 | 7/32 | 7/32 | 7/32 | 1/4  | 1/4  | 1/4  | 1/4  | 1/4  | 9/32 | 9/32 | 5/16 |
|                     | 68         | To decks, slab longitudinal<br>(See Note 2), Type B                                    | 3/16                                                 | 3/16 | 3/16 | 3/16 | 3/16 | 3/16 | 3/16 | 7/32 | 7/32 | 7/32 | 7/32 | 1/4  | 1/4  | 1/4  | 1/4  | 1/4  | 9/32 | 9/32 | 5/16 |
|                     | 73         | To plating and to face plate                                                           | 3/16                                                 | 3/16 | 3/16 | 3/16 | 3/16 | 3/16 | 3/16 | 7/32 | 7/32 | 7/32 | 7/32 | 1/4  | 1/4  | 1/4  | 1/4  | 1/4  | 9/32 | 9/32 | 5/16 |

ADDITIONAL RULES FOR "OIL CARRIER"

|   |    |                            |     |     |      |      |      |       |     |       |      |      |     |     |       |      |      |       |     |       |
|---|----|----------------------------|-----|-----|------|------|------|-------|-----|-------|------|------|-----|-----|-------|------|------|-------|-----|-------|
| N | 83 | Centerline girder to shell | 1/4 | 1/4 | 9/32 | 5/16 | 5/16 | 11/32 | 3/8 | 13/32 | 7/16 | 7/16 | 1/2 | 1/2 | 17/32 | 9/16 | 9/16 | 19/32 | 5/8 | 21/32 |
|   | 90 | Bracketed, Type A          | 1/4 | 1/4 | 9/32 | 5/16 | 5/16 | 11/32 | 3/8 | 13/32 | 7/16 | 7/16 | 1/2 | 1/2 | 17/32 | 9/16 | 9/16 | 19/32 | 5/8 | 21/32 |
|   | 91 | Bottom transverse to shell | 1/4 | 1/4 | 9/32 | 5/16 | 5/16 | 11/32 | 3/8 | 13/32 | 7/16 | 7/16 | 1/2 | 1/2 | 17/32 | 9/16 | 9/16 | 19/32 | 5/8 | 21/32 |

ABS

| Weld<br>Grp. | Ln.<br>No. | Structural Items                                                       | Leg Size for Lesser Thickness of Members Joined, In. |      |      |      |      |      |       |       |       |       |       |      |       |       |       |
|--------------|------------|------------------------------------------------------------------------|------------------------------------------------------|------|------|------|------|------|-------|-------|-------|-------|-------|------|-------|-------|-------|
|              |            |                                                                        | 0.32                                                 | 0.36 | 0.40 | 0.44 | 0.48 | 0.52 | 0.56  | 0.60  | 0.64  | 0.68  | 0.72  | 0.76 | 0.80  | 0.84  | 1.00  |
| O            | 85         | Centerline girder to deck                                              | 1/4                                                  | 1/4  | 1/4  | 9/32 | 5/16 | 5/16 | 11/32 | 3/8   | 3/8   | 13/32 | 7/16  | 7/16 | 15/32 | 1/2   | 1/2   |
|              | 87         | Transverse bulkhead, webs<br>to bulkhead                               | 1/4                                                  | 1/4  | 1/4  | 9/32 | 5/16 | 5/16 | 11/32 | 3/8   | 3/8   | 13/32 | 7/16  | 7/16 | 15/32 | 1/2   | 1/2   |
|              | 93         | Side transverse and<br>longitudinal bulkhead web<br>to plating         | 1/4                                                  | 1/4  | 1/4  | 9/32 | 5/16 | 5/16 | 11/32 | 3/8   | 3/8   | 13/32 | 7/16  | 7/16 | 15/32 | 1/2   | 1/2   |
|              | 94         | Deck transverse to deck                                                | 1/4                                                  | 1/4  | 1/4  | 9/32 | 5/16 | 5/16 | 11/32 | 3/8   | 3/8   | 13/32 | 7/16  | 7/16 | 15/32 | 1/2   | 1/2   |
| P            | 84         | Centerline girder to shell,<br>mid 0.5 span (See Note 3)               | 1/4                                                  | 1/4  | 1/4  | 1/4  | 1/4  | 9/32 | 5/16  | 11/32 | 11/32 | 3/8   | 13/32 | 7/16 | 7/16  | 15/32 | 1/2   |
|              | 92         | Bottom transverse to shell<br>mid 0.5 span (See Note 3)                | 1/4                                                  | 1/4  | 1/4  | 1/4  | 1/4  | 9/32 | 5/16  | 11/32 | 11/32 | 3/8   | 13/32 | 7/16 | 7/16  | 15/32 | 1/2   |
| Q            | 86         | Centerline girder to deck,<br>mid 0.5 span (See Note 3)                | 1/4                                                  | 1/4  | 1/4  | 1/4  | 1/4  | 1/4  | 9/32  | 5/16  | 5/16  | 5/16  | 11/32 | 3/8  | 3/8   | 13/32 | 13/32 |
|              | 88         | Transverse bulkhead, webs to<br>bulkhead, mid 0.5 span<br>(See Note 3) | 1/4                                                  | 1/4  | 1/4  | 1/4  | 1/4  | 1/4  | 9/32  | 5/16  | 5/16  | 5/16  | 11/32 | 3/8  | 3/8   | 13/32 | 13/32 |
|              | 95         | Deck transverse to deck, mid<br>0.5 span (See Note 3)                  | 1/4                                                  | 1/4  | 1/4  | 1/4  | 1/4  | 1/4  | 9/32  | 5/16  | 5/16  | 5/16  | 11/32 | 3/8  | 3/8   | 13/32 | 13/32 |
| R            | 89         | To face bars                                                           | 1/4                                                  | 1/4  | 1/4  | 1/4  | 1/4  | 1/4  | 1/4   | 9/32  | 9/32  | 5/16  | 5/16  | 5/16 | 5/16  | 11/32 | 11/32 |
|              | 96         | To face bars                                                           | 1/4                                                  | 1/4  | 1/4  | 1/4  | 1/4  | 1/4  | 1/4   | 9/32  | 9/32  | 5/16  | 5/16  | 5/16 | 5/16  | 11/32 | 11/32 |

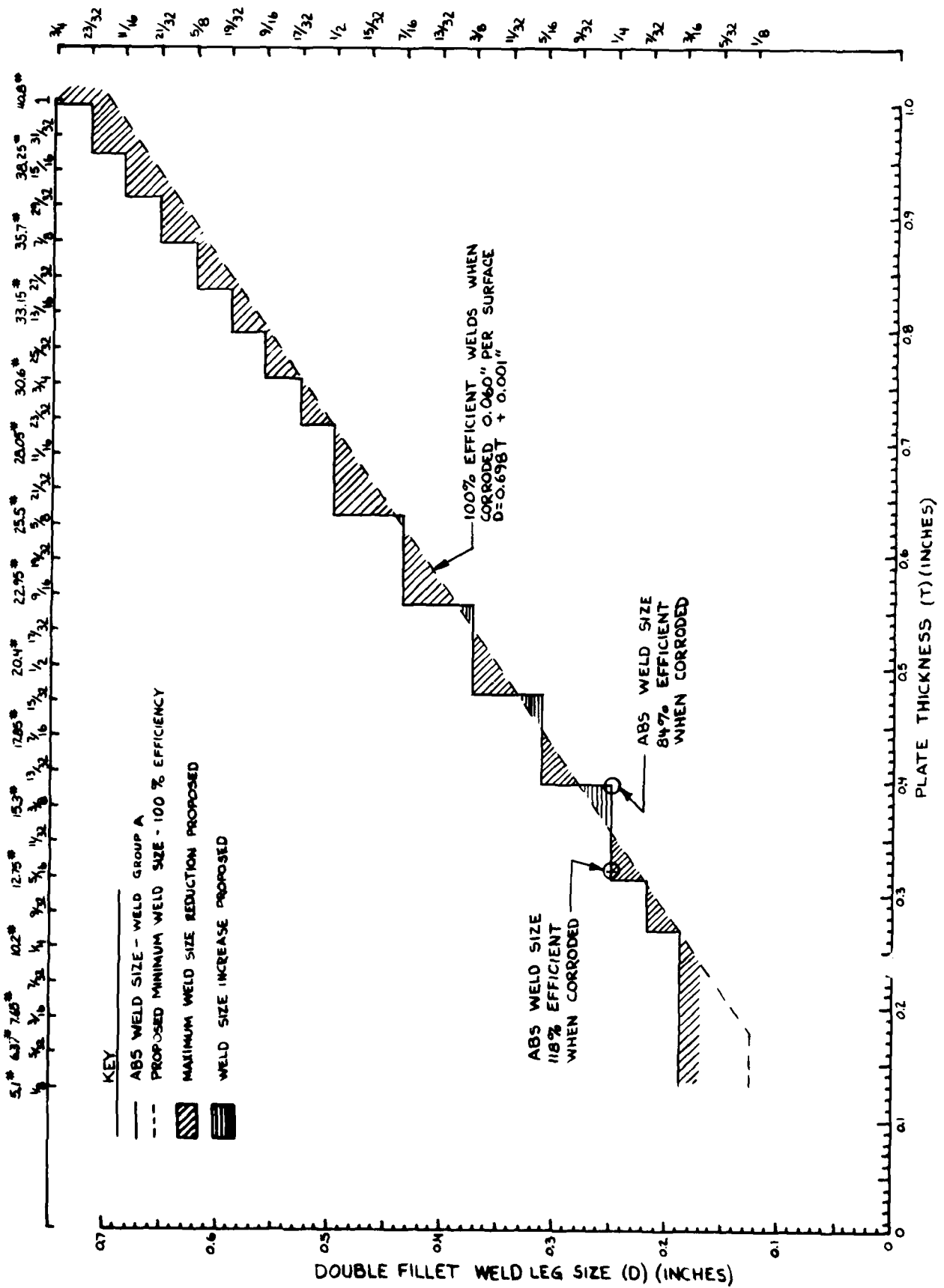
|                     |            | Leg Size for Lesser Thickness of Members Joined, in.                      |      |       |       |      |      |      |      |      |      |      |      |      |      |      |   |
|---------------------|------------|---------------------------------------------------------------------------|------|-------|-------|------|------|------|------|------|------|------|------|------|------|------|---|
|                     |            | 0.20                                                                      | 0.24 | 0.28  | 0.32  | 0.36 | 0.40 | 0.44 | 0.48 | 0.52 | 0.56 | 0.60 | 0.64 |      |      |      |   |
| ABS<br>Weld<br>Grp. | Ln.<br>No. | Nominal leg size of fillet                                                |      | 3/16  | 3/16  | 1/4  | 1/4  | 1/4  | 5/16 | 5/16 | 5/16 | 5/16 | 5/16 | 5/16 | 5/16 | 5/16 |   |
|                     |            | Length of fillet weld                                                     |      | 2-1/8 | 2-1/2 | 3    | 3    | 3    | 3    | 3    | 3    | 3    | 3    | 3    | 3    | 3    | 3 |
|                     |            | Structural Items                                                          |      |       |       |      |      |      |      |      |      |      |      |      |      |      |   |
|                     |            | Spacing of Welds S, in.                                                   |      |       |       |      |      |      |      |      |      |      |      |      |      |      |   |
| C1                  | 56B        | Watertight bulkheads-periphery                                            |      |       |       |      |      |      |      |      |      |      |      |      |      |      |   |
|                     |            | One side                                                                  |      |       |       |      |      |      |      |      |      |      |      |      |      |      |   |
|                     |            | Continuous weld of leg size of plate thickness less 1/16 in.              |      |       |       |      |      |      |      |      |      |      |      |      |      |      |   |
|                     |            | See Table 30.1 for double continuous weld                                 |      |       |       |      |      |      |      |      |      |      |      |      |      |      |   |
| C2                  | 72B        | Other side                                                                |      |       |       |      |      |      |      |      |      |      |      |      |      |      |   |
|                     |            | Continuous weld of same leg size as required for inside intermittent weld |      |       |       |      |      |      |      |      |      |      |      |      |      |      |   |
|                     |            | See Table 30.1 for double continuous weld                                 |      |       |       |      |      |      |      |      |      |      |      |      |      |      |   |
| F1                  | 78         | To side plating                                                           |      |       |       |      |      |      |      |      |      |      |      |      |      |      |   |
|                     |            | 4                                                                         | 5    | 6     | 6     | 5    | 6    | 6    | 6    | 6    | 6    | 6    | 6    | 6    | 6    | 6    |   |
|                     |            | 4                                                                         | 5    | 6     | 6     | 5    | 6    | 6    | 6    | 6    | 6    | 6    | 6    | 6    | 6    | 6    |   |
| F1                  | 80         | To side plating                                                           |      |       |       |      |      |      |      |      |      |      |      |      |      |      |   |
|                     |            | 4                                                                         | 5    | 6     | 6     | 5    | 6    | 6    | 6    | 6    | 6    | 6    | 6    | 6    | 6    | 6    |   |
| F1                  | 81         | To horizontal diaphragms                                                  |      |       |       |      |      |      |      |      |      |      |      |      |      |      |   |
|                     |            | 4                                                                         | 5    | 6     | 6     | 5    | 6    | 6    | 6    | 6    | 6    | 6    | 6    | 6    | 6    | 6    |   |
| -----               |            |                                                                           |      |       |       |      |      |      |      |      |      |      |      |      |      |      |   |
| F2                  | 2          | To shell-aft peaks of high power, fine form vessels                       |      |       |       |      |      |      |      |      |      |      |      |      |      |      |   |
|                     |            | -                                                                         | -    | 6     | 6     | 5    | 6    | 6    | 6    | 6    | 6    | 6    | 6    | 6    | 5    | -    |   |
| F2                  | 7          | To shell-aft peaks of high power, fine form vessels                       |      |       |       |      |      |      |      |      |      |      |      |      |      |      |   |
|                     |            | -                                                                         | -    | 6     | 6     | 5    | 6    | 6    | 6    | 6    | 6    | 6    | 6    | 6    | 5    | -    |   |
| F2                  | 35         | To shell-aft peaks of high power, fine form vessels                       |      |       |       |      |      |      |      |      |      |      |      |      |      |      |   |
|                     |            | -                                                                         | -    | 6     | 6     | 5    | 6    | 6    | 6    | 6    | 6    | 6    | 6    | 6    | 5    | -    |   |
| -----               |            |                                                                           |      |       |       |      |      |      |      |      |      |      |      |      |      |      |   |
| F3                  | 22         | To inner bottom-clear of engine-nonflight                                 |      |       |       |      |      |      |      |      |      |      |      |      |      |      |   |
|                     |            | -                                                                         | 6    | 6     | 6     | 5    | 6    | 6    | 6    | 5    | 5    | 5    | 5    | 5    | -    | -    |   |
| F3                  | 26         | To shell-plate of bottom forward (fore end strengthening)                 |      |       |       |      |      |      |      |      |      |      |      |      |      |      |   |
|                     |            | -                                                                         | 6    | 6     | 6     | 5    | 6    | 6    | 6    | 5    | 5    | 5    | 5    | 5    | -    | -    |   |
| F3                  | 28         | To inner bottom in way of engines                                         |      |       |       |      |      |      |      |      |      |      |      |      |      |      |   |
|                     |            | -                                                                         | 6    | 6     | 6     | 5    | 6    | 6    | 6    | 5    | 5    | 5    | 5    | 5    | -    | -    |   |
| -----               |            |                                                                           |      |       |       |      |      |      |      |      |      |      |      |      |      |      |   |
| G1                  | 49         | To shell and to bulkheads and decks in way of tanks                       |      |       |       |      |      |      |      |      |      |      |      |      |      |      |   |
|                     |            | -                                                                         | 8    | 9     | 9     | 8    | 9    | 9    | 9    | 8    | 7    | 7    | 6    | 6    | 6    | 6    |   |
| -----               |            |                                                                           |      |       |       |      |      |      |      |      |      |      |      |      |      |      |   |
| H1                  | 50         | To decks and bulkheads clear of tanks                                     |      |       |       |      |      |      |      |      |      |      |      |      |      |      |   |
|                     |            | -                                                                         | 9    | 10    | 10    | 9    | 10   | 10   | 10   | 9    | 8    | 8    | 7    | 7    | 7    | 7    |   |
| -----               |            |                                                                           |      |       |       |      |      |      |      |      |      |      |      |      |      |      |   |
| J1                  | 54         | Swash bulkhead-periphery (Same as G1)                                     |      |       |       |      |      |      |      |      |      |      |      |      |      |      |   |
|                     |            | -                                                                         | 8    | 9     | 9     | 8    | 9    | 9    | 9    | 8    | 7    | 7    | 6    | 6    | 6    | 6    |   |

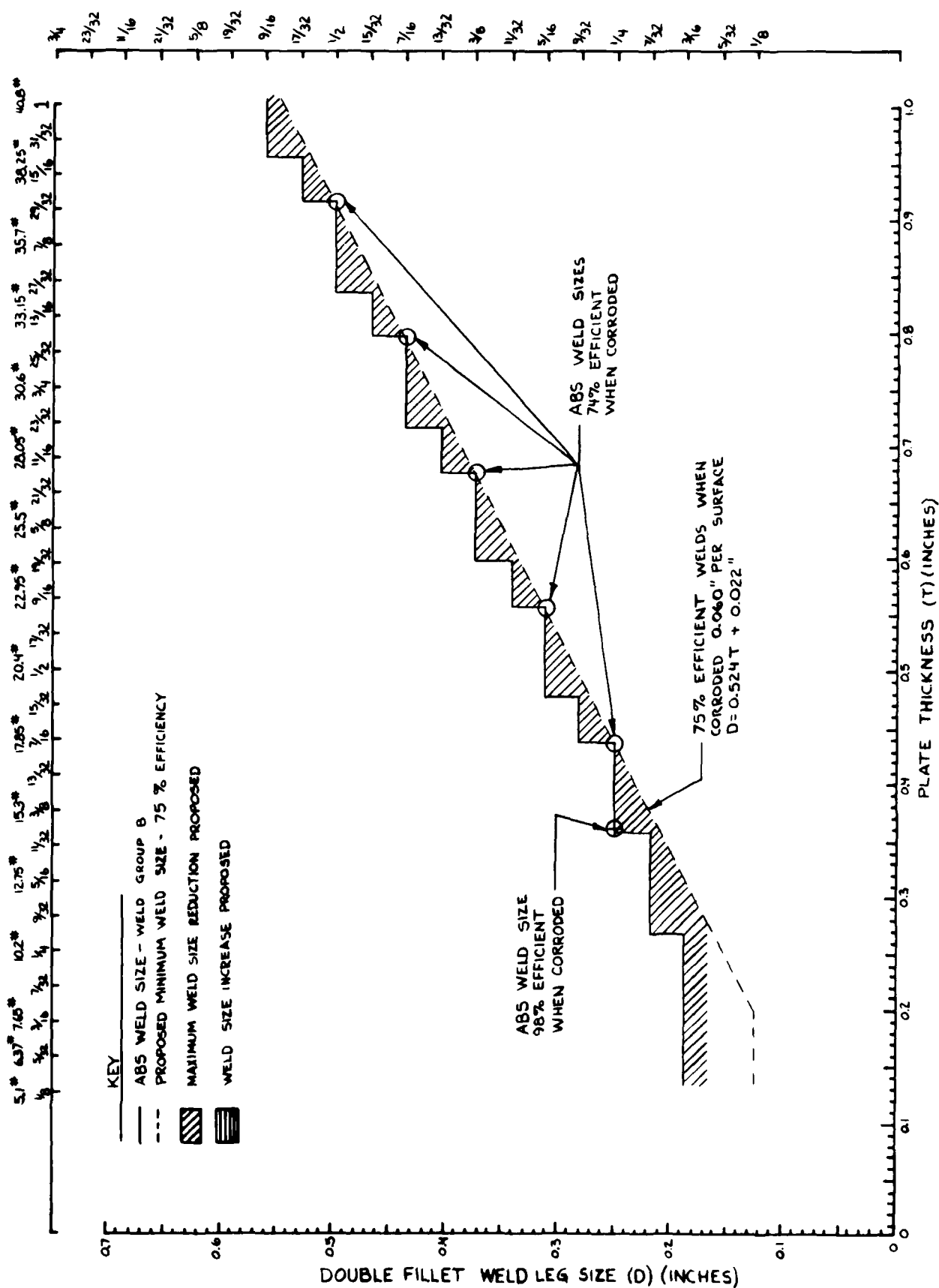
|                     |            | Leg Size for Lesser Thickness of Members Joined, In.               |      |                             |       |      |      |      |      |      |      |      |      |      |      |      |   |
|---------------------|------------|--------------------------------------------------------------------|------|-----------------------------|-------|------|------|------|------|------|------|------|------|------|------|------|---|
|                     |            | 0.20                                                               | 0.24 | 0.28                        | 0.32  | 0.36 | 0.40 | 0.44 | 0.48 | 0.52 | 0.56 | 0.60 | 0.64 |      |      |      |   |
| ABS<br>Weld<br>Grp. | Ln.<br>No. | Nominal leg size of fillet                                         |      | 3/16                        | 3/16  | 1/4  | 1/4  | 1/4  | 1/4  | 5/16 | 5/16 | 5/16 | 5/16 | 5/16 | 5/16 | 5/16 |   |
|                     |            | Length of fillet weld                                              |      | 2-1/8                       | 2-1/2 | 3    | 3    | 3    | 3    | 3    | 3    | 3    | 3    | 3    | 3    | 3    | 3 |
|                     |            | Structural Items                                                   |      |                             |       |      |      |      |      |      |      |      |      |      |      |      |   |
|                     |            | Spacing of Welds S, In.                                            |      |                             |       |      |      |      |      |      |      |      |      |      |      |      |   |
| K1                  | 19         | To center vertical keel                                            | *10  | *10                         | 10    | 10   | 9    | 10   | 10   | 9    | 8    | 8    | 7    | 7    |      |      |   |
| K2                  | 15         | To inner bottom at forward end (fore end strengthening)            | *11  | *11                         | 11    | 11   | 10   | 11   | 11   | 10   | 9    | 9    | 8    | 8    |      |      |   |
| K3                  | 16         | To inner bottom-elsewhere (See Note 5)                             | *12  | *12                         | 12    | 12   | 11   | 12   | 12   | 11   | 10   | 10   | 10   | 10   |      |      |   |
| K3                  | 18         | Stiffeners                                                         | -    | 12                          | 12    | 12   | 11   | 12   | 12   | 11   | 10   | 10   | 10   | 10   |      |      |   |
| K3                  | 25         | Stiffeners                                                         | -    | 12                          | 12    | 12   | 11   | 12   | 12   | 11   | 10   | 10   | 10   | 10   |      |      |   |
| L1                  | 41         | To inner bottom (same as K3)                                       | *12  | *12                         | 12    | 12   | 11   | 12   | 12   | 11   | 10   | 10   | 10   | 10   |      |      |   |
| M1                  | 10         | To center vertical keel and side girders where floor is continuous | *10  | <del>*10</del> <sup>9</sup> | 10    | 10   | 9    | 10   | 10   | 9    | 8    | 8    | 7    | 7    |      |      |   |
| M1                  | 53B        | To face plate area 10 in. <sup>2</sup>                             | -    | -                           | 10    | 10   | 9    | 10   | 10   | 9    | 8    | 8    | 7    | 7    |      |      |   |
| M1                  | 55         | Non-tight structural bulkhead-periphery                            | -    | 9                           | 10    | 10   | 9    | 10   | 10   | 9    | 8    | 8    | 7    | 7    |      |      |   |
| M2                  | 3          | To shell-flat of bottom forward and in peaks                       | -    | -                           | 10    | 10   | 9    | 10   | 10   | 10   | 9    | 9    | 8    | 8    |      |      |   |
| M2                  | 8          | To shell-flat of bottom forward and in peaks                       | -    | -                           | 10    | 10   | 9    | 10   | 10   | 10   | 9    | 9    | 8    | 8    |      |      |   |
| M2                  | 36         | To shell for 0.125L forward                                        | -    | -                           | 10    | 10   | 9    | 10   | 10   | 10   | 9    | 9    | 8    | 8    |      |      |   |
| M2                  | 37         | To shell in peaks                                                  | -    | -                           | 10    | 10   | 9    | 10   | 10   | 10   | 9    | 9    | 8    | 8    |      |      |   |
| M2                  | 43         | To shell for 0.125L forward                                        | -    | -                           | 10    | 10   | 9    | 10   | 10   | 10   | 9    | 9    | 8    | 8    |      |      |   |
| M2                  | 44         | To shell in peaks                                                  | -    | -                           | 10    | 10   | 9    | 10   | 10   | 10   | 9    | 9    | 8    | 8    |      |      |   |
| M3                  | 27         | To shell-elsewhere                                                 | *11  | *11                         | 11    | 11   | 10   | 11   | 11   | 10   | 9    | 9    | 8    | 8    |      |      |   |
| M3                  | 29         | To inner bottom-elsewhere                                          | *11  | *11                         | 11    | 11   | 10   | 11   | 11   | 10   | 9    | 9    | 8    | 8    |      |      |   |
| M3                  | 31         | To floors-elsewhere (Same as K2)                                   | *11  | *11                         | 11    | 11   | 10   | 11   | 11   | 10   | 9    | 9    | 8    | 8    |      |      |   |

|                                                                    |            | Leg Size for Lesser Thickness of Members Joined, In.                                          |            |            |       |      |      |      |      |      |      |      |      |      |      |      |   |
|--------------------------------------------------------------------|------------|-----------------------------------------------------------------------------------------------|------------|------------|-------|------|------|------|------|------|------|------|------|------|------|------|---|
|                                                                    |            | 0.20                                                                                          | 0.24       | 0.28       | 0.32  | 0.36 | 0.40 | 0.44 | 0.48 | 0.52 | 0.56 | 0.60 | 0.64 |      |      |      |   |
| ABS<br>Weld<br>Grp.                                                | Ln.<br>No. | Nominal leg size of fillet                                                                    |            | 3/16       | 3/16  | 1/4  | 1/4  | 1/4  | 5/16 | 5/16 | 5/16 | 5/16 | 5/16 | 5/16 | 5/16 | 5/16 |   |
|                                                                    |            | Length of fillet weld                                                                         |            | 2-1/8      | 2-1/2 | 3    | 3    | 3    | 3    | 3    | 3    | 3    | 3    | 3    | 3    | 3    | 3 |
|                                                                    |            | Structural Items                                                                              |            |            |       |      |      |      |      |      |      |      |      |      |      |      |   |
|                                                                    |            | Spacing of Welds S, In.                                                                       |            |            |       |      |      |      |      |      |      |      |      |      |      |      |   |
| M4                                                                 | 4          | To shell-elsewhere                                                                            | *12        | *12        | 12    | 12   | 11   | 12   | 12   | 11   | 10   | 10   | 10   | 10   | 10   | 10   |   |
| M4                                                                 | 5          | To face plate                                                                                 | *12        | *12        | 12    | 12   | 11   | 12   | 12   | 11   | 10   | 10   | 10   | 10   | 10   | 10   |   |
| M4                                                                 | 9          | To shell elsewhere<br>(See Note 5)                                                            | *12        | *12        | 12    | 12   | 11   | 12   | 12   | 11   | 10   | 10   | 10   | 10   | 10   | 10   |   |
| M4                                                                 | 33         | Stiffeners                                                                                    | 12         | 12         | 12    | 12   | 11   | 12   | 12   | 11   | 10   | 10   | 10   | 10   | 10   | 10   |   |
| M4                                                                 | 38         | To shell-elsewhere<br>(See Note 1)                                                            | *12        | *12        | 12    | 12   | 11   | 12   | 12   | 11   | 10   | 10   | 10   | 10   | 10   | 10   |   |
| M4                                                                 | 46         | To shell elsewhere                                                                            | *12        | *12        | 12    | 12   | 11   | 12   | 12   | 11   | 10   | 10   | 10   | 10   | 10   | 10   |   |
| M4                                                                 | 47         | To inner bottom                                                                               | *12        | 12         | 12    | 12   | 11   | 12   | 12   | 11   | 10   | 10   | 10   | 10   | 10   | 10   |   |
| M4                                                                 | 53A        | To face plate 10 in. <sup>2</sup>                                                             | *10-<br>12 | *10-<br>12 | 12    | 12   | 11   | 12   | 12   | 11   | 10   | 10   | 10   | 10   | 10   | 10   |   |
| M4                                                                 | 58         | To deep tank bulkheads<br>(See Note 1)                                                        | -          | *12        | 12    | 12   | 11   | 12   | 12   | 11   | 10   | 10   | 10   | 10   | 10   | 10   |   |
| M4                                                                 | 59         | To watertight bulkheads and<br>superstructure or deckhouse<br>front-bulkheads<br>(See Note 1) | -          | *12        | 12    | 12   | 11   | 12   | 12   | 11   | 10   | 10   | 10   | 10   | 10   | 10   |   |
| M4                                                                 | 67         | To decks, except slab<br>longitudinals                                                        | *12        | *12        | 12    | 12   | 11   | 12   | 12   | 11   | 10   | 10   | 10   | 10   | 10   | 10   |   |
| M4                                                                 | 73         | To plating and to face<br>plate (See Note 4)                                                  | *12        | *12        | 12    | 12   | 11   | 12   | 12   | 11   | 10   | 10   | 10   | 10   | 10   | 10   |   |
| M5                                                                 | 60         | To non-tight structural<br>bulkhead (See Note 2)                                              | *12        | *12        | 12    | 12   | 12   | 12   | 12   | 12   | 12   | 12   | 12   | 10   | 10   | 10   |   |
| M5                                                                 | 61         | To deckhouse side and<br>superstructure end<br>bulkheads (See Note 2)                         | *12        | *12        | 12    | 12   | 12   | 12   | 12   | 12   | 12   | 12   | 12   | 10   | 10   | 10   |   |
| ADDITIONAL WELDING REQUIREMENTS FOR VESSELS CLASSED "OIL CARRIERS" |            |                                                                                               |            |            |       |      |      |      |      |      |      |      |      |      |      |      |   |
| R1                                                                 | 89         | To face bars                                                                                  | -          | -          | -     | 6    | 6    | 6    | 6    | 5    | 5    | 5    | 5    | -    | -    | -    |   |
| R1                                                                 | 96         | To face bars                                                                                  | -          | -          | -     | 6    | 6    | 6    | 6    | 5    | 5    | 5    | 5    | -    | -    | -    |   |

APPENDIX C

PLOTS OF ABS AND PROPOSED FILLET WELD SIZES









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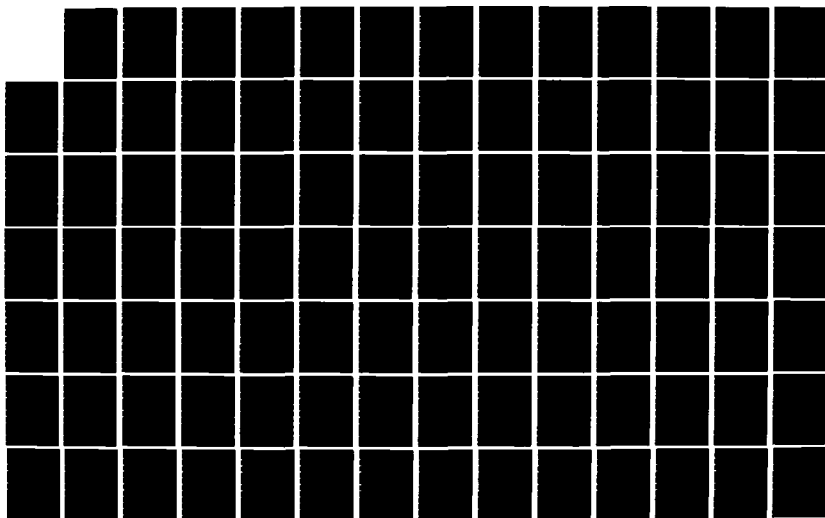
UPDATING OF FILLET WELD STRENGTH PARAMETERS FOR  
COMMERCIAL SHIPBUILDING(U) R P KRUMPEN ET AL. APR 83  
BA-117960 SSC-323 DTCG23-81-C-20030

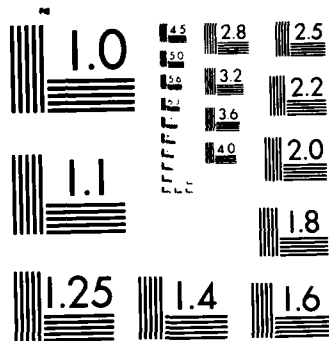
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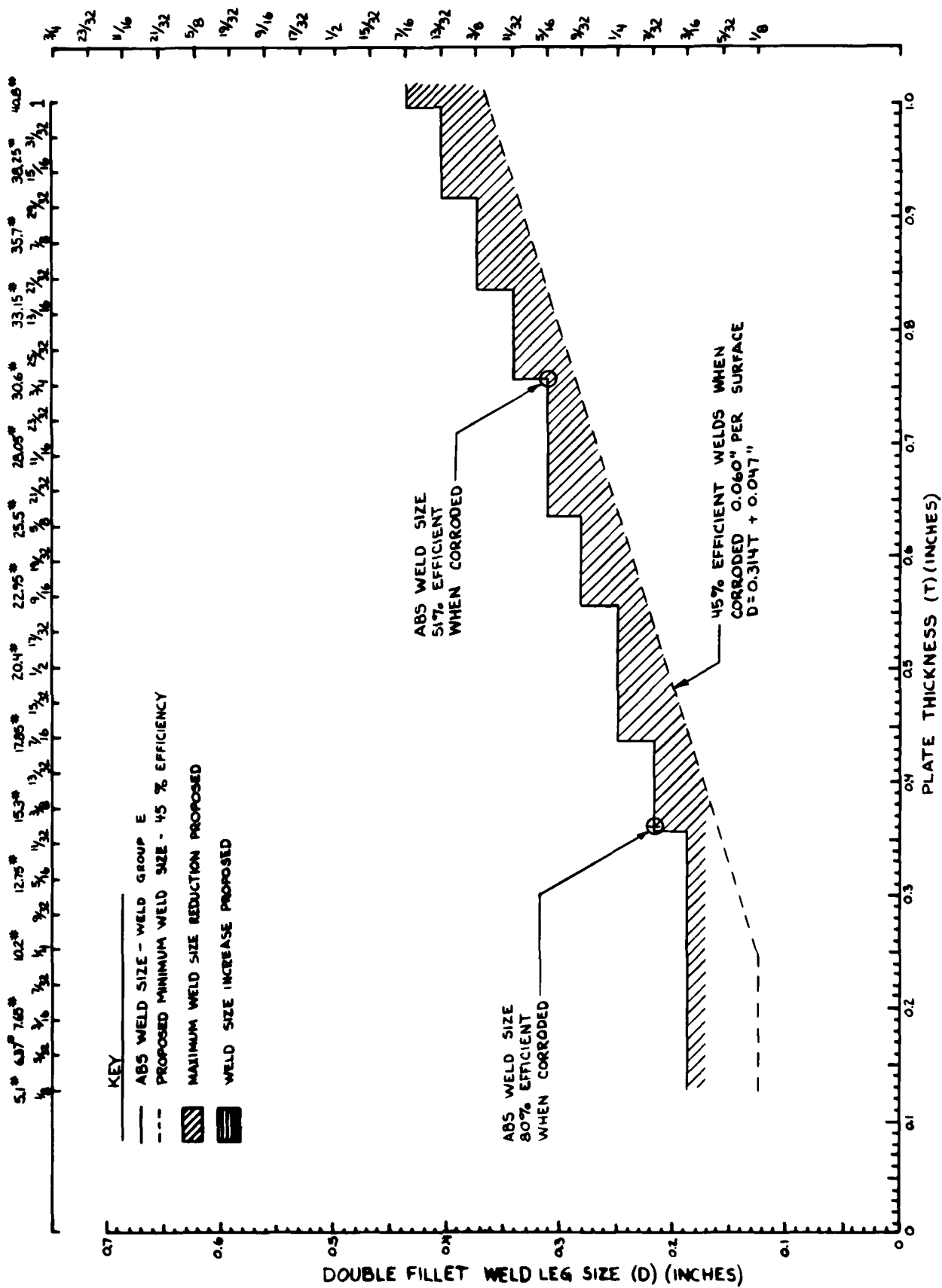
F/G 13/8

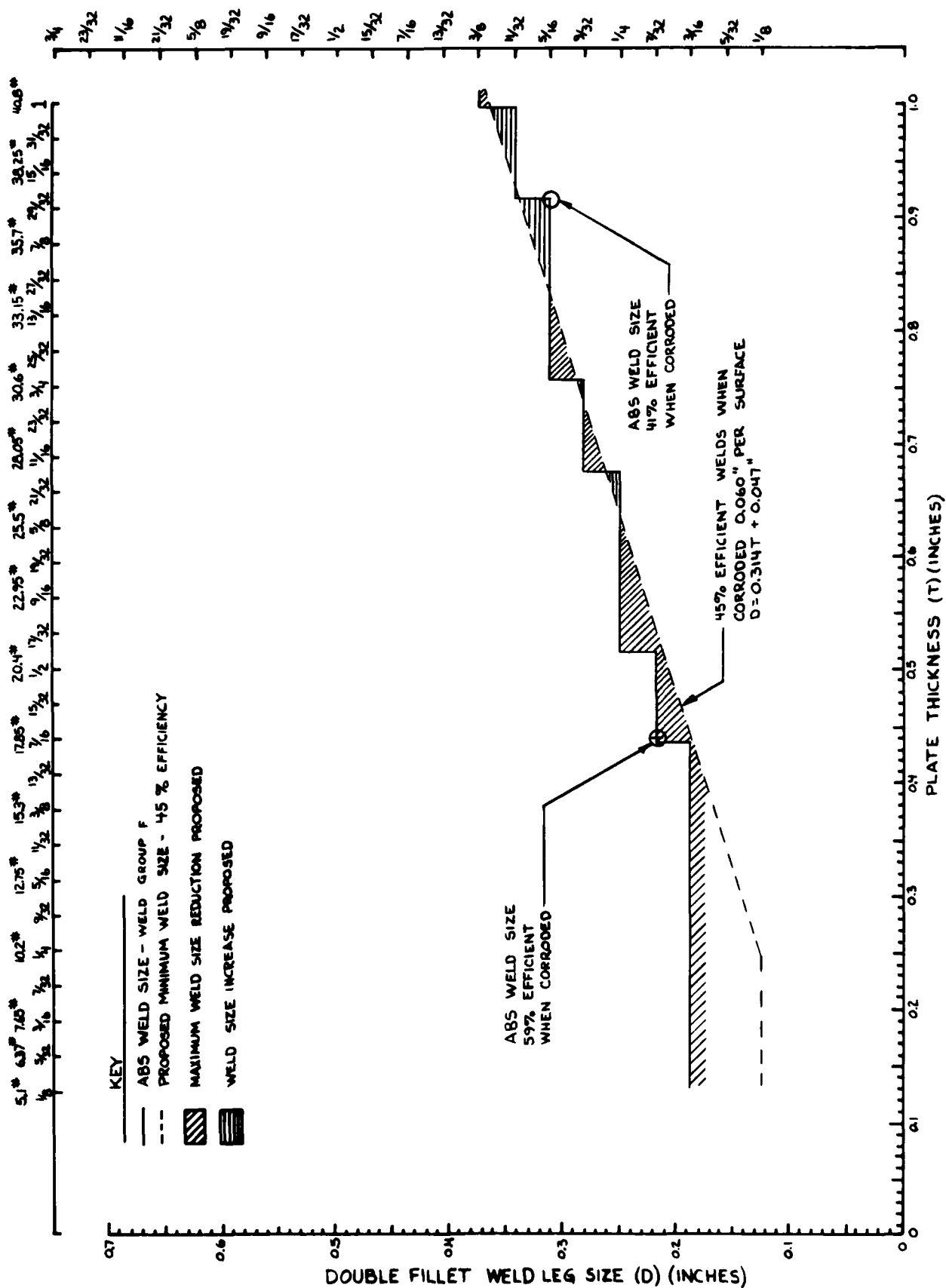
NL

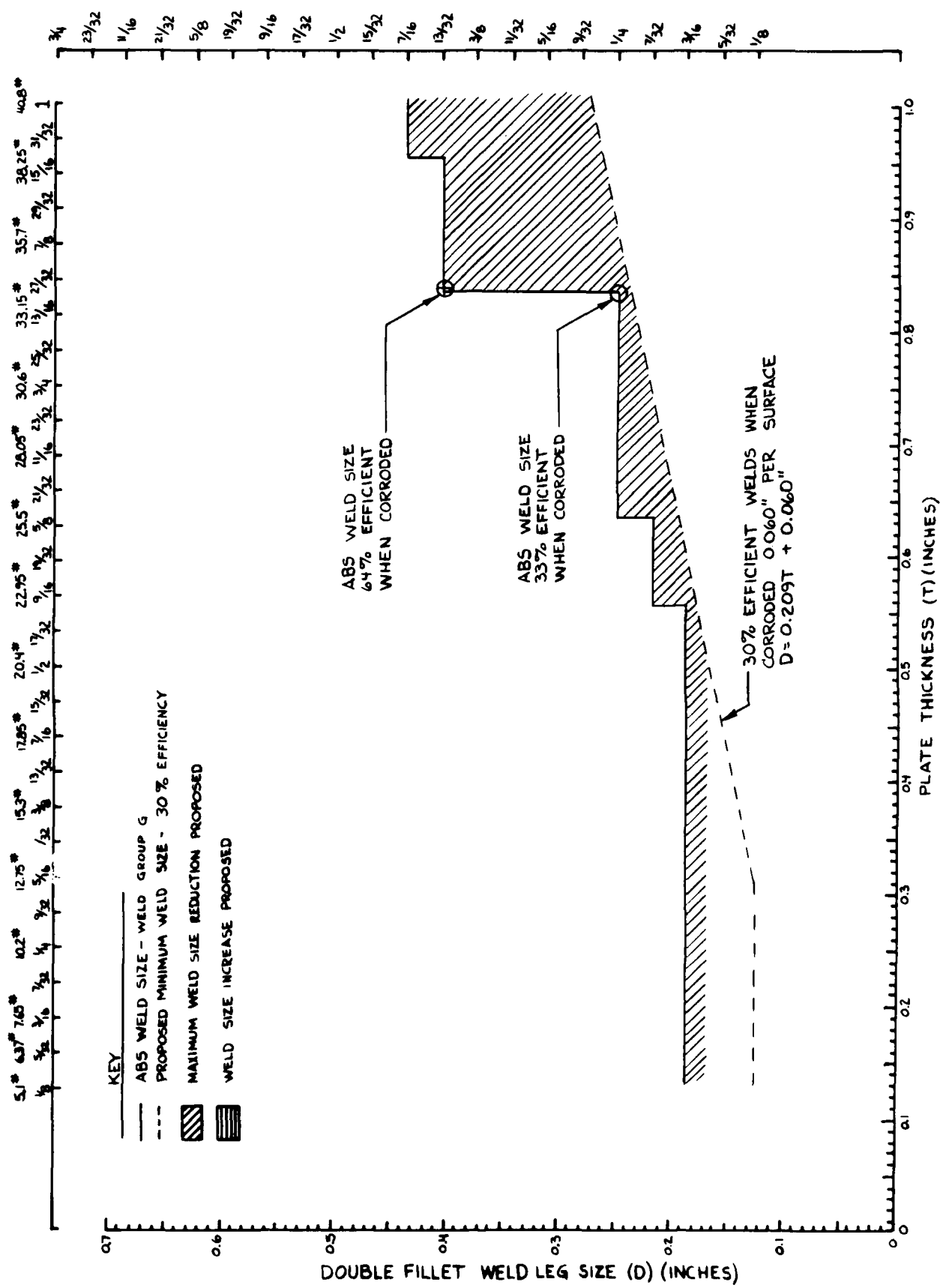


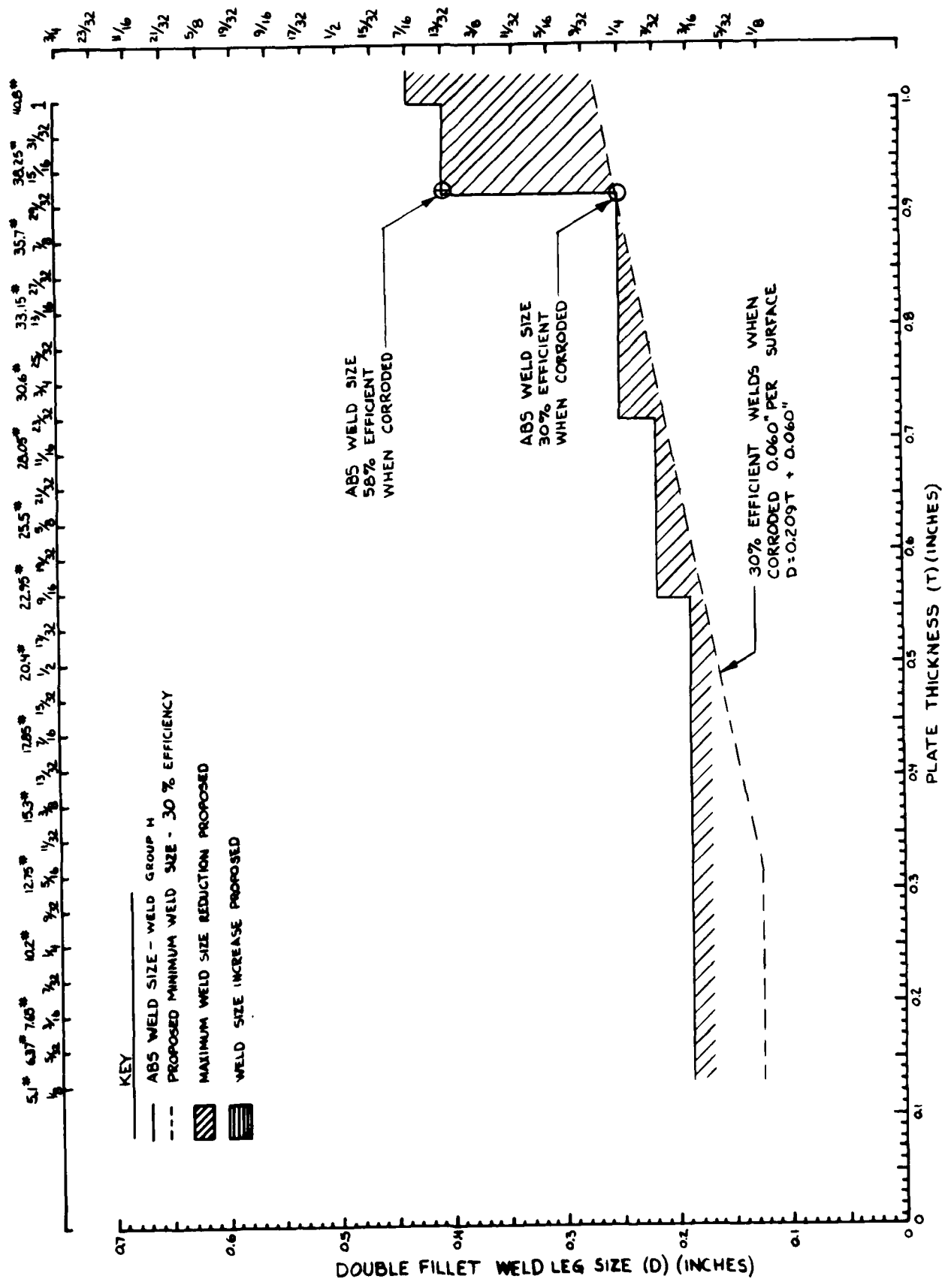


MICROCOPY RESOLUTION TEST CHART  
NATIONAL BUREAU OF STANDARDS 1963-A

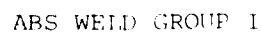


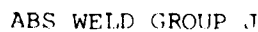


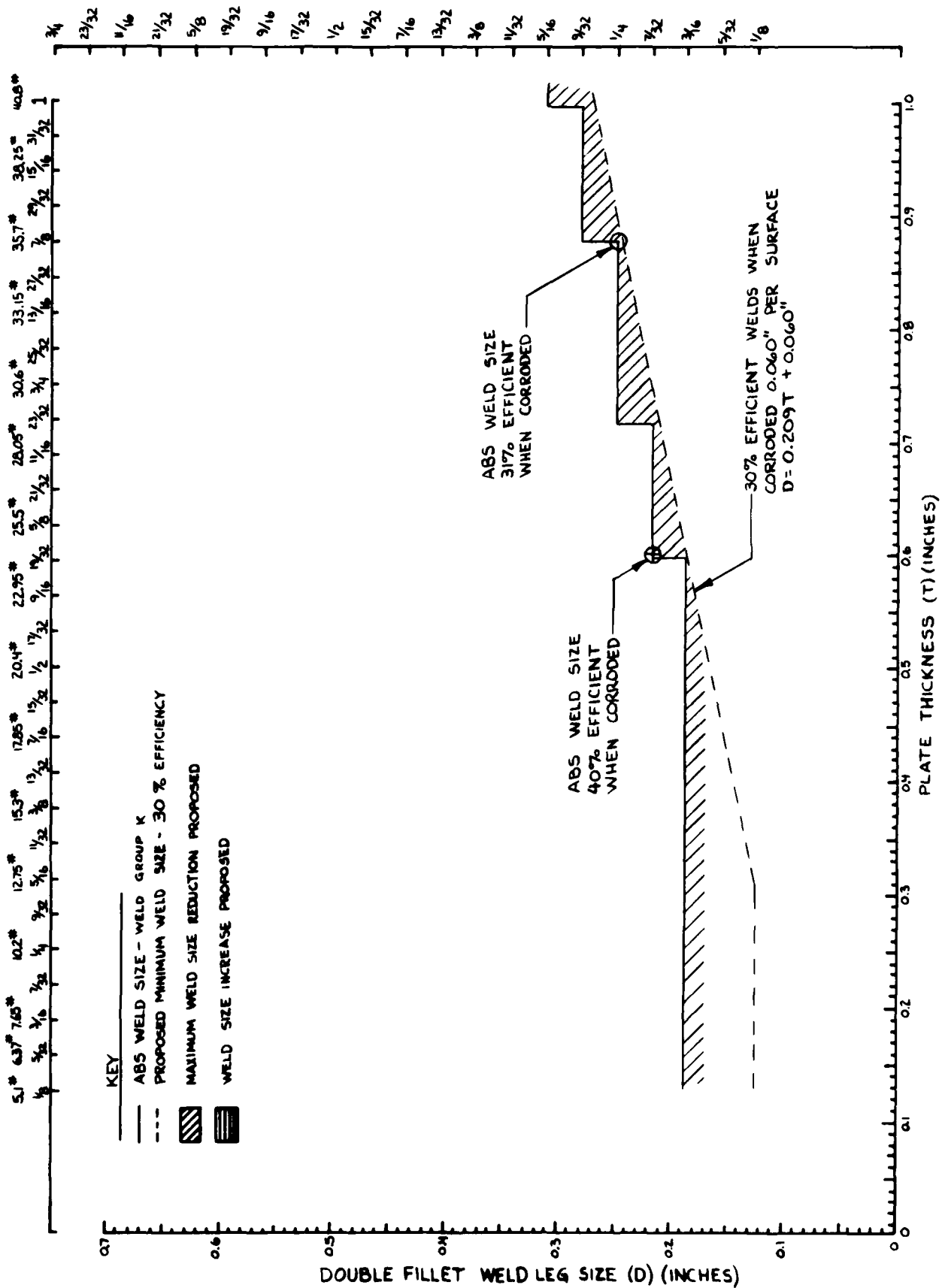


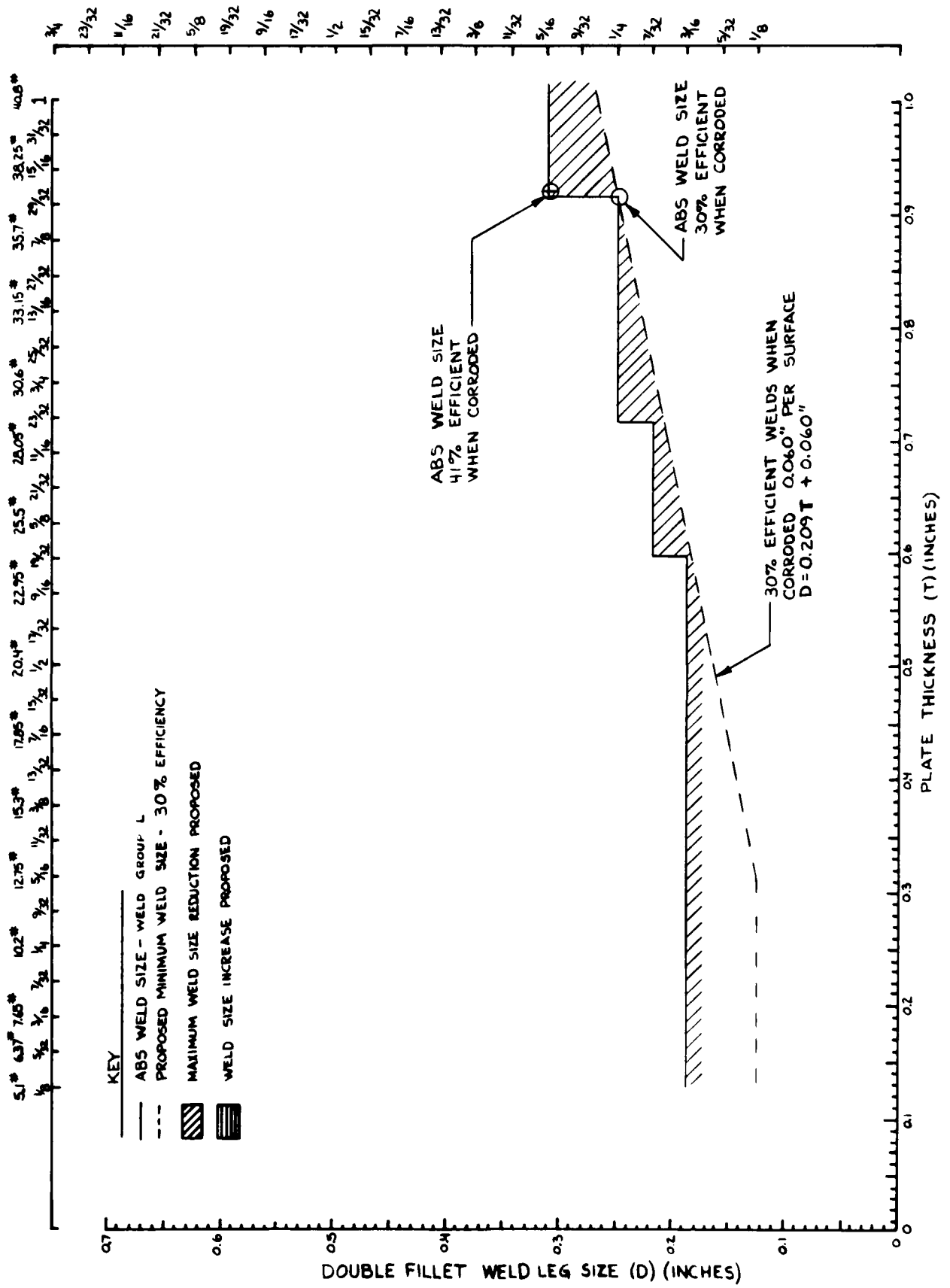


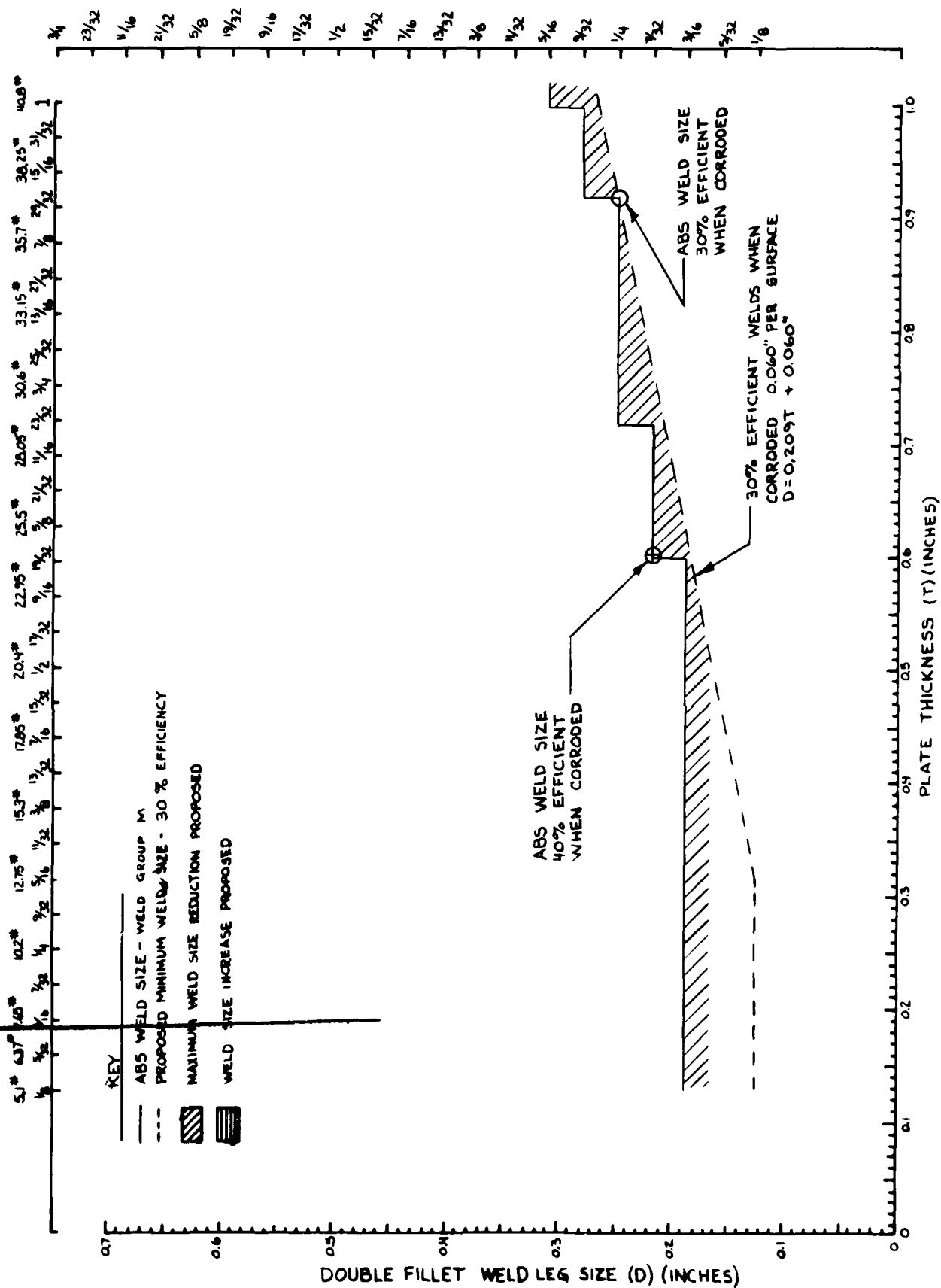
ABS WELD GROUP H



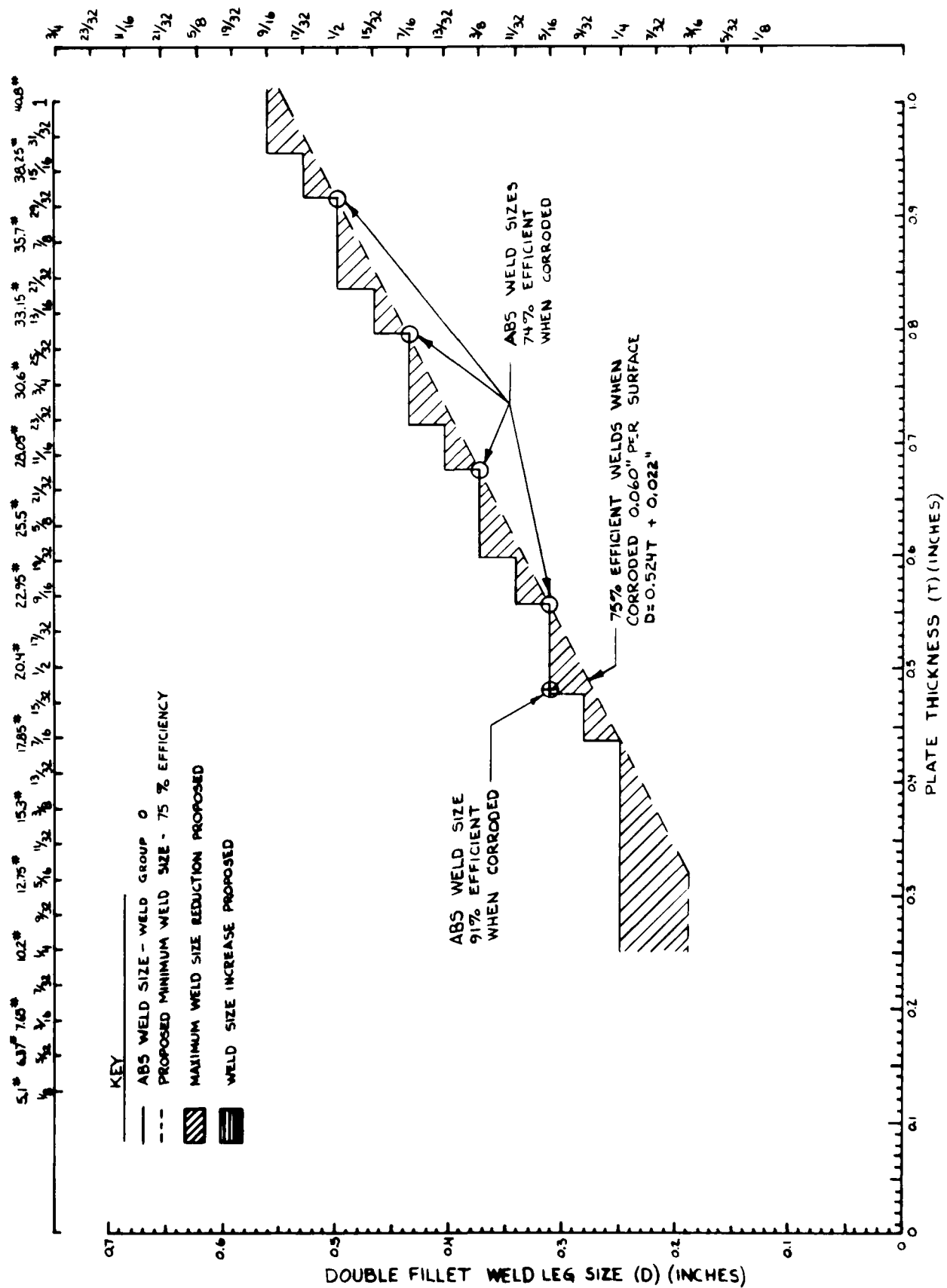


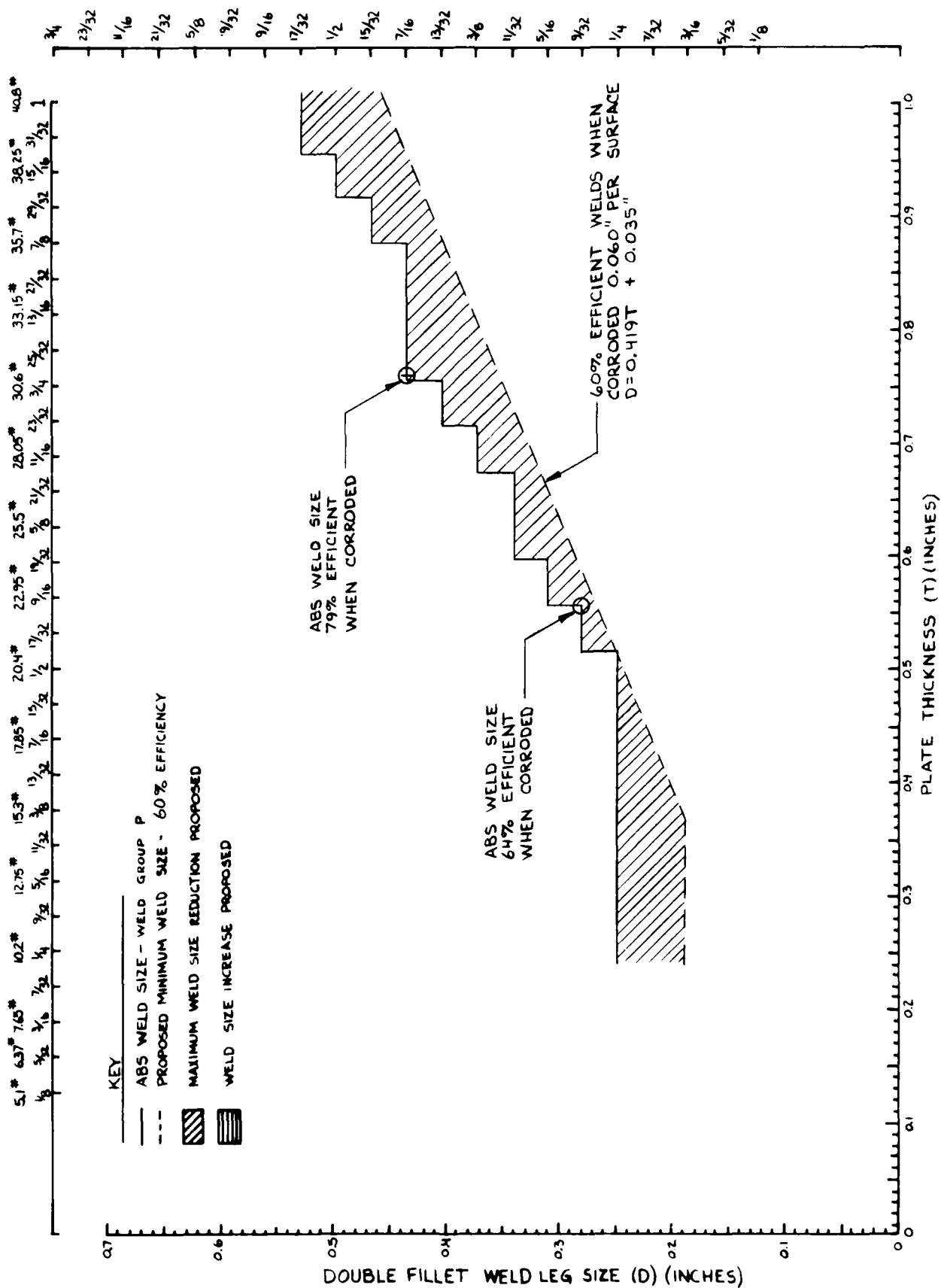




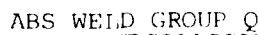




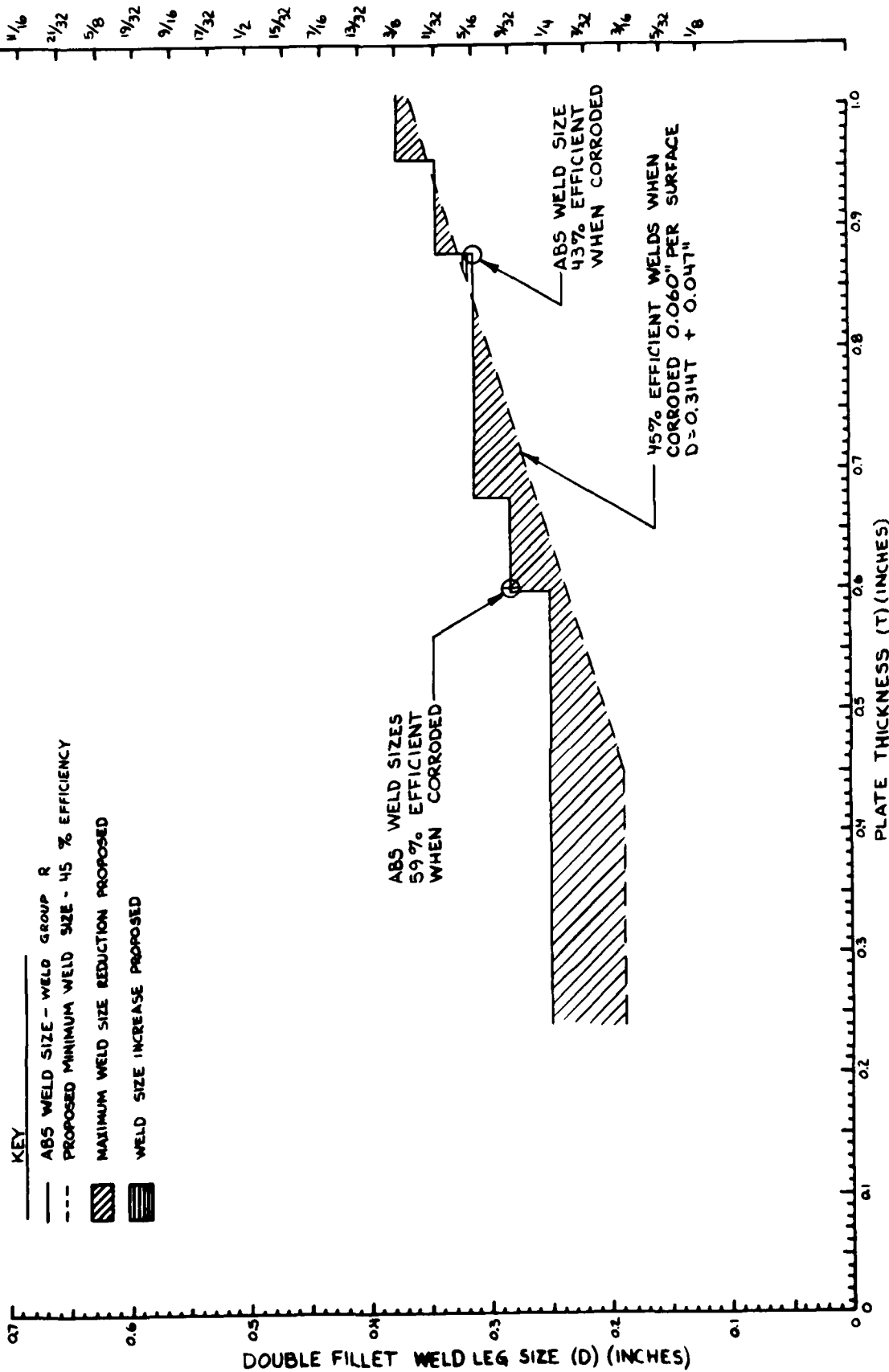




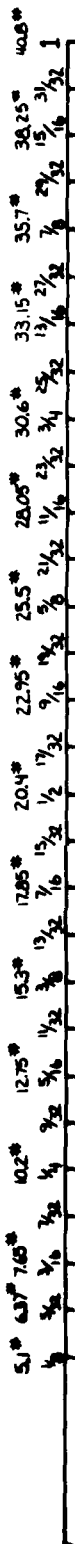
ABS WELD GROUP P



|      |       |       |       |        |       |        |       |        |       |        |       |        |       |        |       |
|------|-------|-------|-------|--------|-------|--------|-------|--------|-------|--------|-------|--------|-------|--------|-------|
| 5.1" | 4.37" | 7.65" | 10.2" | 12.75" | 15.3" | 17.85" | 20.4" | 22.95" | 25.5" | 28.05" | 30.6" | 33.15" | 35.7" | 38.25" | 40.8" |
| 1/8  | 3/32  | 1/16  | 7/32  | 5/16   | 1/2   | 3/8    | 19/32 | 17/32  | 3/8   | 21/32  | 23/32 | 25/32  | 27/32 | 29/32  | 31/32 |







- KEY**
- ABS WELD SIZE - WELD GROUP C2
  - - - PROPOSED MINIMUM WELD SIZE
  - ▨ MAXIMUM WELD SIZE REDUCTION PROPOSED
  - ▩ WELD SIZE INCREASE PROPOSED

DOUBLE FILLET WELD SIZE (D) AND EQUIVALENT  
DOUBLE FILLET WELD SIZE (D<sub>ie</sub>) (INCHES)  
ABS WELD GROUP C2

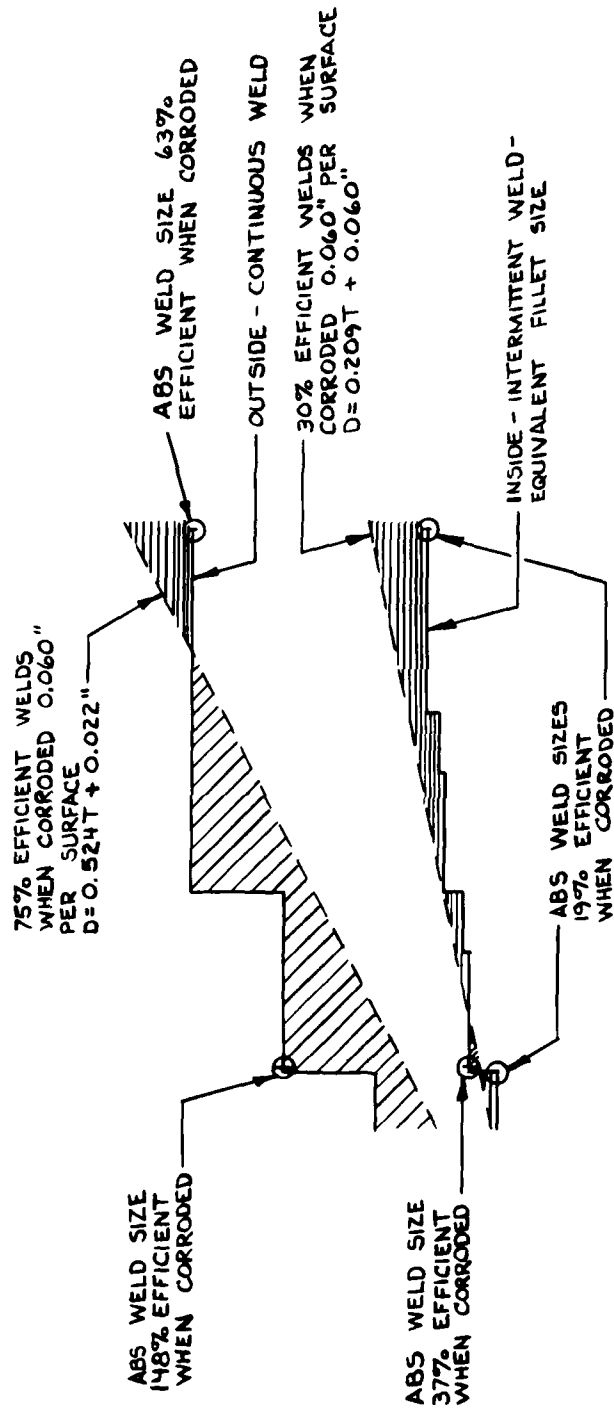
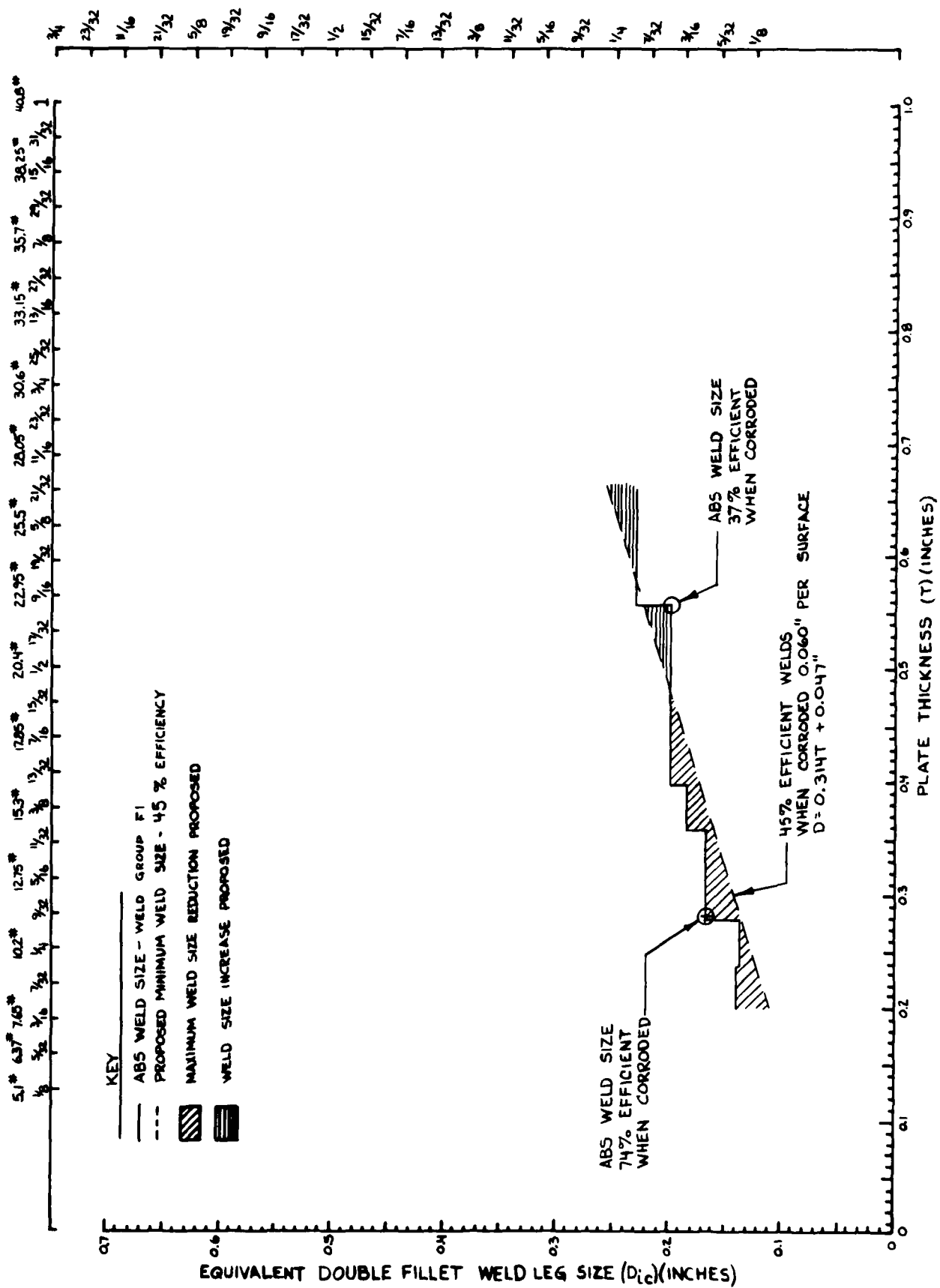
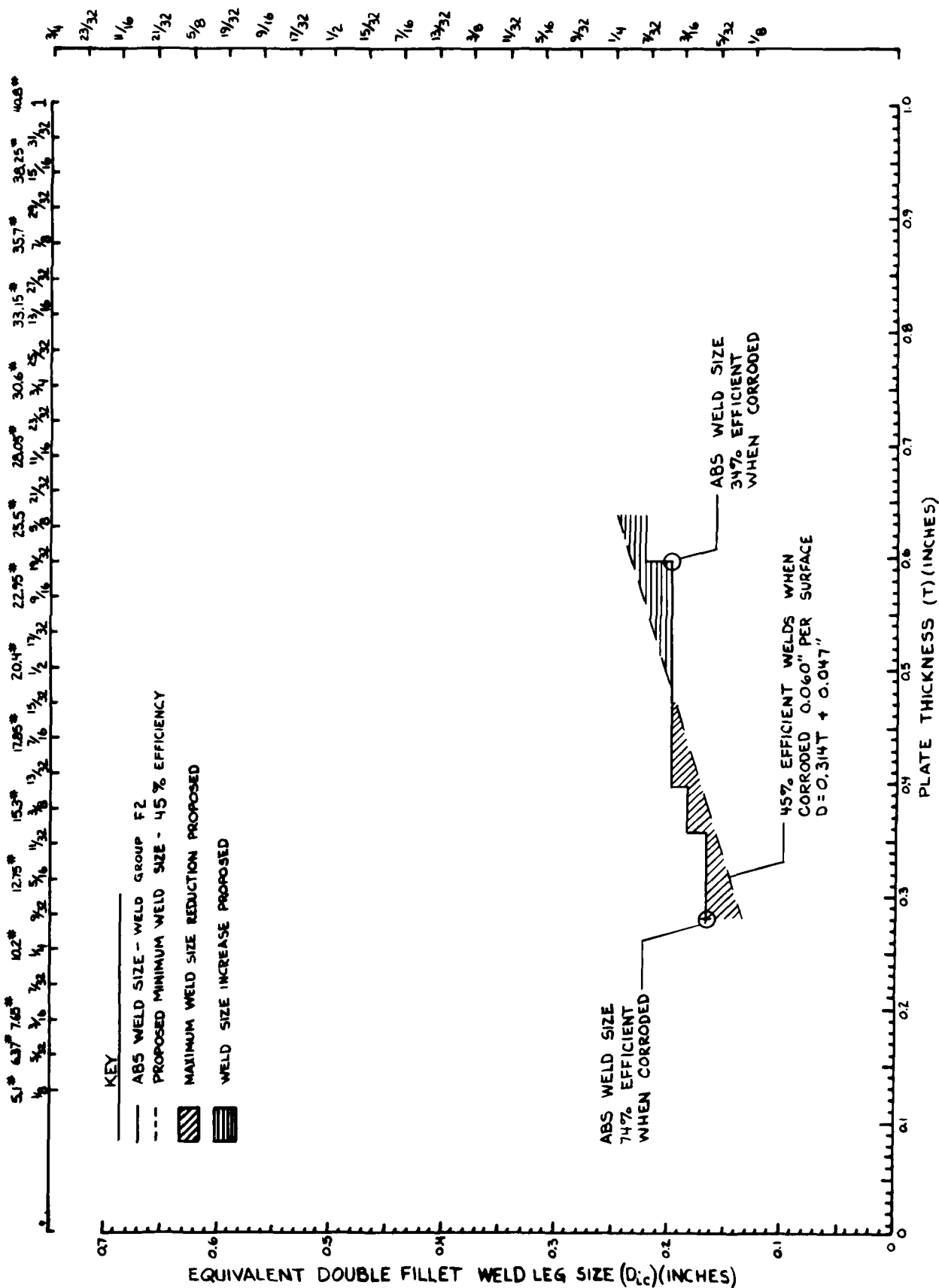


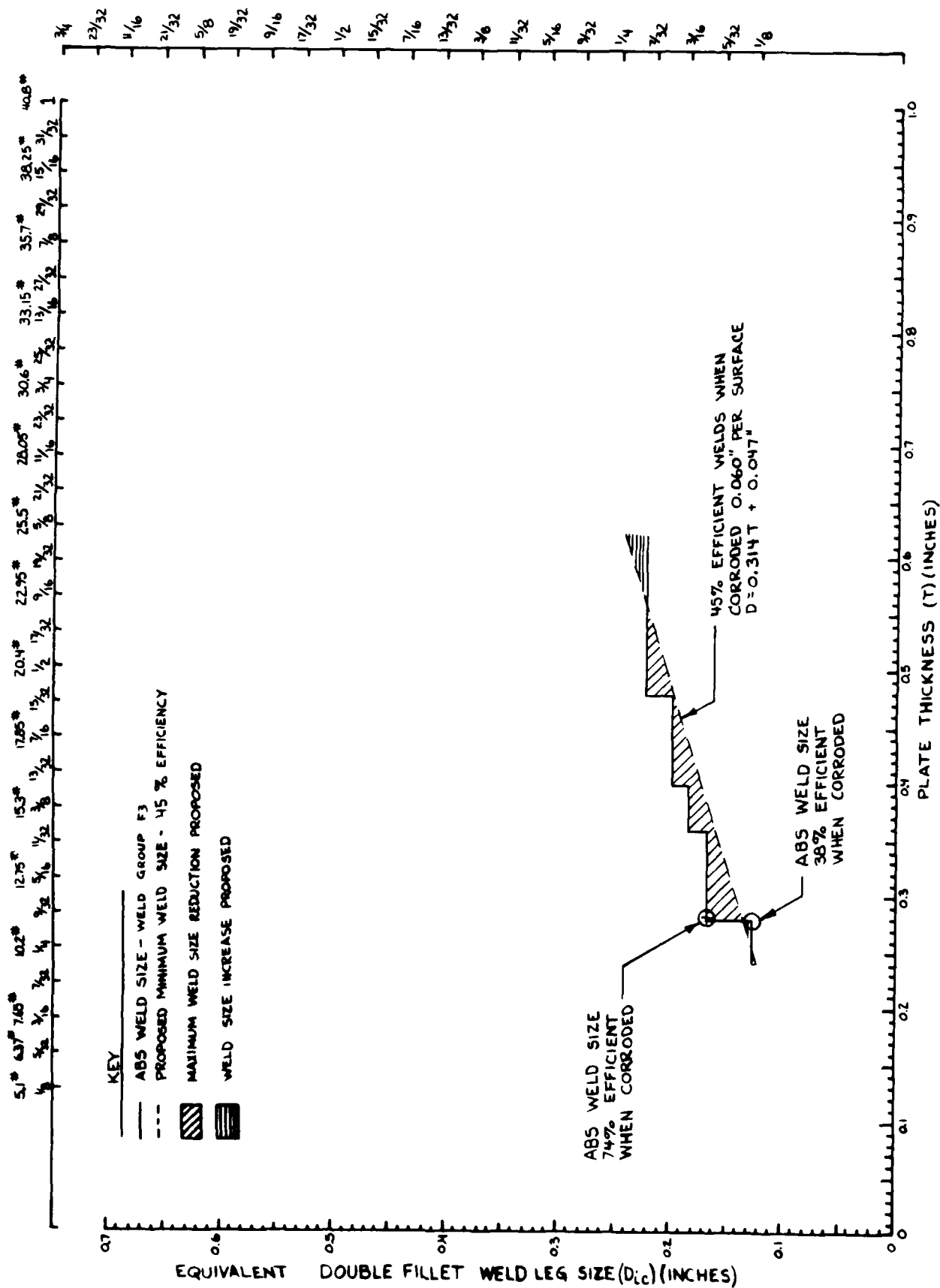
PLATE THICKNESS (T) (INCHES)

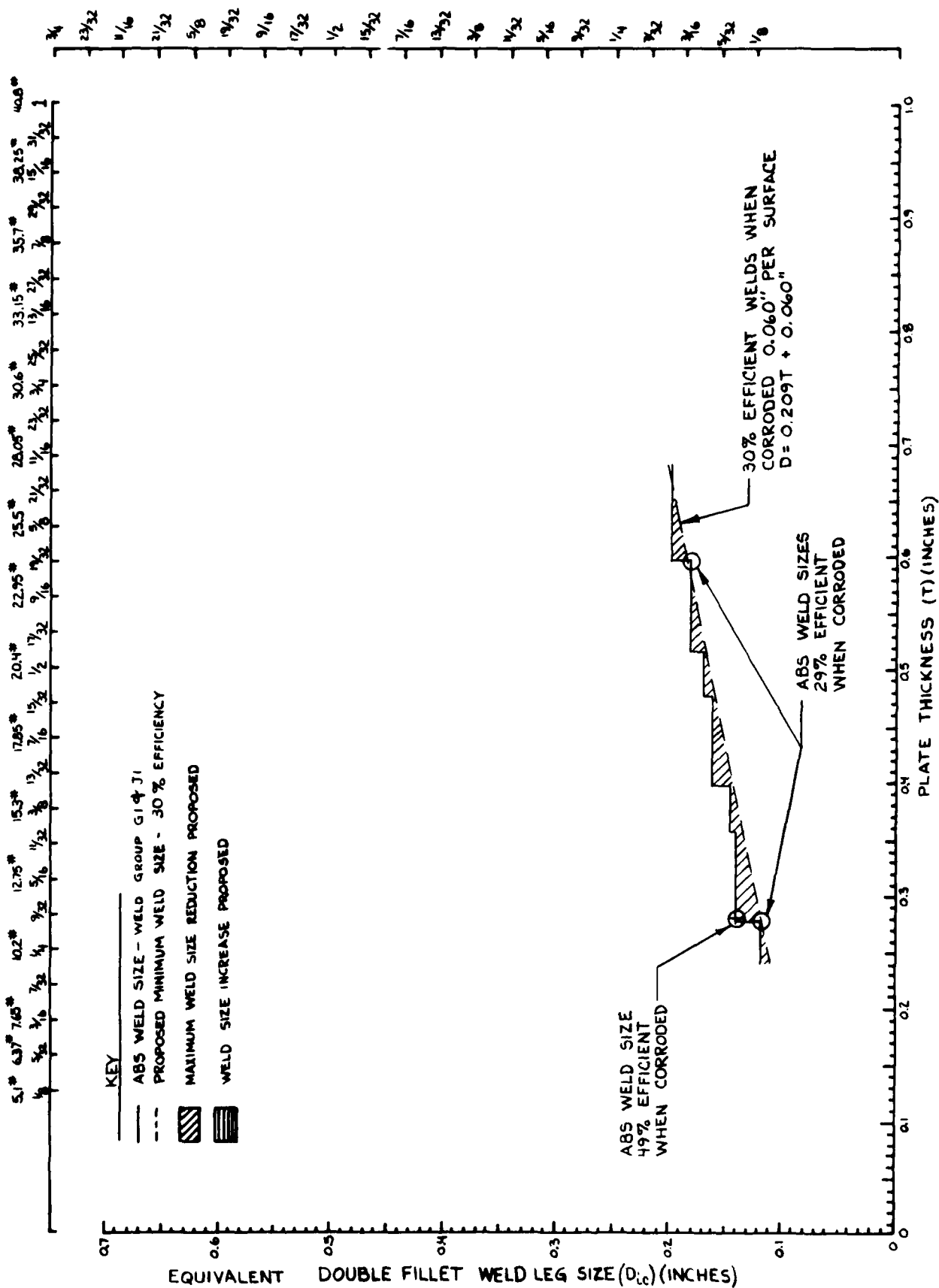


ABS WELD GROUP F1

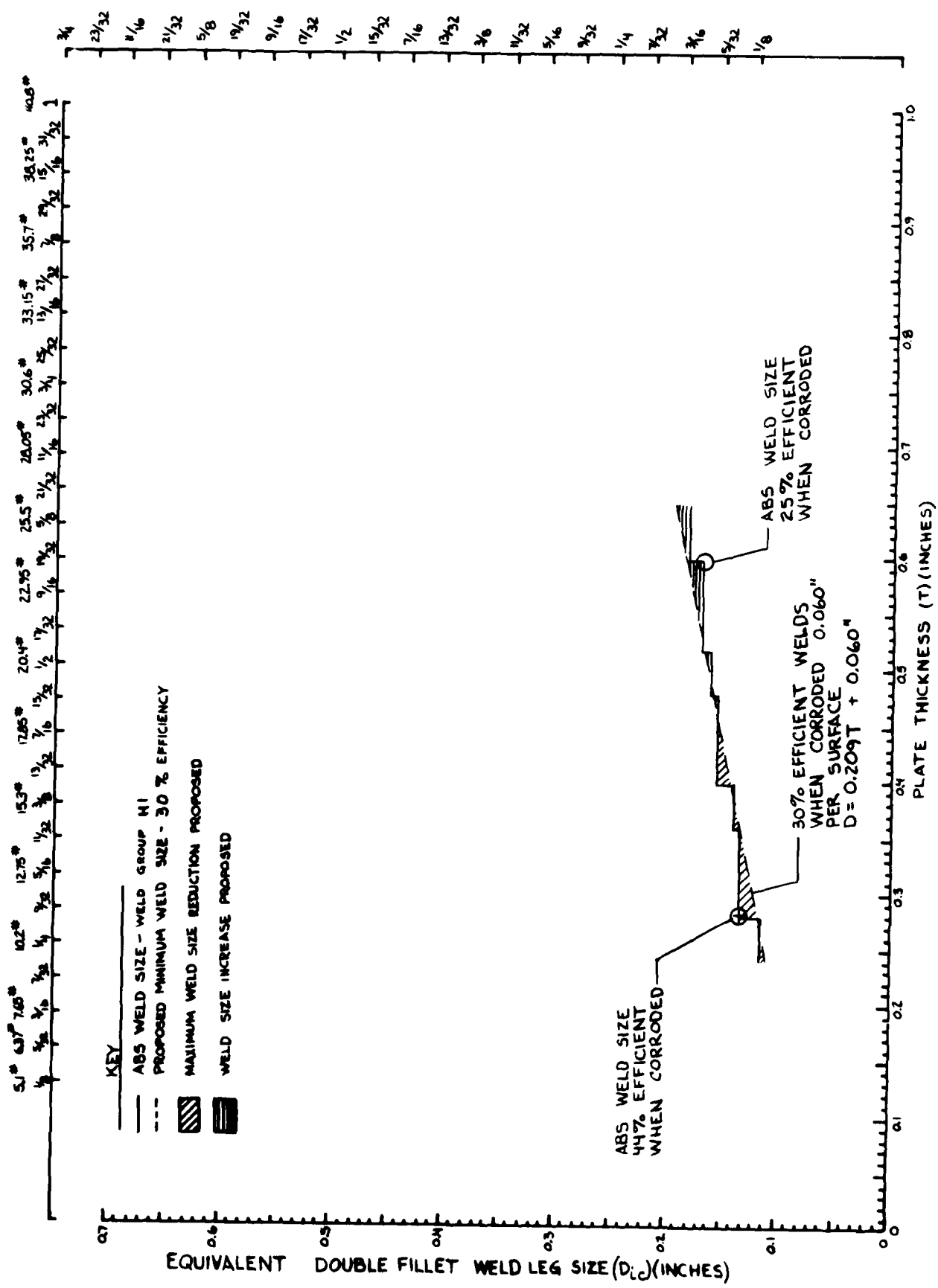


ABS WELD GROUP F2





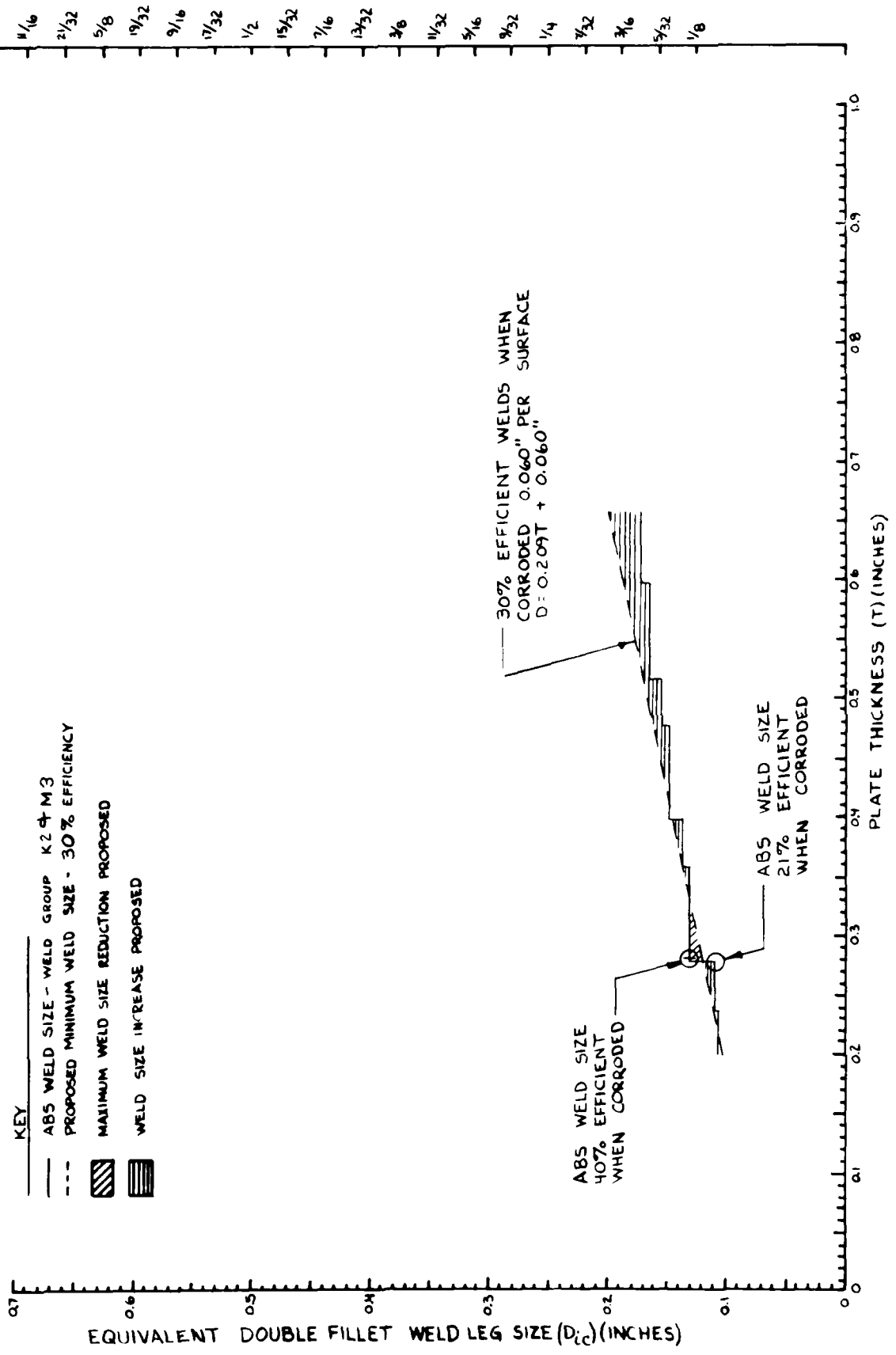
ABS WELD GROUPS G1 & J1



ABS WELD GROUP H1



|      |       |       |       |        |       |        |       |        |       |        |        |        |       |        |        |
|------|-------|-------|-------|--------|-------|--------|-------|--------|-------|--------|--------|--------|-------|--------|--------|
| 5.1" | 6.37" | 7.65" | 10.2" | 12.75" | 15.3" | 17.85" | 20.4" | 22.95" | 25.5" | 28.05" | 30.6"  | 33.15" | 35.7" | 38.25" | 40.8"  |
| 3/16 | 7/32  | 1/4   | 9/32  | 5/16   | 11/32 | 3/8    | 13/32 | 7/16   | 15/32 | 1 1/8  | 1 1/16 | 23/32  | 1 1/8 | 29/32  | 1 5/16 |



ABS WELD GROUPS K2 & M3  
 C-138

5.1" 4.3" 7.65" 10.2" 12.75" 15.3" 17.85" 20.4" 22.95" 25.5" 28.05" 30.6" 33.15" 35.7" 38.25" 40.8"

3/4 23/32 1/16 2/32 5/8 19/32 9/16 17/32 1/2 15/32 7/16 13/32 3/8 11/32 5/16 9/32 1/4 7/32 3/16 5/32 1/8

KEY

- ABS WELD SIZE - WELD GROUP K3 & L1
- - - PROPOSED MINIMUM WELD SIZE - 30 % EFFICIENCY
- ▨ MAXIMUM WELD SIZE REDUCTION PROPOSED
- ▤ WELD SIZE INCREASE PROPOSED

EQUIVALENT DOUBLE FILLET WELD LEG SIZE (D<sub>LC</sub>) (INCHES)

ABS WELD GROUPS K3 & L1

(1-734)

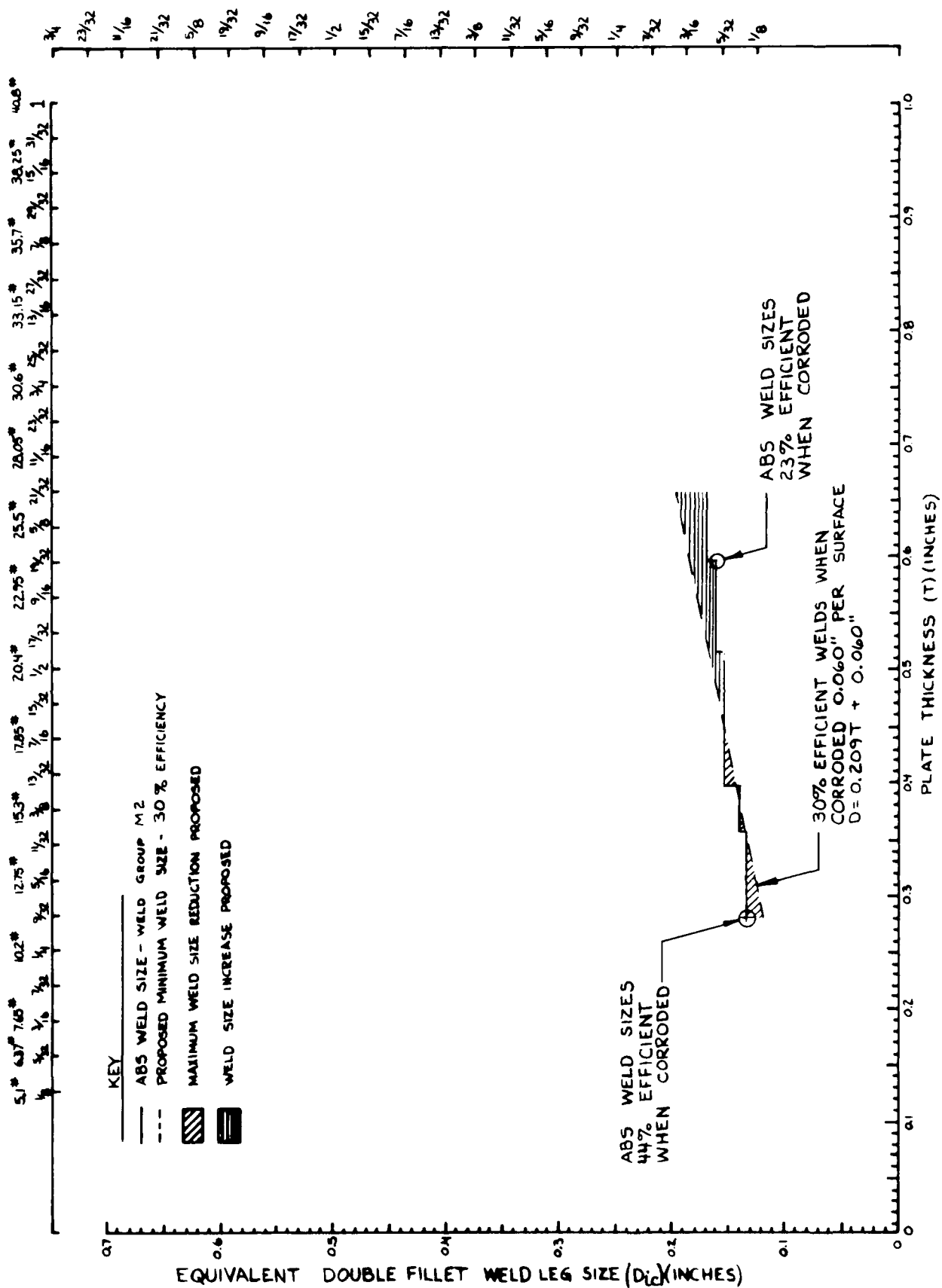
30% EFFICIENT WELDS WHEN CORRODED 0.060" PER SURFACE  
D = 0.209T + 0.060"

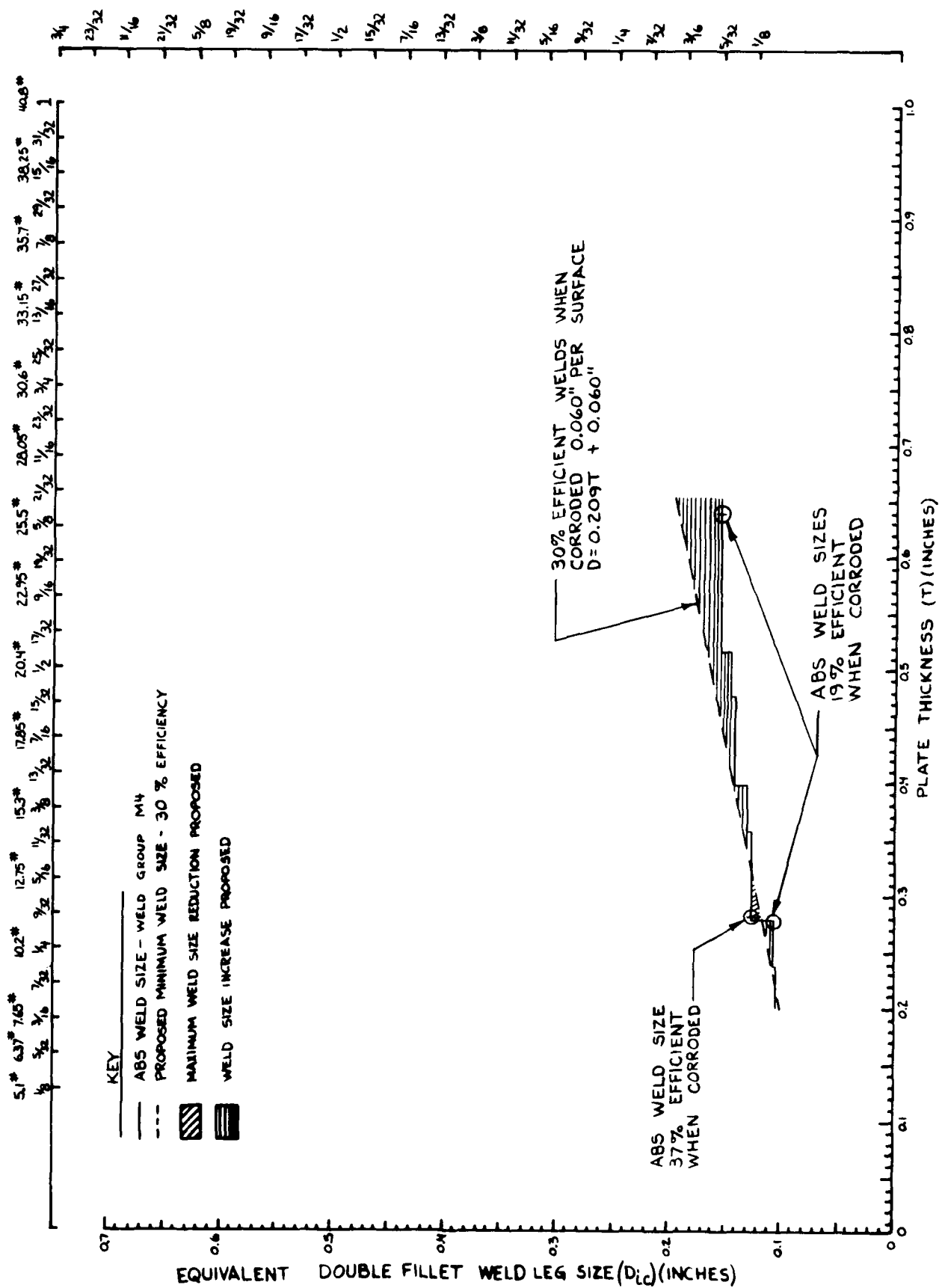
ABS WELD SIZE 37% EFFICIENT WHEN CORRODED

ABS WELD SIZES 19% EFFICIENT WHEN CORRODED

PLATE THICKNESS (T) (INCHES)







|      |      |      |      |      |      |      |       |       |       |       |       |      |       |       |       |       |      |       |      |
|------|------|------|------|------|------|------|-------|-------|-------|-------|-------|------|-------|-------|-------|-------|------|-------|------|
| 5.1* | 4.3* | 3.7* | 3.0* | 2.5* | 2.0* | 1.7* | 1.5*  | 1.3*  | 1.1*  | 0.9*  | 0.8*  | 0.7* | 0.6*  | 0.5*  | 0.4*  | 0.3*  | 0.2* | 0.1*  | 0.0* |
| 1/2  | 3/8  | 1/2  | 5/8  | 3/4  | 7/8  | 1    | 1 1/8 | 1 1/4 | 1 1/2 | 1 3/4 | 1 7/8 | 2    | 2 1/8 | 2 1/4 | 2 1/2 | 2 3/4 | 3    | 3 1/2 | 4    |

KEY

- ABS WELD SIZE - WELD GROUP M5
- PROPOSED MINIMUM WELD SIZE - 30 % EFFICIENCY
- MAXIMUM WELD SIZE REDUCTION PROPOSED
- WELD SIZE INCREASE PROPOSED

EQUIVALENT DOUBLE FILLET WELD LEG SIZE (D<sub>IC</sub>) (INCHES)

ABS WELD GROUP M5

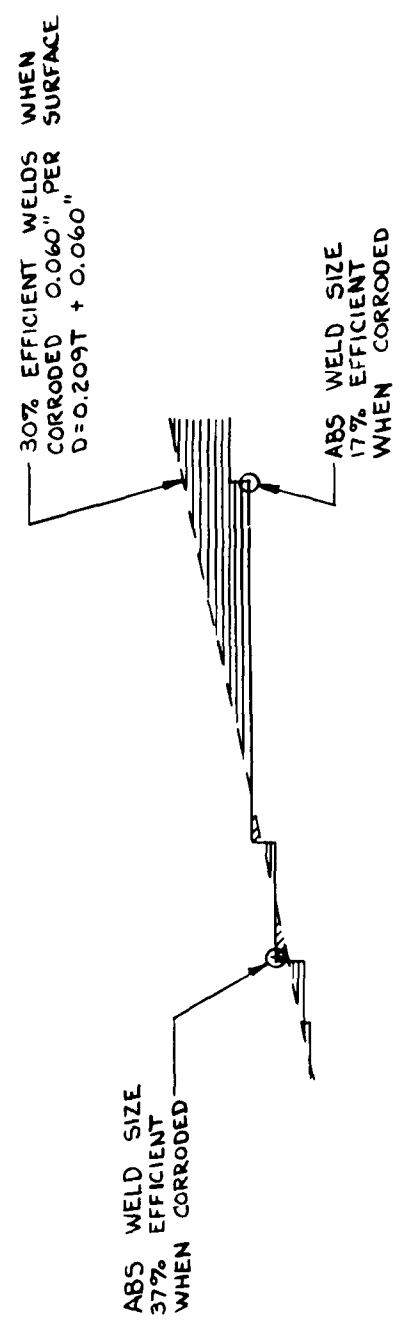


PLATE THICKNESS (T) (INCHES)



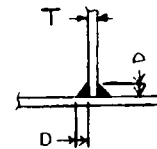
APPENDIX D

PROPOSED FILLET WELD SIZE TABLES

TABLE D-1

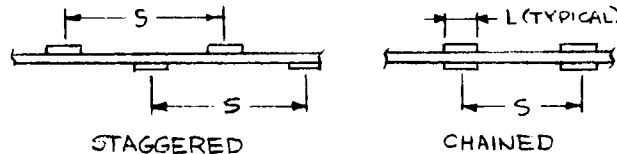
DOUBLE CONTINUOUS AND INTERMITTENT FILLET WELD EFFICIENCIES

For tee type joints, the weld size (D) is to be determined from the thickness (T) of the intercostal member (i.e., the member being attached). For lap joints and corner type joints, the weld size is to be determined from the thickness of the weaker member (i.e., member with lowest product of thickness times tensile strength).



The weld size is not to be less than 1/8". For vessels to be classed "Oil Carrier", the weld size in cargo tanks and in ballast tanks in the cargo area is not be less than 3/16".

Intermittent welds may be either staggered or chained unless otherwise specified.



Where beams, stiffeners, frames, etc., are intermittently welded and pass through slotted girders, shelves or stringers, there is to be a pair of matched intermittent welds on each side of each such intersection and the beams, stiffeners and frames are to be efficiently attached to the girders, shelves and stringers.

TABLE D-1 (Cont'd)

| <u>Line Nos.</u>                           | <u>Structural Items</u>                                                                | <u>Weld Efficiency Required</u> | <u>Intermittent Welding Permitted</u> |
|--------------------------------------------|----------------------------------------------------------------------------------------|---------------------------------|---------------------------------------|
| <b>Single-Bottom Floors</b>                |                                                                                        |                                 |                                       |
| 1,6                                        | To center vertical keel, side shell, longitudinal bulkhead, or other supporting member | 75%                             | No                                    |
| 2                                          | To shell-aft peaks of high power, fine form vessels                                    | 45%                             |                                       |
| 3,4,5                                      | To shell-elsewhere, and to face plate                                                  | 30%                             |                                       |
| <hr/>                                      |                                                                                        |                                 |                                       |
| <b>Double-Bottom Floors - Plate Floors</b> |                                                                                        |                                 |                                       |
| 13                                         | To vertical margin plate or side girder under longitudinal or wing tank bulkhead       | 100%                            | No                                    |
| 12                                         | To sloping margin plate, side shell, and bilge                                         | 75%                             | No                                    |
| 17                                         | At oiltight and watertight periphery connections                                       | 75%                             | No                                    |
| 11                                         | To center vertical keel and side girders where longitudinal girder is continuous       | 75%                             | No                                    |
| 10                                         | To center vertical keel and side girders where floor is continuous                     | 30%                             |                                       |
| 14                                         | To inner bottom in machinery space                                                     | 75%                             | No                                    |
| 15,16                                      | To inner bottom-elsewhere (See Note 3)                                                 | 30%                             |                                       |
| 7                                          | To shell-aft peaks of high power, fine form vessels                                    | 45%                             |                                       |
| 8,9                                        | To shell elsewhere (See Note 3)                                                        | 30%                             |                                       |
| 18                                         | Stiffeners                                                                             | 30%                             |                                       |

TABLE D-1 (Cont'd)

| <u>Line Nos.</u> | <u>Structural Items</u>                                     | <u>Weld<br/>Efficiency<br/>Required</u> | <u>Intermittent<br/>Welding<br/>Permitted</u> |
|------------------|-------------------------------------------------------------|-----------------------------------------|-----------------------------------------------|
|                  | Double-Bottom Floors - Open Floor Brackets                  |                                         |                                               |
| 20               | To margin plate                                             | 75%                                     | No                                            |
| 19               | To center vertical keel                                     | 30%                                     |                                               |
|                  | Double Bottom - Center Girder                               |                                         |                                               |
| 24               | At oiltight and watertight<br>periphery connections         | 75%                                     | No                                            |
| 21               | To inner bottom in way of engine                            | 75%                                     | No                                            |
| 22               | To inner bottom-clear of engine-<br>nontight                | 45%                                     |                                               |
| 23               | To shell or bar keel                                        | 75%                                     | No                                            |
| 25               | Stiffeners                                                  | 30%                                     |                                               |
|                  | Double Bottom - Side Girders                                |                                         |                                               |
| 32               | At oiltight and watertight<br>periphery connections         | 75%                                     | No                                            |
| 30               | To floors in way of transverse<br>bulkheads                 | 75%                                     | No                                            |
| 31               | To floors-elsewhere                                         | 30%                                     |                                               |
| 28               | To inner bottom in way of engines                           | 45%                                     |                                               |
| 29               | To inner bottom-elsewhere                                   | 30%                                     |                                               |
| 26               | To shell-flat of bottom forward<br>(fore end strengthening) | 45%                                     |                                               |
| 27               | To shell-elsewhere                                          | 30%                                     |                                               |
| 33               | Stiffeners                                                  | 30%                                     |                                               |

TABLE D-1 (Cont'd)

| <u>Line Nos.</u> | <u>Structural Items</u>                                                             | <u>Weld<br/>Efficiency<br/>Required</u> | <u>Intermittent<br/>Welding<br/>Permitted</u> |
|------------------|-------------------------------------------------------------------------------------|-----------------------------------------|-----------------------------------------------|
| 34               | Inner Bottom - Plating<br>To shell and to other boundaries                          | 75%                                     | No                                            |
| 39               | Frames - Transverse<br>Unbracketed to inner bottom                                  | 75%                                     | No                                            |
| 40               | Frame brackets to frames, decks<br>and inner bottom                                 | 60%                                     | No                                            |
| 35               | To shell-aft peaks of high power,<br>fine form vessels                              | 45%                                     |                                               |
| 36,37,38         | To shell-elsewhere                                                                  | 30%                                     | See Note 4                                    |
| 42               | Frames - Transverse Reverse<br>To brackets                                          | 60%                                     | No                                            |
| 41               | To inner bottom                                                                     | 30%                                     |                                               |
| 48               | Frames - Longitudinal<br>Brackets to longitudinals,<br>floors, shell, etc.          | 60%                                     | No                                            |
| 45               | To shell on flat bottom forward                                                     | 45%                                     | No                                            |
| 43,44,46         | To shell elsewhere                                                                  | 30%                                     |                                               |
| 47               | To inner bottom                                                                     | 30%                                     |                                               |
| 51               | Girders, Web Frames, Stringers and Deck Transverses<br>End connections, unbracketed | 100%                                    | No                                            |
| 52               | End connections, bracketed                                                          | 75%                                     | No                                            |
| 49,50            | To shell and to bulkheads and decks                                                 | 30%                                     |                                               |
| 53A,53B          | To face plate                                                                       | 30%                                     |                                               |

TABLE D-1 (Cont'd)

| <u>Line Nos.</u> | <u>Structural Items</u>                                                                      | <u>Weld Efficiency Required</u> | <u>Intermittent Welding Permitted</u> |
|------------------|----------------------------------------------------------------------------------------------|---------------------------------|---------------------------------------|
|                  | Bulkheads - Plating                                                                          |                                 |                                       |
| 57               | Exposed bulkheads on freeboard and superstructure decks-periphery                            | 75%                             | No                                    |
| 56A              | Tank bulkheads-periphery                                                                     | 75%                             | No                                    |
| 56B              | Watertight bulkheads-periphery                                                               | 75%                             | See Table D-4                         |
| 54,55            | Swash bulkhead or non-tight structural bulkhead-periphery                                    | 30%                             |                                       |
|                  | Bulkheads - Stiffeners                                                                       |                                 |                                       |
| 62               | End attachments, unbracketed                                                                 | 75%                             | No                                    |
| 63               | Brackets to stiffeners, bulkhead, deck, inner bottom, etc.                                   | 60%                             | No                                    |
| 58,59            | To deep tank bulkheads, watertight bulkheads and superstructure or deckhouse front bulkheads | 30%                             | See Note 4                            |
| 60,61            | To non-tight structural bulkhead, deckhouse side, and superstructure aft end bulkheads       | 30%                             | See Note 5                            |
|                  | Decks - Plating                                                                              |                                 |                                       |
| 64,65            | Strength deck, exposed decks, watertight and oiltight decks - periphery                      | 75%                             | No                                    |
| 66               | Platform decks, non-tight flats-periphery                                                    | 45%                             | No                                    |
|                  | Decks - beams and Longitudinals                                                              |                                 |                                       |
| 69               | End attachments, beams, unbracketed                                                          | 75%                             | No                                    |
| 70               | Beam knees and brackets to beams, longitudinals, decks, bulkheads, etc.                      | 60%                             | No                                    |

TABLE D-1 (Cont'd)

| <u>Line Nos.</u> | <u>Structural Items</u>                                      | <u>Weld Efficiency Required</u> | <u>Intermittent Welding Permitted</u> |
|------------------|--------------------------------------------------------------|---------------------------------|---------------------------------------|
|                  | Decks - Beams and Longitudinals (Cont'd)                     |                                 |                                       |
| 68               | To decks, slab longitudinals                                 | 30%                             | No                                    |
| 67               | To decks, except slab longitudinals                          | 30%                             |                                       |
|                  | Decks - Hatch Coamings and Ventilators                       |                                 |                                       |
| 71               | To deck                                                      | 75%                             | No                                    |
|                  | Hatch Covers - Plating                                       |                                 |                                       |
| 72A              | Watertight or oiltight-periphery                             | 75%                             | No                                    |
| 72B              | Weathertight-periphery                                       | 75%                             | See Table D-4                         |
|                  | Hatch Covers - Stiffeners and Webs                           |                                 |                                       |
| 74               | End attachment-unbracketed to side plate or other stiffeners | 75%                             | No                                    |
| 75               | Bracket to stiffener or side plate                           | 60%                             | No                                    |
| 73               | To plating and to face plate                                 | 30%                             | See Note 7                            |
|                  | Foundations - Main Engine, Boilers, and Auxiliaries          |                                 |                                       |
| 76,77            | To top plate, shell, or inner bottom                         | 75%                             | No                                    |
|                  | Rudders - Horizontal Diaphragms                              |                                 |                                       |
| 79               | To vertical diaphragm in way of rudder axis                  | 75%                             | No                                    |
| 78               | To side plating                                              | 45%                             |                                       |
|                  | - Vertical Diaphragms                                        |                                 |                                       |
|                  | In way of rudder axis to top and bottom castings             | Full Penetration Welds Required |                                       |
| 80,81            | To side plating and horizontal diaphragms                    | 45%                             |                                       |

TABLE D-1 (Cont'd)

| <u>Line Nos.</u>                                                                                            | <u>Structural Items</u>                                                | <u>Weld Efficiency Required</u> | <u>Intermittent Welding Permitted</u> |
|-------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------|---------------------------------|---------------------------------------|
| 82                                                                                                          | Rudders - Side Plating<br>Slot welds (See Note 2)                      | 75%                             | No                                    |
| ADDITIONAL WELDING REQUIREMENTS FOR VESSELS CLASSED "OIL CARRIERS"<br>(See Note 6 for intermittent welding) |                                                                        |                                 |                                       |
| 83                                                                                                          | Girders and Webs<br>Centerline girder to shell                         | 88%                             | No                                    |
| 84                                                                                                          | Centerline girder to shell,<br>mid 0.5 span (See Note 1)               | 60%                             | No                                    |
| 85                                                                                                          | Centerline girder to deck                                              | 75%                             | No                                    |
| 86                                                                                                          | Centerline girder to deck, mid<br>0.5 span (See Note 1)                | 60%                             | No                                    |
| 87                                                                                                          | Transverse bulkhead, webs to<br>bulkhead                               | 75%                             | No                                    |
| 88                                                                                                          | Transverse bulkhead, webs to<br>bulkhead, mid 0.5 span<br>(See Note 1) | 60%                             | No                                    |
| 89                                                                                                          | To face bars                                                           | 45%                             |                                       |
| 90                                                                                                          | End Attachments<br>Bracketed                                           | 88%                             | No                                    |
| 91                                                                                                          | Transverses<br>Bottom transverse to shell                              | 88%                             | No                                    |
| 92                                                                                                          | Bottom transverse to shell<br>mid 0.5 span (See Note 1)                | 60%                             | No                                    |
| 93                                                                                                          | Side transverse and longitudinal<br>bulkhead web to plating            | 75%                             | No                                    |

TABLE D-1 (Cont'd)

| <u>Line Nos.</u> | <u>Structural Items</u>                            | <u>Weld Efficiency Required</u> | <u>Intermittent Welding Permitted</u> |
|------------------|----------------------------------------------------|---------------------------------|---------------------------------------|
|                  | Transverses (Cont'd)                               |                                 |                                       |
| 94               | Deck transverse to deck                            | 75%                             | No                                    |
| 95               | Deck transverse to deck, mid 0.5 span (See Note 1) | 60%                             | No                                    |
| 96               | To face bars                                       | 45%                             |                                       |

See General Notes at Beginning of Table.

NOTES

1. This may be applied only where the shearing forces over the mid-half span are no greater than one half the maximum shearing force on the member and where the web is of the same depth clear of end brackets and of the same thickness throughout the length of the member.
2. The weld size is to be determined from the thickness of the side plating.
3. With longitudinal framing the weld size is to be increased to give an equivalent weld area to that obtained without cut-outs for longitudinals.
4. Unbracketed stiffeners of shell, watertight and oiltight bulkheads and house fronts are to have double continuous welds for one-tenth of their length at each end.
5. Unbracketed stiffeners of nontight structural bulkheads, deckhouse sides and after ends are to have a pair of matched intermittent welds at each end.
6. The welding of deck and shell longitudinals may be as required under decks or frames. In addition the shell longitudinals are to have double continuous welds at the ends and in way of transverses equal in length to the depth of the longitudinal. The deck longitudinals are also to have double continuous welds at the ends equal in length to the depth of the longitudinal, however at transverses a matched pair of welds will be acceptable.
7. Unbracketed stiffeners and webs of hatch covers are to be welded continuously to the plating and to the face plate for a length at ends equal to the end depth of the member.

TABLE D-2

Proposed Double Continuous Fillet Weld Sizes Versus Plate Thickness

| Eff. | Size<br>Equation       | Plate Thickness (T) |                    |                    |                    |                    |                    |                    |                    |                    |                    |                    |                    |                    |                    |                    |
|------|------------------------|---------------------|--------------------|--------------------|--------------------|--------------------|--------------------|--------------------|--------------------|--------------------|--------------------|--------------------|--------------------|--------------------|--------------------|--------------------|
|      |                        | 1/8                 | 3/16               | 1/4                | 5/16               | 3/8                | 7/16               | 1/2                | 9/16               | 5/8                | 11/16              | 3/4                | 13/16              | 7/8                | 15/16              | 1                  |
| 100% | $D=0.698\ T + 0.001''$ | 5.1#                | 7.65#              | 10.2#              | 12.75#             | 15.3#              | 17.85#             | 20.4#              | 22.95#             | 25.5#              | 28.05#             | 30.6#              | 33.15#             | 35.7#              | 38.25#             | 40.8#              |
| 88%  | $D=0.614\ T + 0.011''$ | 1/8                 | $\frac{3/16}{1/8}$ | 3/16               | 1/4                | $\frac{5/16}{1/4}$ | 5/16               | 3/8                | $\frac{7/16}{3/8}$ | 7/16               | 1/2                | $\frac{9/16}{1/2}$ | 5/8                | 5/8                | -                  | -                  |
| 75%  | $D=0.524\ T + 0.022''$ | 1/8                 | $\frac{3/16}{1/8}$ | 3/16               | $\frac{1/4}{3/16}$ | 1/4                | $\frac{5/16}{1/4}$ | $\frac{3/8}{5/16}$ | 3/8                | $\frac{7/16}{3/8}$ | 7/16               | $\frac{1/2}{7/16}$ | $\frac{5/8}{9/16}$ | 5/8                | 5/8                | 5/8                |
| 60%  | $D=0.419\ T + 0.035''$ | 1/8                 | 1/8                | $\frac{3/16}{1/8}$ | 3/16               | $\frac{1/4}{3/16}$ | $\frac{5/16}{1/4}$ | 5/16               | $\frac{3/8}{5/16}$ | 3/8                | $\frac{7/16}{3/8}$ | 7/16               | $\frac{5/8}{9/16}$ | 5/8                | 5/8                | 5/8                |
| 45%  | $D=0.314\ T + 0.047''$ | 1/8                 | 1/8                | $\frac{3/16}{1/8}$ | $\frac{3/16}{1/8}$ | 3/16               | 3/16               | $\frac{1/4}{3/16}$ | 1/4                | $\frac{5/16}{1/4}$ | $\frac{3/8}{5/16}$ | 3/8                | $\frac{7/16}{3/8}$ | 7/16               | 7/16               | 7/16               |
| 30%  | $D=0.209\ T + 0.060''$ | 1/8                 | 1/8                | 1/8                | $\frac{3/16}{1/8}$ | $\frac{3/16}{1/8}$ | 3/16               | $\frac{1/4}{3/16}$ | 1/4                | 1/4                | $\frac{5/16}{1/4}$ | 5/16               | 5/16               | $\frac{3/8}{5/16}$ | 3/8                | 3/8                |
|      |                        |                     |                    |                    | $\frac{3/16}{1/8}$ | $\frac{3/16}{1/8}$ | $\frac{3/16}{1/8}$ | 3/16               | 3/16               | $\frac{1/4}{3/16}$ | 1/4                | 1/4                | 1/4                | 1/4                | $\frac{5/16}{1/4}$ | $\frac{5/16}{1/4}$ |

NOTES: (1) For intermediate plate thicknesses, see Figures D-1 and D-2 or use equation in second column.  
 (2) This table includes a corrosion allowance of 0.060" per surface.

TABLE D-3

Proposed Intermittent Fillet Weld Sizes Versus Plate Thickness

| Eff. | Size<br>Equation                            | Plate Thickness (T) |                   |               |          |         |          |          |         |          |         |         |         |         |         |         |  |
|------|---------------------------------------------|---------------------|-------------------|---------------|----------|---------|----------|----------|---------|----------|---------|---------|---------|---------|---------|---------|--|
|      |                                             | 1/8                 | 3/16              | 1/4           | 5/16     | 3/8     | 7/16     | 1/2      | 9/16    | 5/8      | 11/16   | 3/4     | 7/8     | 15/16   | 1       | 1 1/8   |  |
| 45%  | D=0.314 x<br>(T-0.12") +<br>S/L +<br>0.085" | 5.1#                | 7.65#             | 10.2#         | 12.75#   | 15.3#   | 17.85#   | 20.4#    | 22.95#  | 25.5#    | 28.05#  | 30.6#   | 33.15#  | 35.7#   | 38.25#  | 40.8#   |  |
|      |                                             | -                   | -                 | 1/4 3-12(2)   | 1/4 3-8  | 1/4 3-6 | 5/16 3-6 | 5/16 3-5 | 3/8 3-6 | 3/8 3-5  | -       | -       | -       | -       | -       | -       |  |
| 30%  | D=0.209<br>(T-0.12")<br>S/L +<br>0.085"     | 3/16 2-1/2 -12(2)   | 3/16 2-1/2 -12(2) | 3/16 2-1/2 -8 | 1/4 3-12 | 1/4 3-9 | 1/4 3-7  | 1/4 3-6  | 1/4 3-5 | 5/16 3-6 | 3/8 3-5 | 3/8 3-6 | 3/8 3-5 | 3/8 3-6 | 3/8 3-5 | 3/8 3-6 |  |
|      |                                             | -                   | -                 | -             | -        | -       | -        | -        | -       | -        | -       | -       | -       | -       | -       | -       |  |

NOTES:

- (1) For intermediate plate thicknesses, see Figures D-3 and D-4 or use equations in second column.  
 (2) Fillet welds are to be staggered.  
 (3) Weld sizes other than given in the table may be used provided the length and/or spacing of welds is modified to give equivalent strength. Use equations shown in second column or see Table D-5.  
 (4) This table includes a corrosion allowance of 0.060" per surface.

TABLE D-4

Proposed Weld Sizes For Special Cases

| Line No. | Location                 | Size Equation                    | Notes | Plate Thickness(T) |          |         |         |         |         |          |  |
|----------|--------------------------|----------------------------------|-------|--------------------|----------|---------|---------|---------|---------|----------|--|
|          |                          |                                  |       | 1/4                | 5/16     | 3/8     | 7/16    | 1/2     | 9/16    | 5/8      |  |
|          |                          |                                  |       | 10.2#              | 12.75#   | 15.3#   | 17.85#  | 20.4#   | 22.95#  | 25.5#    |  |
| 50a      | One Side                 | D=T-1/16"                        | (1)   | 3/16               | 1/4      | 5/16    | 3/8     | 7/16    | -       | -        |  |
|          | Other Side<br>(30% eff.) | D=0.209(T-0.12")<br>S/L + 0.085" | (2)   | 3/16 2-1/2 -8      | 1/4 3-12 | 1/4 3-9 | 1/4 3-7 | 1/4 3-6 | -       | -        |  |
| 72b      | Outside<br>(75% eff.)    | D=0.524 T+0.022"                 | (3)   | 3/16               | 3/16     | 1/4     | 5/16    | 5/16    | 3/8     | 3/8      |  |
|          | Inside<br>(30% eff.)     | D=0.209(T-0.12")<br>S/L + 0.085" | (2)   | 3/16 2-1/2 -8      | 1/4 3-12 | 1/4 3-9 | 1/4 3-7 | 1/4 3-6 | 1/4 3-5 | 5/16 3-6 |  |

## NOTES:

- (1) For intermediate plate thicknesses, use size for next larger thickness listed or use equation in third column.  
 (2) For intermediate plate thicknesses, see Figure D-4 or use equation in third column.  
 (3) For intermediate plate thicknesses, see Figure D-1 or use equation in third column.  
 (4) This table includes a corrosion allowance of 0.060" per surface.

TABLE D-5

Equivalent Continuous Fillet Weld Sizes for Intermittent Welds Including Corrosion Allowance and Maximum Plate Thickness Allowed for 45% and 30% Efficient Welds

| Intermittent<br>Weld Size<br>D x L - S                                                          | Equiv. Cont.<br>Fillet Weld<br>$D_1 = (D - 0.085")$<br>$L/S + 0.085"$<br>(Inches)  | $T_{max}$ for 45% Eff.<br>$= \frac{D_1}{L} - 0.047"$<br>0.314<br>(Inches)    | $T_{max}$ for 30% Eff.<br>$= \frac{D_1}{L} - 0.060"$<br>0.209<br>(Inches)    | Intermittent<br>Weld Size<br>D x L - S                                                                                                          | Equiv. Cont.<br>Fillet Weld<br>$D_1 = (D - 0.085")$<br>$L/S + 0.085"$<br>(Inches)    | $T_{max}$ for 45% Eff.<br>$= \frac{D_1}{L} - 0.047"$<br>0.314<br>(Inches)    | $T_{max}$ for 30% Eff.<br>$= \frac{D_1}{L} - 0.060"$<br>0.209<br>(Inches)    |
|-------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------|------------------------------------------------------------------------------|------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------|------------------------------------------------------------------------------|------------------------------------------------------------------------------|
| 3/8 3-5<br>3/8 3-6                                                                              | 0.259<br>0.230                                                                     | 0.6752<br>0.5828                                                             |                                                                              |                                                                                                                                                 |                                                                                      |                                                                              |                                                                              |
| 5/16 3-5<br>5/16 3-6<br>5/16 3-7<br>5/16 3-8<br>5/16 3-9<br>5/16 3-10<br>5/16 3-11<br>5/16 3-12 | 0.2215<br>0.19875<br>0.1825<br>0.17031<br>0.16083<br>0.15325<br>0.14705<br>0.14188 | 0.5557<br>0.4853<br>0.4315<br>0.3927<br>0.3625<br>0.3384<br>0.3186<br>0.3022 | 0.7727<br>0.6639<br>0.5861<br>0.5278<br>0.4824<br>0.4462<br>0.4165<br>0.3918 | 3/16 2-1/2 - 5<br>3/16 2-1/2 - 6<br>3/16 2-1/2 - 7<br>3/16 2-1/2 - 8<br>3/16 2-1/2 - 9<br>3/16 2-1/2 - 10<br>3/16 2-1/2 - 11<br>3/16 2-1/2 - 12 | 0.13625<br>0.12771<br>0.12161<br>0.11703<br>0.11347<br>0.11062<br>0.10830<br>0.10636 | 0.2842<br>0.2570<br>0.2376<br>0.2230<br>0.2117<br>0.2026<br>0.1952<br>0.1890 | 0.3648<br>0.3240<br>0.2948<br>0.2729<br>0.2558<br>0.2422<br>0.2311<br>0.2218 |
| 1/4 3-5<br>1/4 3-6<br>1/4 3-7<br>1/4 3-8<br>1/4 3-9<br>1/4 3-10<br>1/4 3-11<br>1/4 3-12         | 0.1840<br>0.1675<br>0.1557<br>0.14688<br>0.1400<br>0.1345<br>0.1300<br>0.12625     | 0.4363<br>0.3838<br>0.3462<br>0.3181<br>0.2962<br>0.2787<br>0.2643<br>0.2524 | 0.5933<br>0.5144<br>0.4579<br>0.4157<br>0.3828<br>0.3565<br>0.3349<br>0.3170 | 3/16 2-1/8 - 4<br>3/16 2-1/8 - 10<br>3/16 2-1/8 - 11<br>3/16 2-1/8 - 12                                                                         | 0.13945<br>0.10678<br>0.10480<br>0.10315                                             | 0.2944<br>0.1904<br>0.1841<br>0.1788                                         | 0.3801<br>0.2238<br>0.2144<br>0.2065                                         |

NOTES: (1) This table includes a corrosion allowance of 0.060" per surface

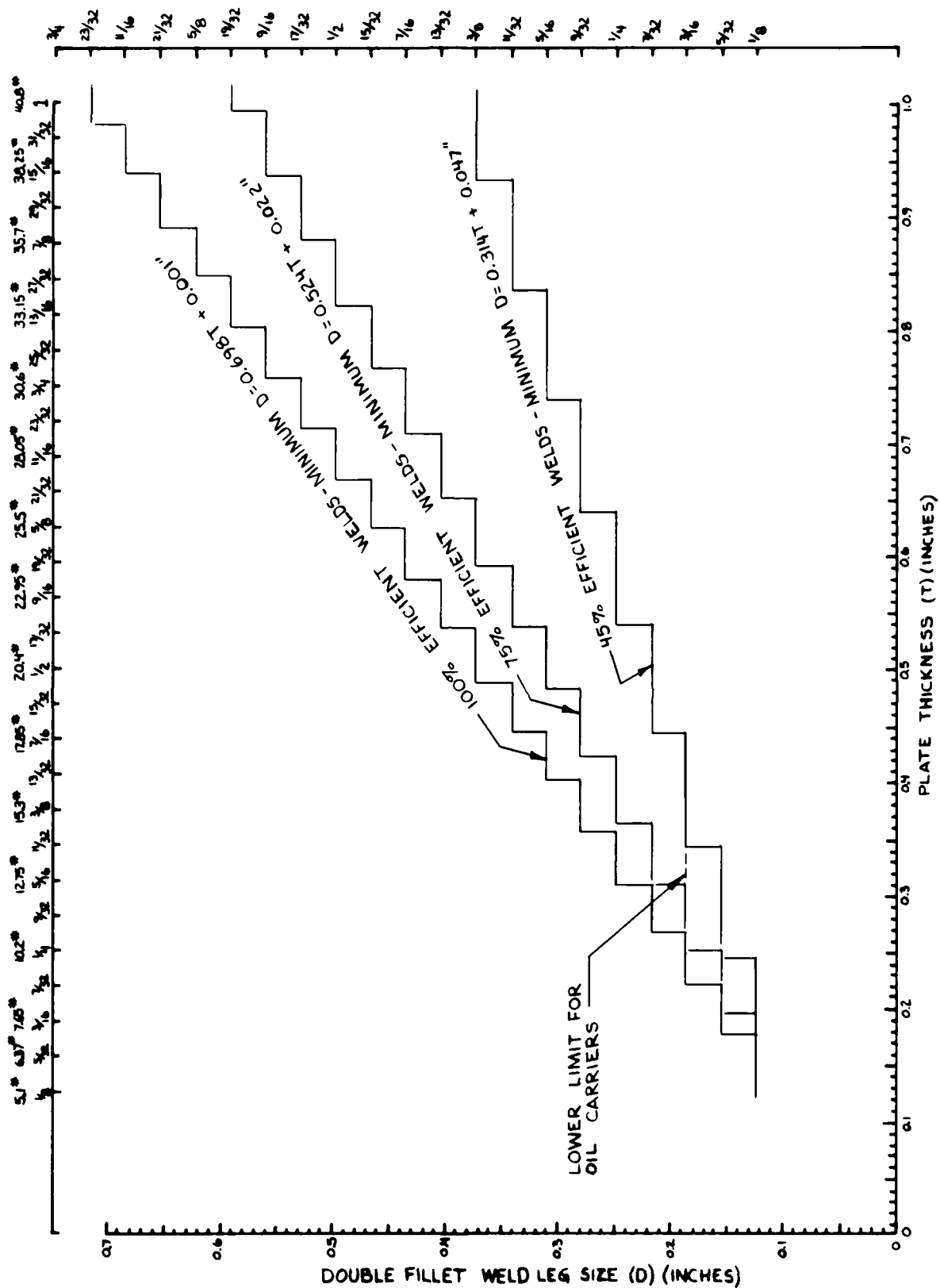
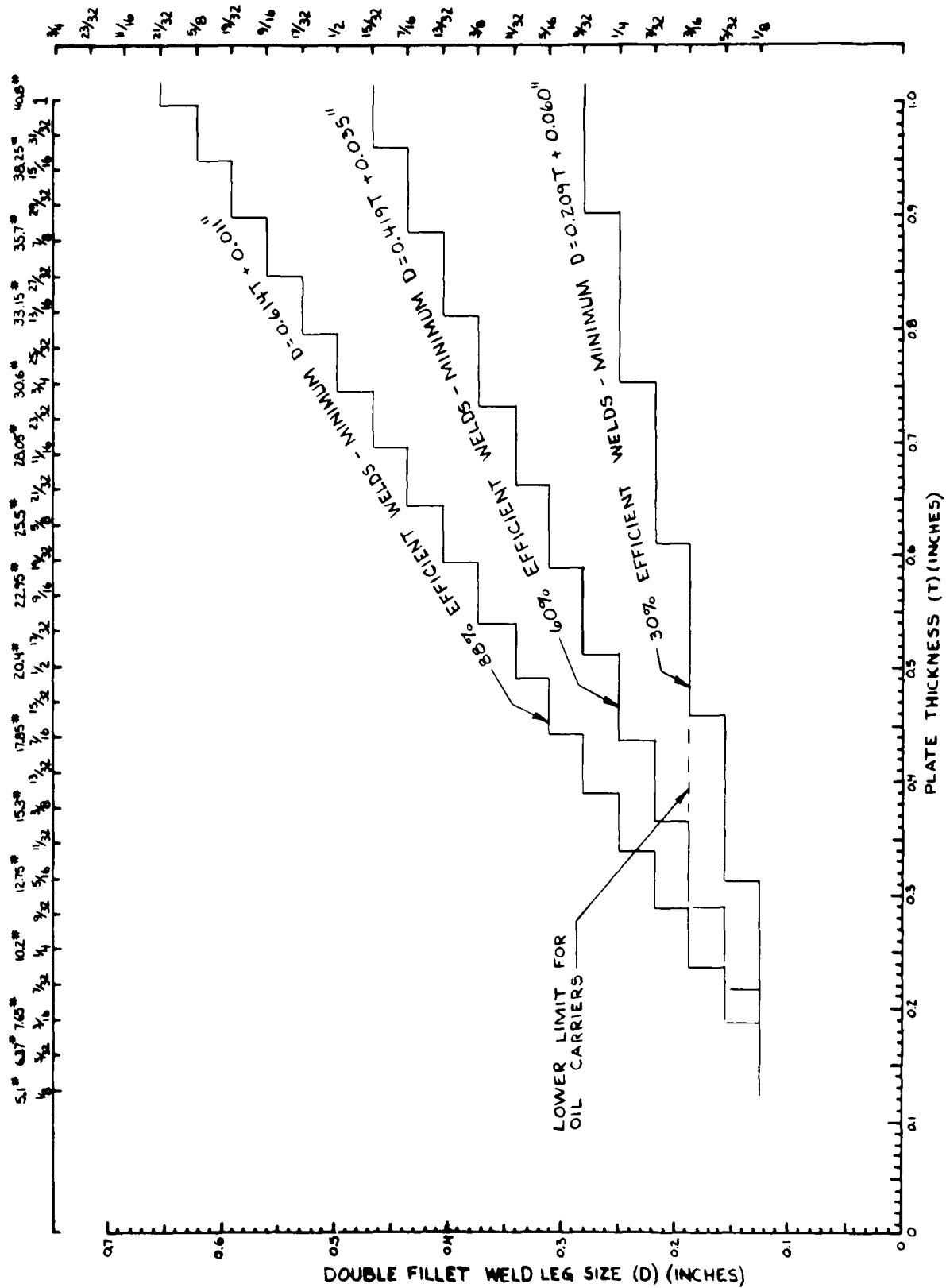


FIGURE D-1  
PROPOSED 100%, 75%, & 45% EFFICIENT DOUBLE CONTINUOUS  
FILLET WELDS INCLUDING CORROSION ALLOWANCE



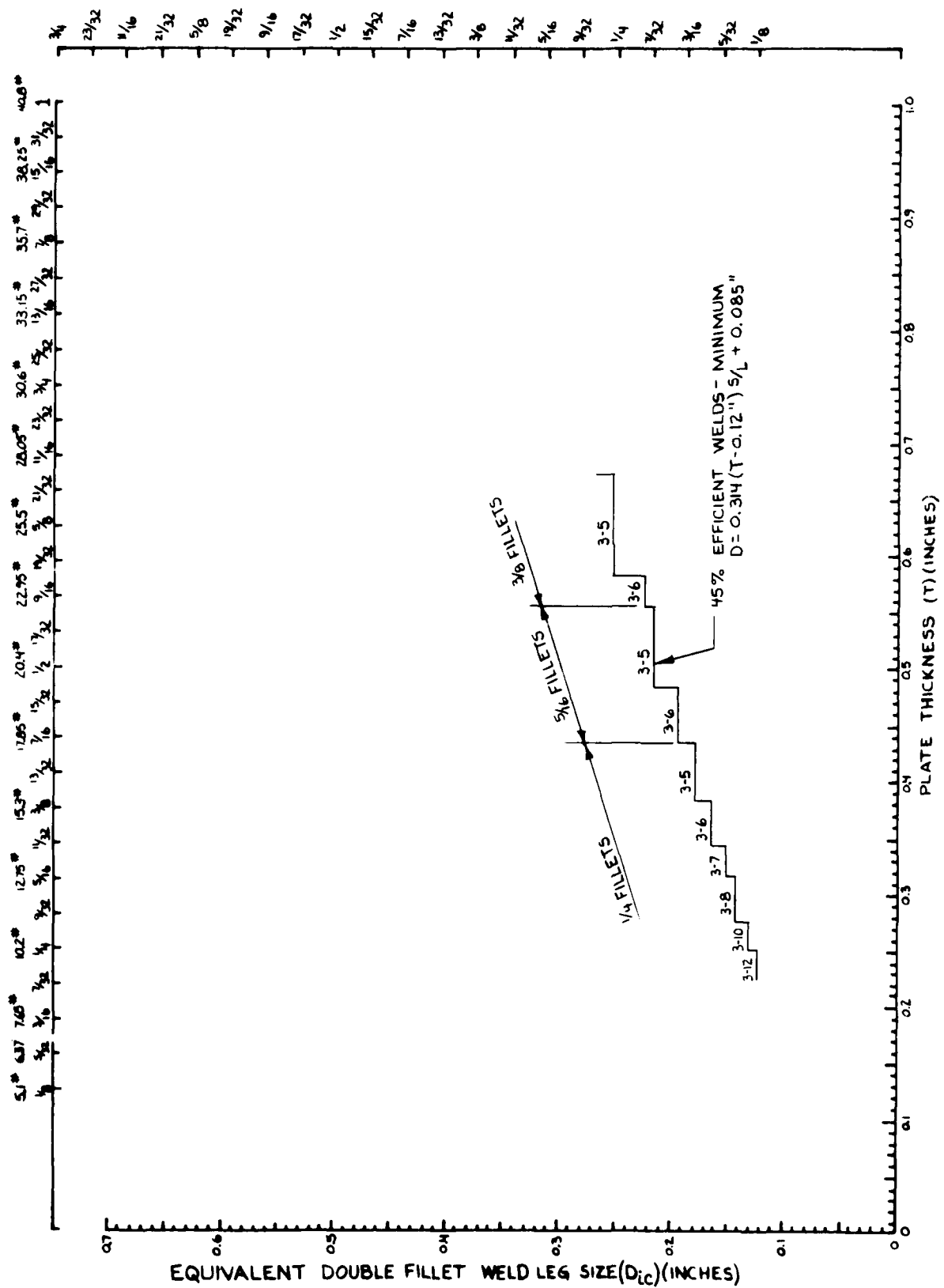


FIGURE D-3  
PROPOSED 45% EFFICIENT INTERMITTANT FILLET WELDS  
INCLUDING CORROSION ALLOWANCE

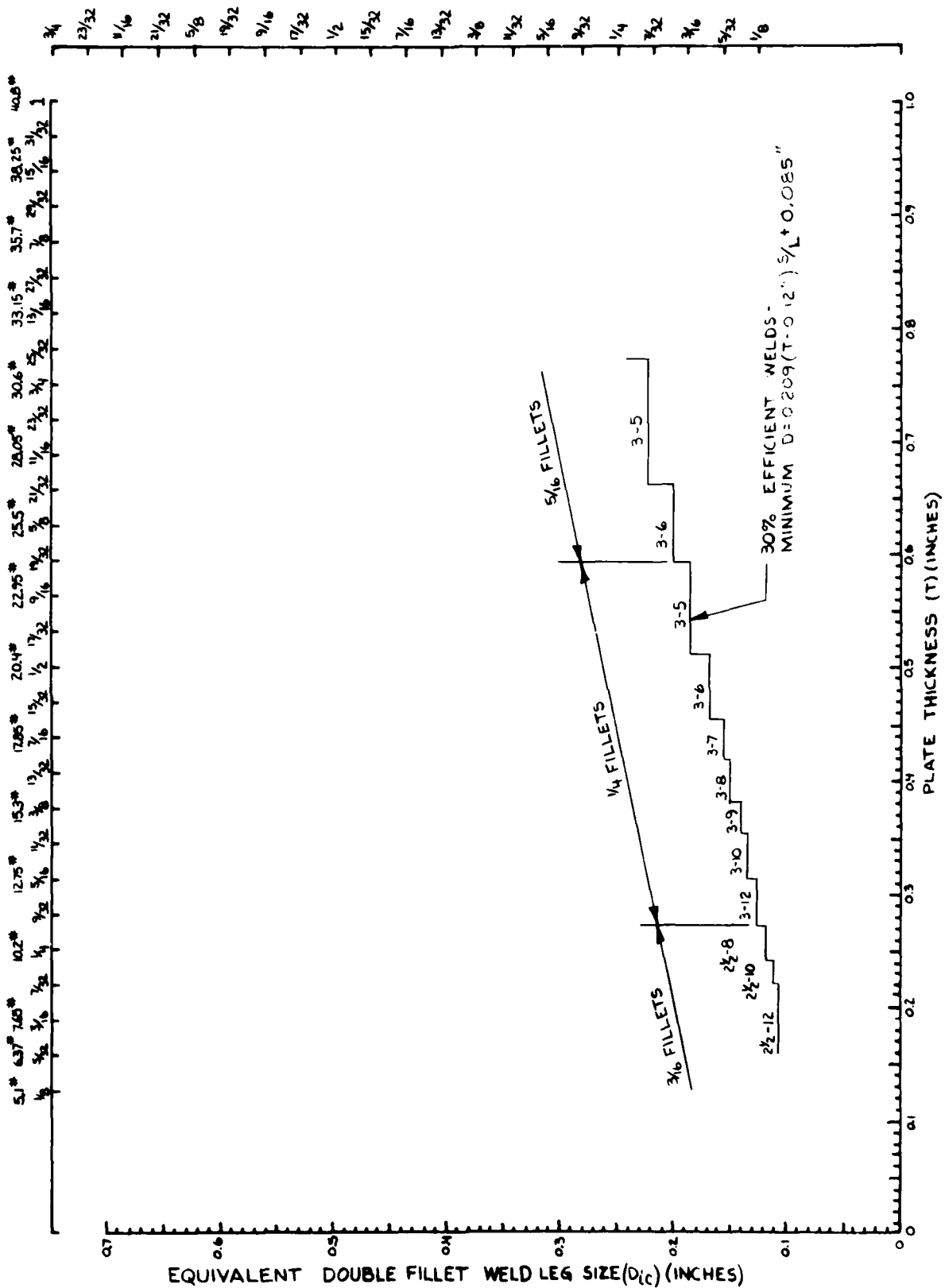


FIGURE D-4  
PROPOSED 30% EFFICIENT INTERMITTENT FILLET WELDS  
INCLUDING CORROSION ALLOWANCE

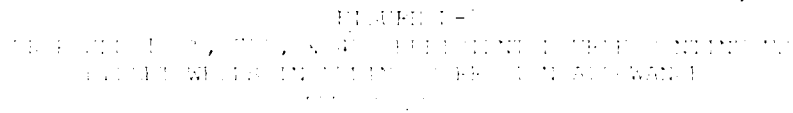
TABLE D-6

Proposed Double Continuous Fillet Weld Sizes Versus Plate Thickness - Mild Steel Only

| Eff. | Size<br>Equation      | Plate Thickness (T) |                    |                    |                    |                    |                    |                    |                    |                    |                    |                    |                    |                    |                    |
|------|-----------------------|---------------------|--------------------|--------------------|--------------------|--------------------|--------------------|--------------------|--------------------|--------------------|--------------------|--------------------|--------------------|--------------------|--------------------|
|      |                       | 1/8                 | 3/16               | 1/4                | 5/16               | 3/8                | 7/16               | 1/2                | 9/16               | 5/8                | 11/16              | 3/4                | 13/16              | 7/8                | 15/16              |
|      |                       | 5.1#                | 7.65#              | 10.2#              | 12.75#             | 15.3#              | 17.85#             | 20.4#              | 22.95#             | 25.5#              | 28.05#             | 30.6#              | 33.15#             | 35.7#              | 38.25#             |
| 100% | D=0.628 T<br>+ 0.010" | 1/8                 | $\frac{3/16}{1/8}$ | $\frac{3/16}{1/8}$ | $\frac{1/4}{3/16}$ | 1/4                | 5/16               | $\frac{3/8}{5/16}$ | 3/8                | $\frac{7/16}{3/8}$ | $\frac{1/2}{7/16}$ | 1/2                | $\frac{9/16}{1/2}$ | 9/16               | 5/8                |
| 88%  | D=0.553 T<br>+ 0.019" | 1/8                 | 1/8                | $\frac{3/16}{1/8}$ | $\frac{1/4}{3/16}$ | 1/4                | $\frac{5/16}{1/4}$ | 5/16               | $\frac{3/8}{5/16}$ | 3/8                | $\frac{7/16}{3/8}$ | 7/16               | $\frac{1/2}{7/16}$ | $\frac{9/16}{1/2}$ | $\frac{5/8}{9/16}$ |
| 75%  | D=0.471 T<br>+ 0.028" | 1/8                 | 1/8                | $\frac{3/16}{1/8}$ | 3/16               | $\frac{1/4}{3/16}$ | 1/4                | $\frac{5/16}{1/4}$ | 5/16               | $\frac{3/8}{5/16}$ | 3/8                | $\frac{7/16}{3/8}$ | 7/16               | $\frac{1/2}{7/16}$ | $\frac{9/16}{1/2}$ |
| 60%  | D=0.377 T<br>+ 0.040" | 1/8                 | 1/8                | $\frac{3/16}{1/8}$ | $\frac{3/16}{1/8}$ | 3/16               | $\frac{1/4}{3/16}$ | 1/4                | $\frac{5/16}{1/4}$ | $\frac{5/16}{1/4}$ | 5/16               | $\frac{3/8}{5/16}$ | 3/8                | 3/8                | $\frac{7/16}{3/8}$ |
| 45%  | D=0.283 T<br>+ 0.051" | 1/8                 | 1/8                | 1/8                | $\frac{3/16}{1/8}$ | 3/16               | 3/16               | $\frac{1/4}{3/16}$ | 1/4                | 1/4                | 1/4                | $\frac{5/16}{1/4}$ | 5/16               | 5/16               | $\frac{3/8}{5/16}$ |
| 30%  | D=0.188 T<br>+ 0.062" | 1/8                 | 1/8                | 1/8                | 1/8                | $\frac{3/16}{1/8}$ | $\frac{3/16}{1/8}$ | $\frac{3/16}{1/8}$ | 3/16               | 3/16               | $\frac{1/4}{3/16}$ | $\frac{1/4}{3/16}$ | $\frac{1/4}{3/16}$ | 1/4                | 1/4                |

NOTES: (1) For intermediate plate thicknesses, see Figures D-5 and D-6 or use equations in second column.

(2) This Table includes a corrosion allowance of 0.060" per surface



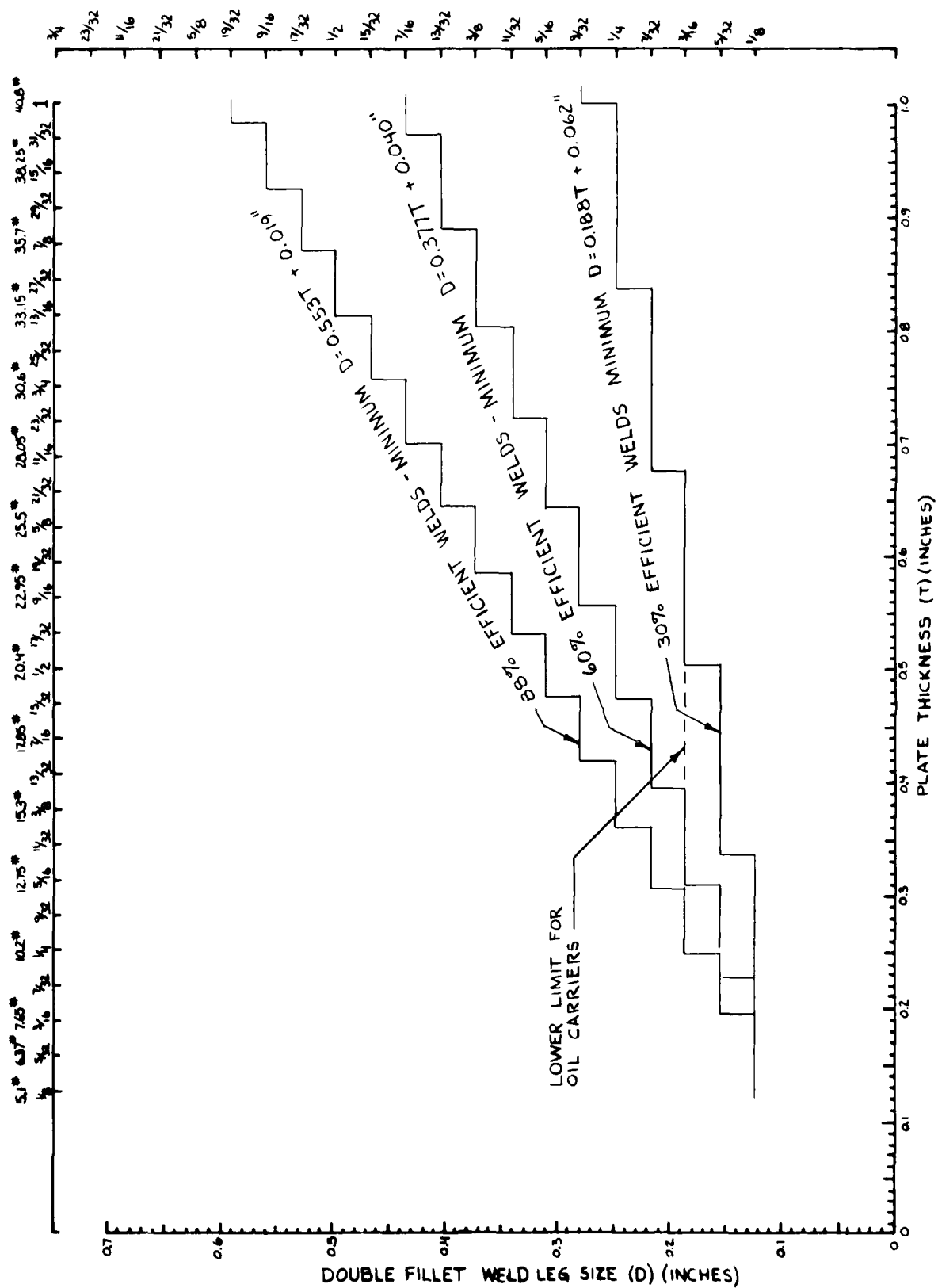


FIGURE D-6  
PROPOSED 88%, 60%, & 30% EFFICIENT DOUBLE CONTINUOUS  
FILLET WELDS INCLUDING CORROSION ALLOWANCE  
MILD STEEL ONLY

APPENDIX E

CALCULATIONS FOR VOYAGER CLASS TANKER



FIGURE E-1  
GENERAL ARRANGEMENT DRAWINGS OF VOYAGER CLASS TANKER

**NOTE:**

1. SCANTLINGS SHOWN ARE TO 1981 ABS RULES.
2. MATERIAL NOT NOTED TO BE ABS-MS.
3. KEY TO WELD SIZES:
  - a. UPPER WELD SIZES ARE FROM EXISTING ABS RULES. THE CIRCLED VALUE IS THE LINE NUMBER FROM THOSE RULES.
  - b. LOWER WELD SIZES ARE FROM PROPOSED WELD SIZE TABLES. THE PERCENTAGE SHOWN IS THE MINIMUM JOINT EFFICIENCY AFTER WELD AND BASE MATERIALS HAVE BEEN CORRODED 0.060 INCH P.I.R SURFACE.

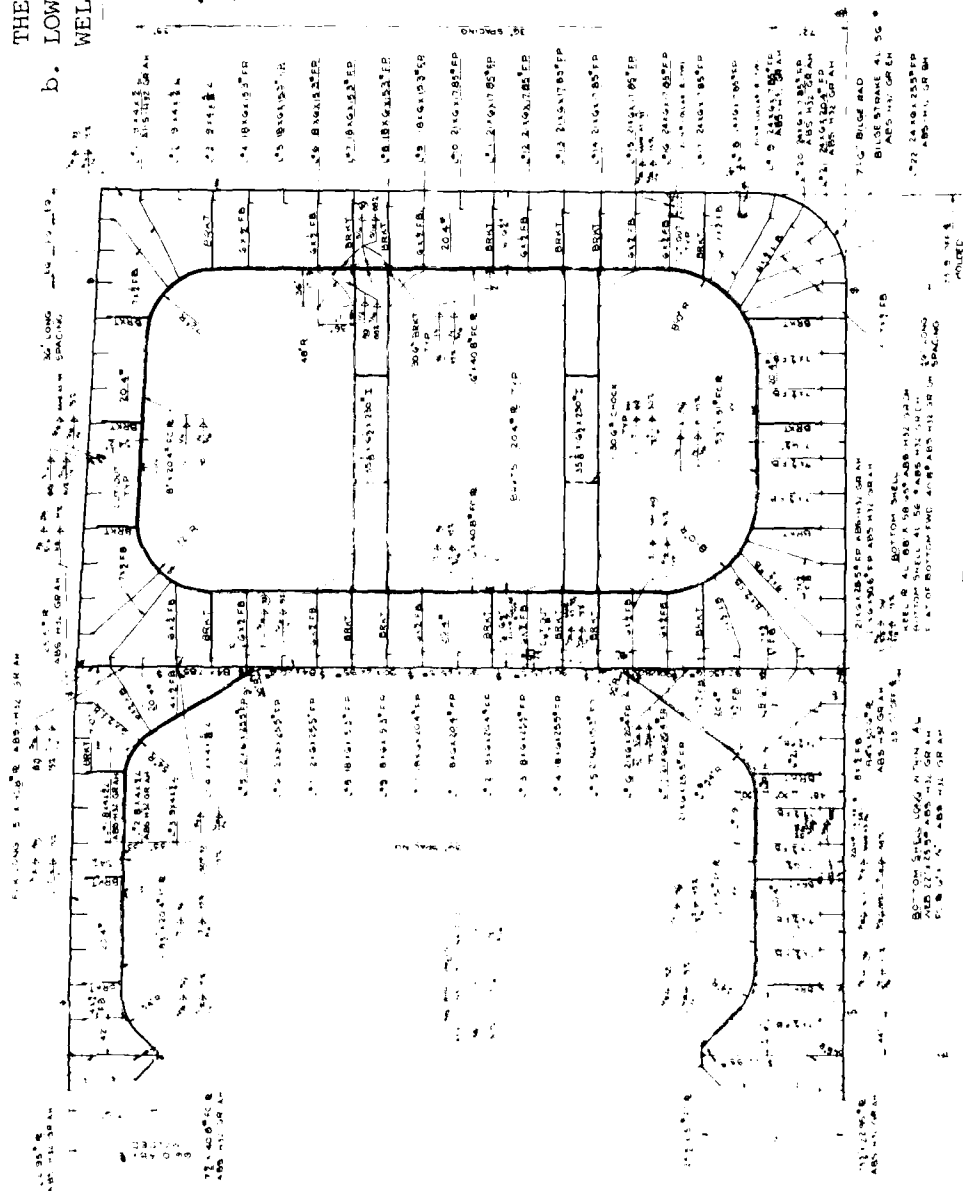
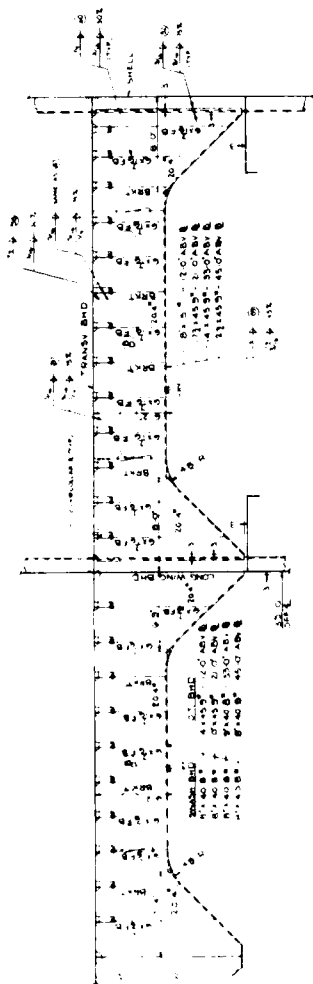


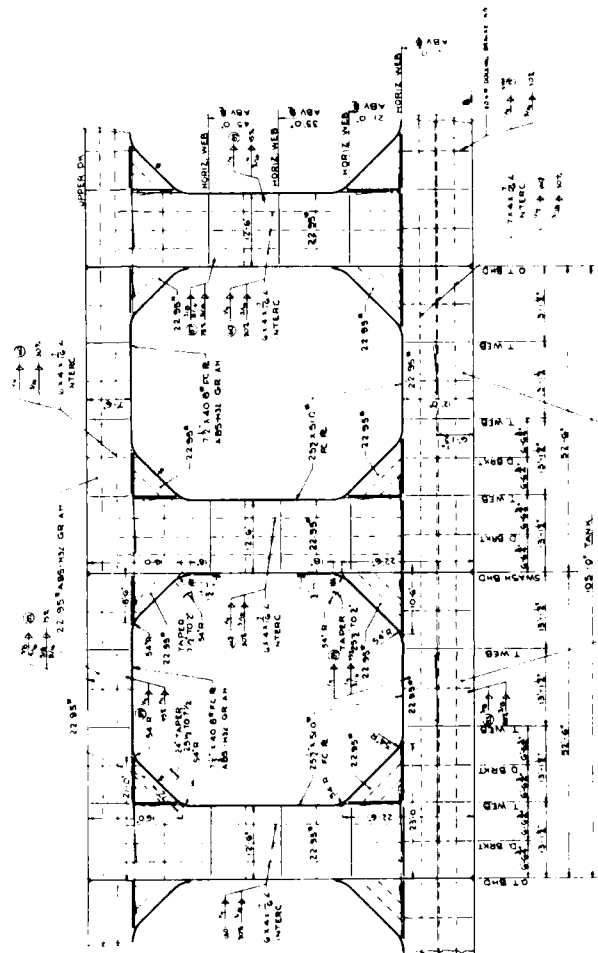
FIGURE E-2

MIDSHIP SECTION OF VOYAGER CLASS TANKER





HORIZONTAL WEB - 33'-0" ABV B  
12'-0" 21'-0" 45'-0" WEB SIMILAR



ELEVATION AT C SHIP

FIGURE E-4

VERTICAL, LONGITUDINAL, AND HORIZONTAL GIRDERS OF VOYAGER CLASS TANKER

TABLE E-1

## LENGTHS AND WEIGHTS OF ALTERED WELDS FOR VOYAGER CLASS TANKER

| STRUCTURAL CONNECTION                                  | Length<br>(Feet) | No.  | Total Length<br>of Double<br>Fillet Welds<br>(Feet) | Design Weld<br>Size<br>(Inches) |                        | Weight of Design<br>Welds<br>(Pounds) |          |
|--------------------------------------------------------|------------------|------|-----------------------------------------------------|---------------------------------|------------------------|---------------------------------------|----------|
|                                                        |                  |      |                                                     | Existing                        | Proposed               | Existing                              | Proposed |
| Deck Longitudinals to deck                             | 630              | 46   | 28980                                               | 5/16                            | $\frac{5/16}{1/4}$     | 9622                                  | 7890     |
| Longitudinal bulkhead to deck                          | 630              | 2    | 1260                                                | $\frac{3/8}{5/16}$              | 3/8 (2)                | 510                                   | 602      |
| Long. bhd. long'ls 1-19 to bhd.                        | 630              | 38   | 23940                                               | 1/4                             | 3/16                   | 5087                                  | 2862     |
| Long. bhd. long'ls 20-21 to bhd.                       | 630              | 4    | 2520                                                | 1/4                             | $\frac{1/4}{3/16}$     | 536                                   | 418      |
| Side shell long'ls 1-21 to shell                       | 630              | 42   | 26460                                               | 1/4                             | 3/16                   | 5623                                  | 3163     |
| Side shell long'l 22 to shell                          | 630              | 2    | 1260                                                | 1/4                             | $\frac{1/4}{3/16}$     | 268                                   | 209      |
| Bottom long'l webs to shell                            | 630              | 42   | 26460                                               | 1/4                             | $\frac{1/4}{3/16}$     | 5623                                  | 4393     |
| Bottom long'l webs to face plate                       | 630              | 42   | 26460                                               | 1/4                             | $\frac{1/4}{3/16}$     | 5623                                  | 4393     |
| C.V.K. to face plate                                   | 630              | 1    | 630                                                 | 1/4                             | $\frac{1/4}{3/16}$     | 134                                   | 105      |
| Panel stiff. on centerline girder<br>and C.V.K.        | 630              | 5    | 3150                                                | 1/4                             | 3/16                   | 669                                   | 377      |
| SUBTOTAL-Long'l. Str. of Cargo Sect.                   | -                | -    | 141,120                                             | 0.265 avg                       | 0.226 avg              | 33,695                                | 24,412   |
| Deck transv. to deck - inbd.                           | 47.83            | 36   | 1722                                                | 5/16                            | $\frac{5/16}{1/4}$     | 572                                   | 469      |
| Deck transv. to deck - outbd.                          | 57.84            | 42   | 2429                                                | 5/16                            | $\frac{5/16}{1/4}$     | 807                                   | 661      |
| Deck transv. & bhd. transv. to<br>long. bhd.           | 28.0             | 36   | 1008                                                | 1/4                             | $\frac{5/16}{1/4}$ (2) | 214                                   | 274      |
| Deck transv. to CL gird. & to<br>long. bhd.            | 30.0             | 36   | 1080                                                | 5/16                            | $\frac{5/16}{1/4}$     | 359                                   | 294      |
| Deck transv. to deck long.                             | 1.00             | 1812 | 1812                                                | 5/16                            | $\frac{5/16}{1/4}$     | 602                                   | 493      |
| Side transv. to side shell                             | 97.2             | 42   | 4082                                                | 5/16                            | $\frac{5/16}{1/4}$     | 1355                                  | 1111     |
| Side transv. & collar plates<br>to long'ls.            | 1.20             | 3696 | 4435                                                | 5/16                            | $\frac{5/16}{1/4}$     | 1473                                  | 1208     |
| Bhd. transv. to long. bhd.                             | 90.6             | 42   | 3805                                                | 5/16                            | $\frac{5/16}{1/4}$     | 1263                                  | 1036     |
| Bhd. transv. & collar plates<br>to long. bhd. long'ls. | 1.00             | 3528 | 3528                                                | 5/16                            | $\frac{5/16}{1/4}$     | 1171                                  | 961      |
| Bottom transv. to long.<br>bhd. & CVK                  | 62.0             | 36   | 2232                                                | 5/16                            | $\frac{5/16}{1/4}$     | 741                                   | 608      |
| Face plate to transv. - inbd.                          | 158.6            | 36   | 5710                                                | 1/4                             | $\frac{1/4}{3/16}$     | 1213                                  | 948      |
| Face plate to transv. - outbd.                         | 295.4            | 42   | 12407                                               | 1/4                             | $\frac{1/4}{3/16}$     | 2636                                  | 2060     |
| Panel stiff. - inbd.                                   | 240.0            | 36   | 8640                                                | 1/4                             | 3/16                   | 1836                                  | 1033     |
| Panel stiff. - outbd.                                  | 624.0            | 42   | 26208                                               | 1/4                             | 3/16                   | 5569                                  | 3133     |
| End brackets on struts                                 | 44.0             | 42   | 1848                                                | 1/2                             | 7/16                   | 1571                                  | 1203     |
| Chocks on struts                                       | 65.4             | 42   | 2747                                                | 1/4                             | $\frac{1/4}{3/16}$     | 584                                   | 456      |
| Docking brackets                                       | 34.0             | 48   | 1632                                                | 1/4                             | 3/16                   | 347                                   | 195      |
| SUBTOTAL-Transv. Str. of Cargo Sect.                   | -                | -    | 85,325                                              | 0.277 avg                       | 0.236 avg              | 22,313                                | 16,143   |

TABLE E-1, LENGTHS AND WEIGHTS OF ALTERED WELDS FOR VOYAGER CLASS TANKER (Cont'd)

| STRUCTURAL CONNECTION                                   | Length<br>(Feet) | No.  | Total Length<br>of Double<br>Fillet Welds<br>(Feet) | Design Weld<br>Size<br>(inches) |                           | Weight of Design<br>Welds<br>(Pounds) |          |
|---------------------------------------------------------|------------------|------|-----------------------------------------------------|---------------------------------|---------------------------|---------------------------------------|----------|
|                                                         |                  |      |                                                     | Existing                        | Proposed                  | Existing                              | Proposed |
| O.T. bhd. stiff. to bhd.                                | 62.5             | 322  | 20126                                               | 1/4                             | 3/16                      | 4277                                  | 2406     |
| Horiz. girder webs to O.T. bhd.                         | 100.2            | 28   | 2806                                                | 5/16                            | <u>5/16</u><br><u>1/4</u> | 932                                   | 764      |
| Horiz. girder webs to face plates                       | 160.0            | 28   | 4480                                                | 1/4                             | <u>1/4</u><br><u>3/16</u> | 952                                   | 744      |
| Horiz. girder webs & collar plates<br>to bhd. stiff.    | 1.00             | 2576 | 2576                                                | 5/16                            | <u>5/16</u><br><u>1/4</u> | 855                                   | 701      |
| Horiz. girder web panel stiff.                          | 276.0            | 28   | 7728                                                | 1/4                             | 3/16                      | 1642                                  | 924      |
| Centerline girder web to O.T. bhd.                      | 46.0             | 7    | 322                                                 | <u>3/8</u><br><u>5/16</u>       | 5/16                      | 130                                   | 107      |
| Centerline girder web to face<br>plate                  | 27.0             | 7    | 189                                                 | 1/4                             | <u>1/4</u><br><u>3/16</u> | 40                                    | 31       |
| Centerline girder web panel stiff.                      | 186.0            | 7    | 1302                                                | 1/4                             | 3/16                      | 277                                   | 156      |
| SUBTOTAL-7 O.T. Bhds.                                   | -                | -    | 39,529                                              | 0.260 avg                       | 0.208 avg                 | 9,105                                 | 5,833    |
| Swash bhd. periphery                                    | 265.6            | 6    | 1594                                                | 1/4                             | 3/16                      | 339                                   | 191      |
| Swash bhd. stiff. to bhd.                               | 630.0            | 6    | 3780                                                | 1/4                             | 3/16                      | 803                                   | 452      |
| Swash bhd. panel stiff. to bhd.                         | 527.0            | 6    | 3162                                                | 1/4                             | 3/16                      | 672                                   | 378      |
| Horiz. girder webs to swash bhd.                        | 47.4             | 24   | 1138                                                | 5/16                            | <u>5/16</u><br><u>1/4</u> | 378                                   | 310      |
| Horiz. girder webs to face plate                        | 74.0             | 24   | 1776                                                | 1/4                             | <u>1/4</u><br><u>3/16</u> | 377                                   | 295      |
| Horiz. girder webs & collar<br>plates to bhd. stiff.    | 1.00             | 960  | 960                                                 | 5/16                            | <u>5/16</u><br><u>1/4</u> | 319                                   | 262      |
| Horiz. girder web panel stiff.                          | 120.0            | 24   | 2880                                                | 1/4                             | 3/16                      | 612                                   | 344      |
| Centerline girder web to swash bhd.                     | 46.0             | 6    | 276                                                 | <u>3/8</u><br><u>5/16</u>       | 5/16                      | 112                                   | 92       |
| Centerline girder web to face plate                     | 27.0             | 6    | 162                                                 | 1/4                             | <u>1/4</u><br><u>3/16</u> | 34                                    | 27       |
| Centerline girder web panel stiff.                      | 186.0            | 6    | 1116                                                | 1/4                             | 3/16                      | 237                                   | 133      |
| SUBTOTAL-6 Swash Bhds.                                  | -                | -    | 16,844                                              | 0.260 avg                       | 0.208 avg                 | 3,883                                 | 2,484    |
| SUBTOTAL-All Cargo Sect. Structure                      | -                | -    | 282,818                                             | 0.268 avg                       | 0.225 avg                 | 68,996                                | 48,872   |
| ESTIMATE FOR BOW, STERN AND<br>DECKHOUSE <sup>(1)</sup> | -                | -    | 59,392                                              | 0.268 avg                       | 0.225 avg                 | 14,504                                | 10,223   |
| TOTALS                                                  | -                | -    | 342,210                                             | 0.268 avg                       | 0.225 avg                 | 83,500                                | 59,095   |

NOTE: (1) The 630 foot long cargo section is assumed to be prismatic. Therefore, the length and weight estimates for the cargo section should be slightly high. This is compensated for by deliberately underestimating weld lengths and weights for the bow, stern, and deckhouse.

(2) Proposed weld sizes which are increased from existing values are highlighted by reference to this note.

TABLE E-2

## LENGTHS AND WEIGHTS OF UNALTERED WELDS FOR VOYAGER CLASS TANKER

| STRUCTURAL CONNECTION                | Length<br>(Feet) | No.  | Total Length<br>of Double<br>Fillet Welds<br>(Feet) | Design Weld<br>Size<br>(Inches) | Weight of Design<br>Welds<br>(Pounds) |
|--------------------------------------|------------------|------|-----------------------------------------------------|---------------------------------|---------------------------------------|
| Centerline girder web to deck        | 630              | 1    | 630                                                 | $\frac{3}{8}$<br>5/16           | 255                                   |
| Centerline girder web to face plate  | 582              | 1    | 582                                                 | 1/4                             | 124                                   |
| Longitudinal bulkhead to bot. shell  | 630              | 2    | 1260                                                | $\frac{7}{16}$<br>3/8           | 711                                   |
| C.V.K. to shell                      | 630              | 1    | 630                                                 | 3/8                             | 301                                   |
| SUBTOTAL-Long'l. Str. of Cargo Sect. | -                | -    | 3,102                                               | 0.363 avg.                      | 1,391                                 |
| Side transv. collar plate lap welds  | 1.37             | 1848 | 2532                                                | 5/16                            | 841                                   |
| Bhd. transv. collar plate lap welds  | 1.17             | 1764 | 2064                                                | 5/16                            | 685                                   |
| Bottom transv. to shell - inboard    | 47.83            | 36   | 1722                                                | 5/16                            | 572                                   |
| Bottom transv. to shell - outboard   | 57.84            | 42   | 2429                                                | 5/16                            | 807                                   |
| Bot.transv.& collar plates to long.  | 1.50             | 3288 | 4932                                                | 5/16                            | 1638                                  |
| Bot.transv. collar plate lap welds   | 1.67             | 1644 | 2745                                                | 5/16                            | 911                                   |
| End brackets on struts               | 96.0             | 42   | 4032                                                | 5/16                            | 1339                                  |
| SUBTOTAL-Transv.Str. of Cargo Sect.  | -                | -    | 20,456                                              | 0.313 avg.                      | 6,793                                 |

TABLE E-2, LENGTHS AND WEIGHTS OF UNALTERED WELDS FOR VOYAGER CLASS TANKER (Cont'd)

| STRUCTURAL CONNECTION                       | Length<br>(Feet) | No.  | Total Length<br>of Double<br>Fillet Welds<br>(Feet) | Design Weld<br>Size<br>(Inches) | Weight of Design<br>Welds<br>(Pounds) |
|---------------------------------------------|------------------|------|-----------------------------------------------------|---------------------------------|---------------------------------------|
| O.T. bhd. periphery inc. collar<br>plates   | 555.5            | 7    | 3888                                                | $\frac{3}{8}$<br>5/16           | 1575                                  |
| O.T. bhd. periphery inc. collar<br>plates   | 125.0            | 7    | 875                                                 | $\frac{5}{16}$<br>1/4           | 238                                   |
| O.T. bhd. periphery inc. collar<br>plates   | 120.0            | 7    | 840                                                 | 5/16                            | 279                                   |
| O.T. bhd. periphery inc. collar<br>plates   | 138.0            | 7    | 966                                                 | 3/8                             | 462                                   |
| O.T. bhd. periphery inc. collar<br>plates   | 947.5            | 7    | 6632                                                | $\frac{7}{16}$<br>3/8           | 3743                                  |
| Horiz. girder web collar plate<br>lap welds | 1.17             | 1288 | 1507                                                | 5/16                            | 500                                   |
| Horiz. girder web end connections           | 104.0            | 7    | 728                                                 | 5/16                            | 242                                   |
| SUBTOTAL-7 O.T. Bulkheads                   | -                | -    | 15,436                                              | 0.366 avg.                      | 7,039                                 |
| Swash bhd. & collar plates to bot.<br>long. | 1.50             | 240  | 360                                                 | 5/16                            | 120                                   |
| Bot. long. collar plate lap welds           | 1.67             | 120  | 200                                                 | 5/16                            | 66                                    |
| Girder collar plate lap welds               | 1.17             | 480  | 562                                                 | 5/16                            | 187                                   |
| Horiz. girder web end connections           | 52.0             | 6    | 312                                                 | 5/16                            | 104                                   |
| SUBTOTAL-6 Swash Bulkheads                  | -                | -    | 1,434                                               | 0.313 avg.                      | 477                                   |
| SUBTOTAL-All Cargo Section Struct.          | -                | -    | 40,428                                              | 0.338 avg.                      | 15,700                                |
| ESTIMATE FOR BOW, STERN, AND<br>DECKHOUSE   | -                | -    | 8,490                                               | 0.338 avg.                      | 3,298                                 |
| TOTALS                                      | -                | -    | 48,918                                              | 0.338 avg.                      | 18,998                                |

# MIDSHIP SECTION - 1981 ABS RULES

(Terms are as defined in ABS Rules unless noted otherwise)

## Principal Dimensions

LOA 950'-0"  
LWL 925'-0"  
LBP 900'-0"  
B 147'-6"  
D 63'-6"  
d 48'-6"

## Weights (Long Tons)

|                         |                |
|-------------------------|----------------|
| Light Ship              | 22,200         |
| Fuel Oil                | 4,600          |
| D.O. & L.O.             | 60             |
| Fresh water             | 280            |
| Crew & Stores           | 50             |
| Cargo                   | 120,200        |
| <u>TOTAL DEADWEIGHT</u> | <u>125,190</u> |
| DISPLACEMENT            | 147,390        |

## REQUIRED SECTION MODULUS - MILD STEEL

Section 2.1 Scantling length =  $L = 0.97 \times \text{LWL} = 897.25'$

Section 6.3.1(a)  $SM = M_t / f_p$   
 $f_p = 10.56 + \frac{L-790}{2045} = 10.612 \text{ LT/in}^2$

Section 6.3.1(b)  $C_1 = 0.01441 \left[ 10.75 - \left( \frac{984-L}{328} \right)^{1.5} \right] = 0.15295$   
 $C_b = \frac{\text{Displacement} \times 35 \text{ ft}^3/\text{LT}}{L \times B \times d} = 0.80375$

Min.  $SM = 0.01C_1L^2B(C_b + 0.7) = 273,114 \text{ in}^2 \text{ ft}$

Section 6.3.2.(a)  $C_{st} = \left[ 0.275 - \frac{L-820}{11,600} \right] 10^{-3} = 0.26834 \times 10^{-3}$

$M_{sw} = C_{st} L^{2.5} B (C_b + 0.5) = 1,244,387 \text{ Ft-LT}$

Section 6.3.2(b)  $K_b = 1.0$

$C_2 = [6.53C_b + 0.57] 10^{-4} = 5.8185 \times 10^{-4}$

$H_e = [4.50 L - 0.00216L^2 + 335] 10^{-2} = 26.337 \text{ ft}$

$M_w = C_2 L^2 B H_e K_b = 1,819,700 \text{ ft-LT}$

$M_t = M_{sw} + M_w = 3,064,087 \text{ ft-LT}$

$SM = M_t / f_p = 288,738 \text{ in}^2 \text{ ft}$  (97 and 95% of 1970  
ABS Rules Deck and Baseline values)

#### REQUIRED MOMENT OF INERTIA AND SECTION MODULUS - H32 STEEL

Section 6.13.2  $I_{H32} = L \times SM/34.1 = 7,597,400 \text{ in}^2 \text{ ft}^2$

Table 43.2  $Y = \text{Yield Stress} = 45,500 \text{ PSI}$

$U = \text{Ultimate Tensile Stress} = 68,000 \text{ PSI}$

Section 6.13.3  $Q = 70,900/(Y + 2U/3) = 0.78050$

$SM_{H32} = Q(SM) = 225,360 \text{ in}^2 \text{ ft}$

#### SCANTLINGS

Use H32 material in deck and bottom structure with mild steel elsewhere.

Reduce deck longitudinal from 15" x 1.25" to 15" x 1.00"

Reduce bottom longitudinal flanges from 6" x 1.375" to 6" x 1.25"

Resulting properties:

$$I = 7,850,007 \text{ in}^2 \text{ ft}^2 > 7,597,400 \text{ in}^2 \text{ ft}^2$$

$$SM_{dk} = 240,281 \text{ in}^2 \text{ ft} > 225,360 \text{ in}^2 \text{ ft}$$

$$SM_{bl} = 254,622 \text{ in}^2 \text{ ft} > 225,360 \text{ in}^2 \text{ ft}$$

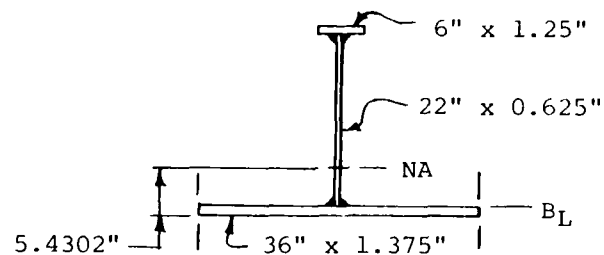
#### MAXIMUM HULL GIRDER SHEARING FORCE

Section 6.3.3(a)  $V_p = F_{sw} + F_w$

Section 6.3.3(b)  $V_p = 5.0 M_{sw}/L + 2.6 M_w/L = 12,207^{LT}$

# VON MISES COMBINED STRESS ANALYSIS FOR BOTTOM LONGITUDINALS

Bottom longitudinals are built up sections with 22" x 0.625" AH32 webs, 6" x 1.25" AH32 flanges, 36" spacing on 56.1# DH32 bottom plate, and spans of 13'-1.5".

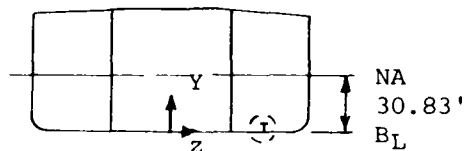


## PRIMARY STRESSES

ABS Rule Loading: Total bending moment = 3,064,087 ft-LT  
Hull girder shearing force = 12,207 LT

Longitudinal Stresses:

$$\sigma_x @ B_L = \frac{3,064,087 \text{ ft-LT} \times 2240 \text{ #/LT}}{254,622 \text{ in}^2 \text{ ft}} = 26,956 \text{ PSI}$$

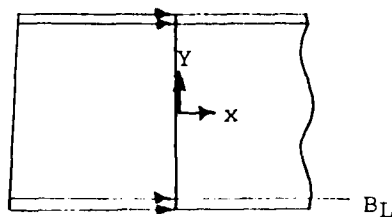


$$\sigma_x = -25,262 \text{ PSI}$$

$$-25,353 \text{ PSI}$$

$$-26,956 \text{ PSI}$$

$$-27,056 \text{ PSI}$$



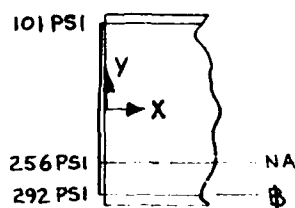
## Longitudinal Stresses

(Hogging condition shown - reverse for sagging condition)

Primary Shear Stresses: The upper surface of the flange is a free surface so the shear stress must be zero and shear stresses within the web may be calculated from:

$$\tau_{xy} = \frac{V_p (AY)_p}{I_p T} = \frac{12,207^{LT} \times 2240 \text{ \#/LT} \times (AY)_p}{7,850,007 \text{ in}^2 \text{ ft}^2 \times 0.625 \text{ in.}} = 5.5732 (AY)_p \frac{\#}{\text{in}^3 \text{ ft}^2}$$

| Point         | $(AY)_p (\text{in ft}^2)$ | $\tau_{xy} (\text{PSI})$ |
|---------------|---------------------------|--------------------------|
| Web at Flange | 18.090                    | 101                      |
| Web at NA     | 45.890                    | 256                      |
| Web at Shell  | 52.366                    | 292                      |

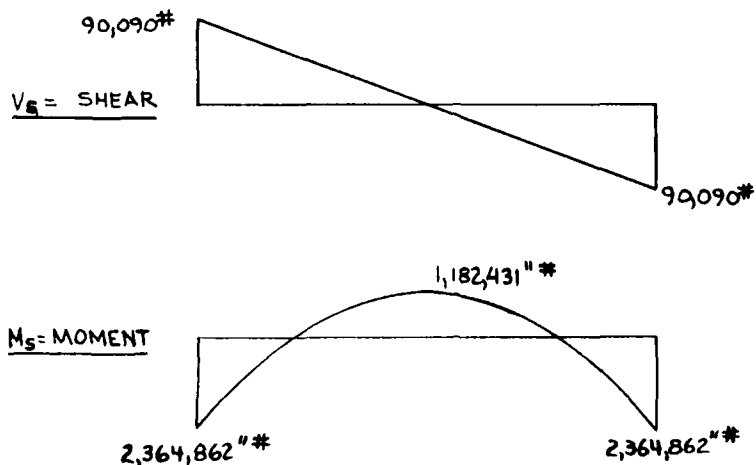
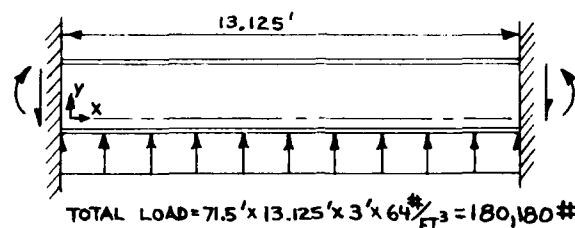


## SECONDARY STRESSES

ABS Rule Loading: From Section 22.29.2, design head is 8' above deck at side which is 71.5' above baseline. Because the longitudinals are continuous through all transverse supporting structure and the loading is symmetric, the longitudinals can be considered as fixed ended beams. External load shown, reverse all signs for internal load.

## SECTION PROPERTIES:

Area = 70.75 in<sup>2</sup>  
 $I_{NA} = 4926.22 \text{ in}^4$   
 $Z_{flg} = 256.64 \text{ in}^3$   
 $Z_{plt} = 907.19 \text{ in}^3$   
 $(AY)_s \text{ for web at flg} = 139.27 \text{ in}^3$   
 $(AY)_s \text{ for web at NA} = 239.90 \text{ in}^3$   
 $(AY)_s \text{ for web at shell} = 234.76 \text{ in}^3$

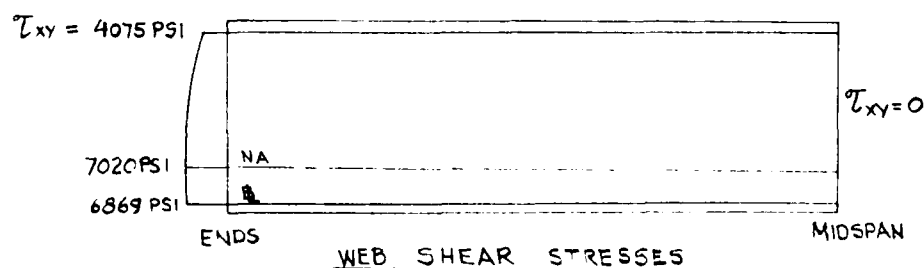
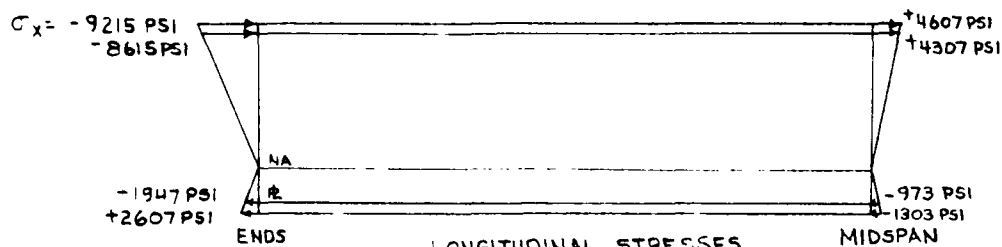


Longitudinal Stresses =  $M_S/Z$

Shear Stresses in Web =  $\frac{V_S(AY)_S}{I_{NA}T}$

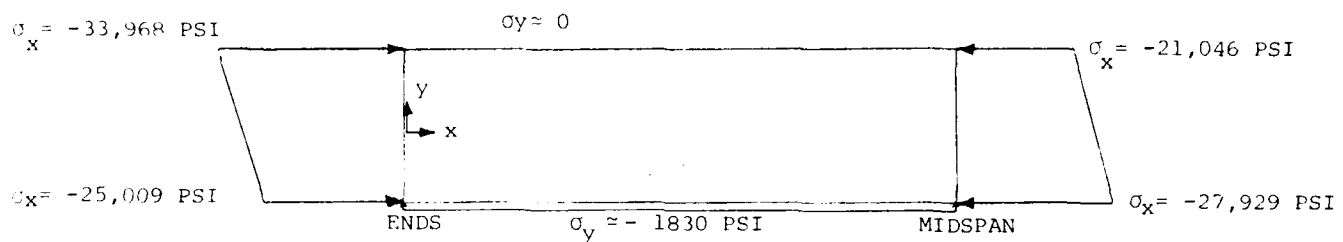
In addition to longitudinal and shear stresses, there is a compressive stress in the web varying from near zero at the flange to a maximum value at the shell of about:

$$\sigma_y = \frac{71.5' \times 3' \times 64\#/Ft^3}{0.625" \times 12"/'} = 1830 \text{ PSI.}$$

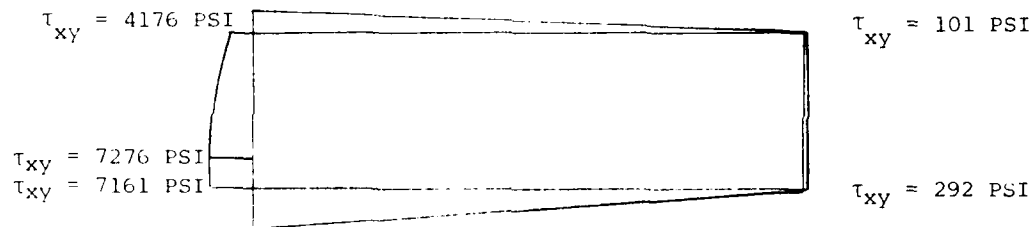


# COMBINED PRIMARY AND SECONDARY STRESSES IN WEB - CASE I

Hogging condition with external secondary load shown - reverse all signs for sagging condition with internal secondary load.



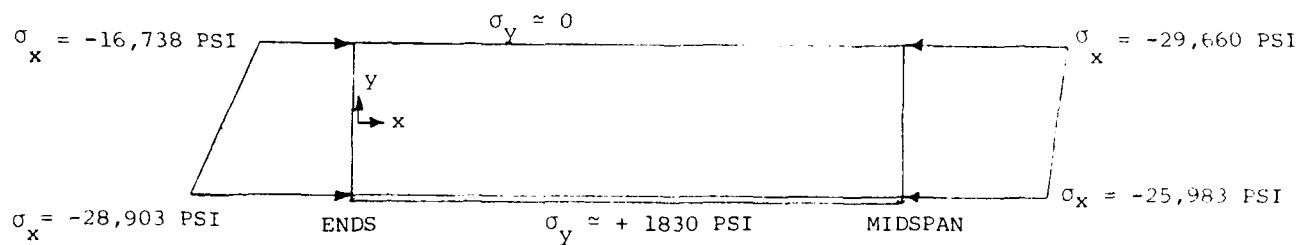
## COMBINED NORMAL STRESSES



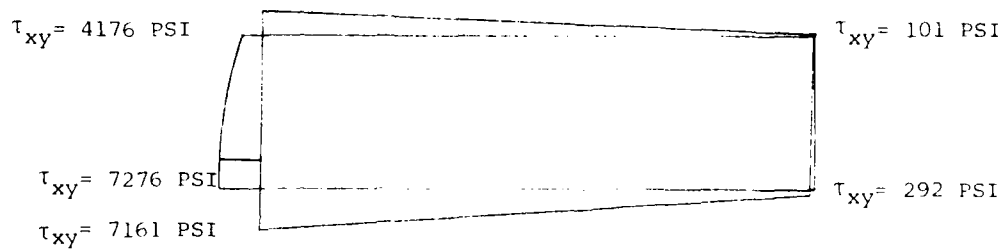
## COMBINED SHEAR STRESSES

# COMBINED PRIMARY AND SECONDARY STRESSES IN WEB - CASE II

Hogging condition with internal secondary load shown - reverse all signs for sagging condition with external secondary load.



COMBINED NORMAL STRESSES



COMBINED SHEAR STRESSES

### VON MISES COMBINED STRESSES

In terms of principal stresses  $\sigma_1$  and  $\sigma_2$ , the two dimensional von Mises criteria states that yielding will occur when the following combination of principal stresses reach the yield stress,  $Y$ :

$$\sigma_1^2 + (\sigma_1 - \sigma_2)^2 + \sigma_2^2 = 2Y^2$$

$$\text{or } \sigma_1^2 - \sigma_1 \sigma_2 + \sigma_2^2 = Y^2$$

For the two dimensional case at hand, the principal stresses are:

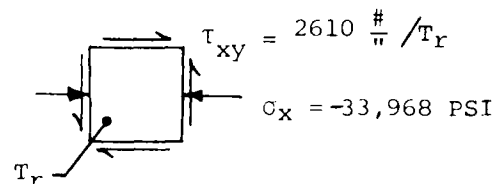
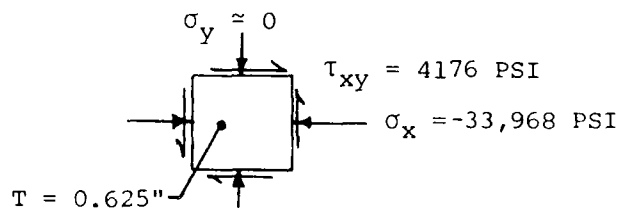
$$\sigma_{1,2} = 1/2 (\sigma_x + \sigma_y) \pm \sqrt{[1/2(\sigma_x - \sigma_y)]^2 + \tau_{xy}^2}$$

These two equations can be combined to express the von Mises criteria in terms of  $\sigma_x$ ,  $\sigma_y$ , and  $\sigma_{xy}$  directly:

$$\sigma_x^2 - \sigma_x \sigma_y + \sigma_y^2 + 3 \tau_{xy}^2 = Y^2$$

WELD REQUIRED FOR WEB TO FLANGE CONNECTION USING  
VON MISES COMBINED STRESS CRITERIA

The Case I load combination is the most severe for this connection.



When determining a required web thickness,  $T_r$ , on which to base the fillet weld, it should be noted that only  $\tau_{xy}$  would vary significantly if the web thickness in way of the flange were locally altered as shown below. The longitudinal stress would remain essentially constant. Material is AH32 plate with yield stress =  $Y = 45,500$  PSI.

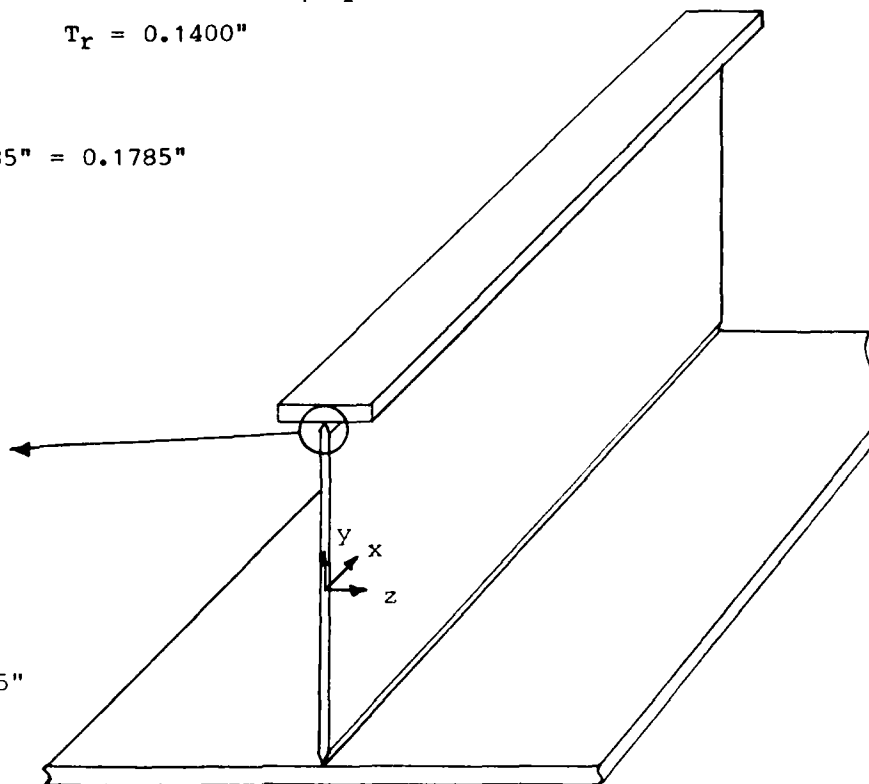
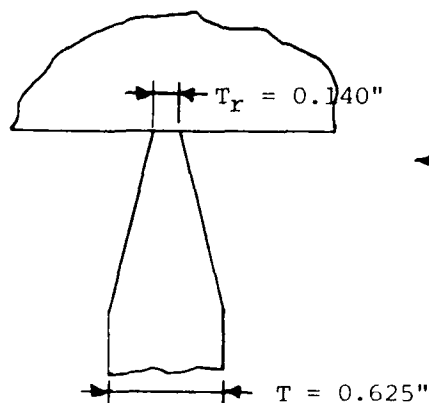
$$\sigma_x^2 - \sigma_x \sigma_y + \sigma_y^2 + 3 \tau_{xy}^2 = Y^2$$

$$(-33,968)^2 - (-33,968)(0) + (0)^2 + 3 \left( \frac{2610}{T_r} \right)^2 = (45,500)^2$$

$$T_r = 0.1400"$$

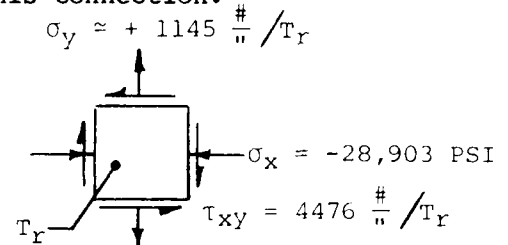
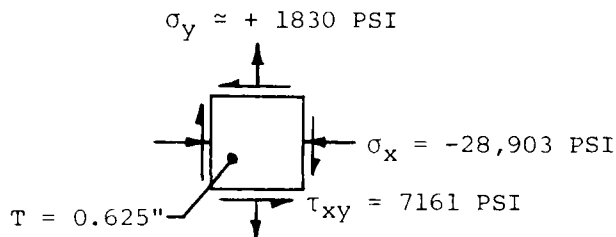
Required fillet weld size is:

$$D = 0.668(0.1400") + 0.085" = 0.1785"$$



WELD REQUIRED FOR WEB TO SHELL PLATING CONNECTION USING  
VON MISES COMBINED STRESS CRITERIA

Case II load combination is the most severe for this connection.



In this case, both  $\sigma_y$  and  $\tau_{xy}$  will vary significantly if the web thickness in way of the shell plating were altered.

$$\sigma_x^2 - \sigma_x \sigma_y + \sigma_y^2 + 3 \tau_{xy}^2 = \gamma^2$$

$$(-28,903)^2 - (-28,903) \left( + \frac{1145}{T_r} \right) + \left( + \frac{1145}{T_r} \right)^2 + 3 \left( \frac{4476}{T_r} \right)^2 = (45,500)^2$$

$$T_r^2 - 0.026800 T_r - 0.049734 = 0$$

$$T_r = 0.23681"$$

$$D = 0.668(0.23681") + 0.085" = 0.2432"$$

These two welds are covered by line 46 which falls in ABS weld groups M and M4.

ABS weld size is  $7/32" = 0.2188"$ ,

or  $5/16" \text{ 3-10}$  which has an equivalent weld size of  $0.1532"$

Therefore, this analysis procedure is excessively conservative. One of the reasons for this conservatism is that the Von Mises criteria defines initial yielding only, not necessarily ultimate failure. For example, the von Mises criteria for pure shear gives an allowable shear stress of 57.7% of the uniaxial tensile yield stress. However, tests show that the ultimate shear stress of most steels can be 67 to 75% of the uniaxial tensile ultimate stress. Since the weld strength values are necessarily breaking strengths, a higher ratio than 57.7% for shear to tensile strength is appropriate. Various attempts to modify the von Mises criteria to more accurately reflect experimental failure data have been suggested. For example, reference (15), page 69, shows a  $\tau_{xy}$  coefficient of 1.8 rather than 3. The value of 1.8 gives an allowable shear stress of 74.5% of the uniaxial tensile stress which is more in line with experimental results.

WELD REQUIRED FOR WEB TO FLANGE CONNECTION USING  
MODIFIED VON MISES COMBINED STRESS CRITERIA

$$\sigma_x^2 - \sigma_x \sigma_y + \sigma_y^2 + 1.8 \tau_{xy}^2 = Y^2$$

$$(-33,968)^2 - (-33,968)(0) + (0)^2 + 1.8 \left( \frac{2610}{T_R} \right)^2 = (45,500)^2 \quad (\text{see page E-18})$$

$$T_R = 0.11567"$$

$$D = 0.668 (0.11567") + 0.085" = 0.1623"$$

WELD REQUIRED FOR WEB TO SHELL PLATING CONNECTION USING  
MODIFIED VON MISES COMBINED STRESS CRITERIA

$$\sigma_x^2 - \sigma_x \sigma_y + \sigma_y^2 + 1.8 \tau_{xy}^2 = Y^2$$

$$(-28,903)^2 - (-28,903) \left( + \frac{1145}{T_R} \right) + \left( + \frac{1145}{T_R} \right)^2 + 1.8 \left( \frac{4476}{T_R} \right)^2 = (45,500)^2$$

(See page E-19)

$$T_R^2 - 0.026800 T_R - 0.030265 = 0$$

$$T_R = 0.18788"$$

$$D = 0.668 (0.18788") + 0.085" = 0.2105"$$

This calculation gives a weld size less than ABS continuous weld of 0.2188" but still greater than the ABS intermittent weld equivalent size of 0.1532".

### SIMPLIFIED STRESS ANALYSIS PROCEDURES

For members where the most significant stresses in the fillet welds are longitudinal shear, the required thickness,  $T_r$ , can be determined as follows:

$$\tau_T = \tau_p + \tau_s$$

$$\tau_T = \frac{V_p (AY)_p}{I_p T_r} + \frac{V_s (AY)_s}{I_s T_r}$$

$$\text{or} \quad T_r = \frac{1}{\tau_T} \left[ \frac{V_p (AY)_p}{I_p} + \frac{V_s (AY)_s}{I_s} \right]$$

where:  $V$  = Shear Force

$AY$  = Area moment about appropriate neutral axis

$I$  = Moment of inertia

Subscripts  $p$  and  $s$  refer to primary and secondary values, respectively.

To use these equations, allowable shear stresses are needed. Fortunately, the ABS Rules give the majority of the required values. Those that are missing can be conservatively taken as 60% of the respective tensile stresses.

# ABS ALLOWABLE STRESSES FOR VOYAGER CLASS TANKER

## PRIMARY STRESSES

From Section 6.3.1(a) for an 897.25' ship,  $f_p = \sigma_p = 10.612 \text{ LT/in}^2 = 23,771 \text{ PSI}$   
 From Section 6.3.3,  $\tau_p = 6.75 \text{ LT/in}^2 = 15,120 \text{ PSI}$  (63.6% of  $\sigma_p$ )

| <u>Material</u> | <u>Q</u> | $\sigma_p = \frac{23,771 \text{ PSI}}{Q}$ | $\tau_p = \frac{15,120 \text{ PSI}}{Q}$ |
|-----------------|----------|-------------------------------------------|-----------------------------------------|
| MS              | 1.0      | 23,771                                    | 15,120                                  |
| H32             | 0.7805   | 30,456                                    | 19,372                                  |
| H36             | 0.7210   | 32,969                                    | 20,971                                  |

## SECONDARY STRESSES FOR TRANSVERSE STRUCTURE (WEBS, GIRDERS, AND TRANSVERSES)

From Section 22.27.2,  $f = \sigma_s = 9 \text{ LT/in}^2 = 20,160 \text{ PSI}$   
 From Section 22.27.4,  $q = \tau_s = 5.5 \text{ LT/in}^2 = 12,320 \text{ PSI}$  (61.1% of  $\sigma_p$ )

| <u>Material</u> | <u>Q</u> | $\sigma_s = \frac{20,160 \text{ PSI}}{Q}$ | $\tau_s = \frac{12,320 \text{ PSI}}{Q}$ |
|-----------------|----------|-------------------------------------------|-----------------------------------------|
| MS              | 1.0      | 20,160                                    | 12,320                                  |
| H32             | 0.7805   | 25,830                                    | 15,785                                  |
| H36             | 0.7210   | 27,961                                    | 17,087                                  |

## SECONDARY AND COMBINES STRESSES FOR LONGITUDINAL STRUCTURE (WEBS AND GIRDERS)

From Section 22.27.2,  $f = \sigma_s = 6 \text{ LT/in}^2 = 13,440 \text{ PSI}$   
 From Section 22.27.4,  $q = \tau_s = 4.4 \text{ LT/in}^2 = 9,856 \text{ PSI}$  (73.3% of  $\sigma_p$ )

| <u>Material</u> | <u>Q</u> | $\sigma_s = \frac{13,440 \text{ PSI}}{Q}$ | $\frac{\sigma_T = \sigma_s + \sigma_p}{\sigma_s + \sigma_p}$ | <u>Y (PSI)</u> | $\frac{\sigma_T}{\text{VS. Y}}$ | $\tau_s = \frac{9856 \text{ PSI}}{Q}$ | $\frac{\tau_T = \tau_s + \tau_p}{\tau_s + \tau_p}$ | $\frac{\tau_T}{\sigma_T}$ |
|-----------------|----------|-------------------------------------------|--------------------------------------------------------------|----------------|---------------------------------|---------------------------------------|----------------------------------------------------|---------------------------|
| MS              | 1.0      | 13,440                                    | 37,211                                                       | 34,000         | + 9.4%                          | 9,856                                 | 24,976                                             | 67.1%                     |
| H32             | 0.7805   | 17,220                                    | 47,676                                                       | 45,500         | + 4.8%                          | 12,628                                | 32,000                                             | 67.1%                     |
| H36             | 0.7210   | 18,641                                    | 51,610                                                       | 51,000         | + 1.2%                          | 13,670                                | 34,641                                             | 67.1%                     |

## SECONDARY AND COMBINED STRESSES FOR STRUCTURAL SECTIONS

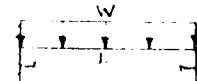
From Section 22.29.2,

$$SM = 0.0041 c h s L^2 \text{ (in}^3\text{) where } c \text{ varies with location}$$

h = hydrostatic head in feet  
s = spacing in feet  
L = length between supports in feet.

Consider a fixed end, uniformly loaded beam.

Maximum bending moment is at supports with value:



$$BM = w L^2 / 12$$

$$w = \text{unit load} = \text{pressure} \times \text{spacing} = h \text{ (feet)} \times 64 \text{ lbs/ft}^3 \times$$

$$s \text{ (feet)} = 64 h s \text{ lbs/ft}$$

$$\sigma_s = \frac{BM}{SM} \quad \text{or} \quad SM = \frac{BM}{\sigma_s}$$

$$SM = \frac{w L^2}{12 \sigma_s} = \frac{64 h s \text{ (lbs/Ft)} L^2 \text{ (Ft}^2\text{)} \times 12 \text{ in/Ft}}{12 \sigma_s \text{ (lbs/in}^2\text{)}} = \frac{64 h s L^2}{\sigma_s} \text{ (in}^3\text{)}$$

Equating the two SM expressions,

$$0.0041 c h s L^2 = \frac{64 h s L^2}{s}$$

$$\sigma_s = \frac{64}{0.0041c}$$

$$\sigma_s = \frac{15,610 \text{ PSI}}{c}$$

## MILD STEEL STRUCTURAL SECTIONS

| Location      | c    | $\sigma_s = \frac{15,610}{c}$ | $\sigma_T = \sigma_s + 23,771$ | $\sigma_T$<br>vs. 34,000 | $\tau_s = 0.6 \times \sigma_s$ | $\tau_T = \tau_s + 15,120$ | $\frac{\tau_T}{\sigma_T}$ |
|---------------|------|-------------------------------|--------------------------------|--------------------------|--------------------------------|----------------------------|---------------------------|
| Dk. Long.     | 1.25 | 12,488                        | 36,259                         | + 6.6%                   | 7,493                          | 22,613                     | 62.4%                     |
| Side Long.    | 0.95 | 16,431                        | <40,202                        | -                        | 9,859                          | <24,979                    | -                         |
| Horiz. Stiff. |      |                               |                                |                          |                                |                            |                           |
| on Long.      |      |                               |                                |                          |                                |                            |                           |
| Bhd.          | 0.90 | 17,344                        | <41,115                        | -                        | 10,406                         | <25,526                    | -                         |
| Bottom Long.  | 1.40 | 11,150                        | 34,921                         | + 2.7%                   | 6,690                          | 21,810                     | 62.5%                     |
| Vert. Frames  | 1.00 | 15,610                        | -                              | -                        | 9,366                          | -                          | -                         |
| Transv. Bhd.  |      |                               |                                |                          |                                |                            |                           |
| Stiff.        | 1.00 | 15,610                        | -                              | -                        | 9,366                          | -                          | -                         |

### H32 STRUCTURAL SECTIONS (Q=0.7805)

| <u>Location</u> | <u>c</u> | $\frac{\sigma_s = 15,610}{c \times 0.7805}$ | $\frac{\sigma_T = \sigma_s + 30,456}{\sigma_s}$ | $\frac{\sigma_T \text{ vs. } 45,500}{\sigma_T}$ | $\frac{\tau_s = 0.6 \times \sigma_s}{\tau_s}$ | $\frac{\tau_T = \tau_s + 19,372}{\tau_T}$ | $\frac{\tau_T}{\sigma_T}$ |
|-----------------|----------|---------------------------------------------|-------------------------------------------------|-------------------------------------------------|-----------------------------------------------|-------------------------------------------|---------------------------|
| Dk. Long.       | 1.25     | 16,000                                      | 46,456                                          | + 2.1%                                          | 9,600                                         | 28,972                                    | 62.4%                     |
| Side Long.      | 0.95     | 21,053                                      | <51,509                                         | -                                               | 12,632                                        | <32,004                                   | -                         |
| Horiz. Stiff.   |          |                                             |                                                 |                                                 |                                               |                                           |                           |
| on Long.        |          |                                             |                                                 |                                                 |                                               |                                           |                           |
| Bhd.            | 0.90     | 22,222                                      | <52,678                                         | -                                               | 13,333                                        | <32,705                                   | -                         |
| Bottom Long.    | 1.40     | 14,286                                      | 44,742                                          | - 1.7%                                          | 8,572                                         | 27,944                                    | 62.5%                     |
| Vert. Frames    | 1.00     | 20,000                                      | -                                               | -                                               | 12,000                                        | -                                         | -                         |
| Transv. Bhd.    |          |                                             |                                                 |                                                 |                                               |                                           |                           |
| Stiff.          | 1.00     | 20,000                                      | -                                               | -                                               | 12,000                                        | -                                         | -                         |

### H36 STRUCTURAL SECTIONS (Q=0.7210)

| <u>Location</u> | <u>c</u> | $\frac{\sigma_s = 15,610}{c \times 0.7210}$ | $\frac{\sigma_T = \sigma_s + 32,969}{\sigma_s}$ | $\frac{\sigma_T \text{ vs. } 51,000}{\sigma_T}$ | $\frac{\tau_s = 0.6 \times \sigma_s}{\tau_s}$ | $\frac{\tau_T = \tau_s + 20,971}{\tau_T}$ | $\frac{\tau_T}{\sigma_T}$ |
|-----------------|----------|---------------------------------------------|-------------------------------------------------|-------------------------------------------------|-----------------------------------------------|-------------------------------------------|---------------------------|
| Dk. Long.       | 1.25     | 17,320                                      | 50,289                                          | - 1.4%                                          | 10,392                                        | 31,363                                    | 62.4%                     |
| Side Long.      | 0.95     | 22,790                                      | <55,759                                         | -                                               | 13,674                                        | <34,645                                   | -                         |
| Horiz. Stiff.   |          |                                             |                                                 |                                                 |                                               |                                           |                           |
| on Long.        |          |                                             |                                                 |                                                 |                                               |                                           |                           |
| Bhd.            | 0.90     | 24,056                                      | <57,025                                         | -                                               | 14,434                                        | <35,405                                   | -                         |
| Bottom Long.    | 1.40     | 15,465                                      | 48,434                                          | - 5.0%                                          | 9,279                                         | 30,250                                    | 62.5%                     |
| Vert. Frames    | 1.00     | 21,650                                      | -                                               | -                                               | 12,990                                        | -                                         | -                         |
| Transv. Bhd.    |          |                                             |                                                 |                                                 |                                               |                                           |                           |
| Stiff.          | 1.00     | 21,650                                      | -                                               | -                                               | 12,990                                        | -                                         | -                         |

### SIMPLIFIED STRESS ANALYSIS FOR BOTTOM LONGITUDINALS

From Page E-13,  $V_p = 12,207 \text{ LT} = 27,343,680\#$   
 $(AY)_p$  for web at flange = 18.090 in.  $\text{Ft}^2$   
 $(AY)_p$  for web at shell = 52.366 in.  $\text{Ft}^2$   
 $I_p = 7,850,007 \text{ in}^2 \text{ Ft}^2$

From Page E-13,  $V_s = 90,090\#$   
 $(AY)_s$  for web at flange = 139.27  $\text{in}^3$   
 $(AY)_s$  for web at shell = 234.76  $\text{in}^3$   
 $I_s = 4926.22 \text{ in}^4$

From Page E-24,  $\tau_T$  for H32 bottom long. = 27,944 PSI

For web to flange connection,

$$\tau_r = \frac{1}{\tau_T} \left[ \frac{V_p (AY)_s}{I_p} + \frac{V_s (AY)_s}{I_s} \right]$$

$$\tau_r = \frac{1}{27,944 \text{ \#/in}^2} [63.012 \text{ \#/in.} + 2546.95 \text{ \#/in.}] = 0.09340 \text{ in.}$$

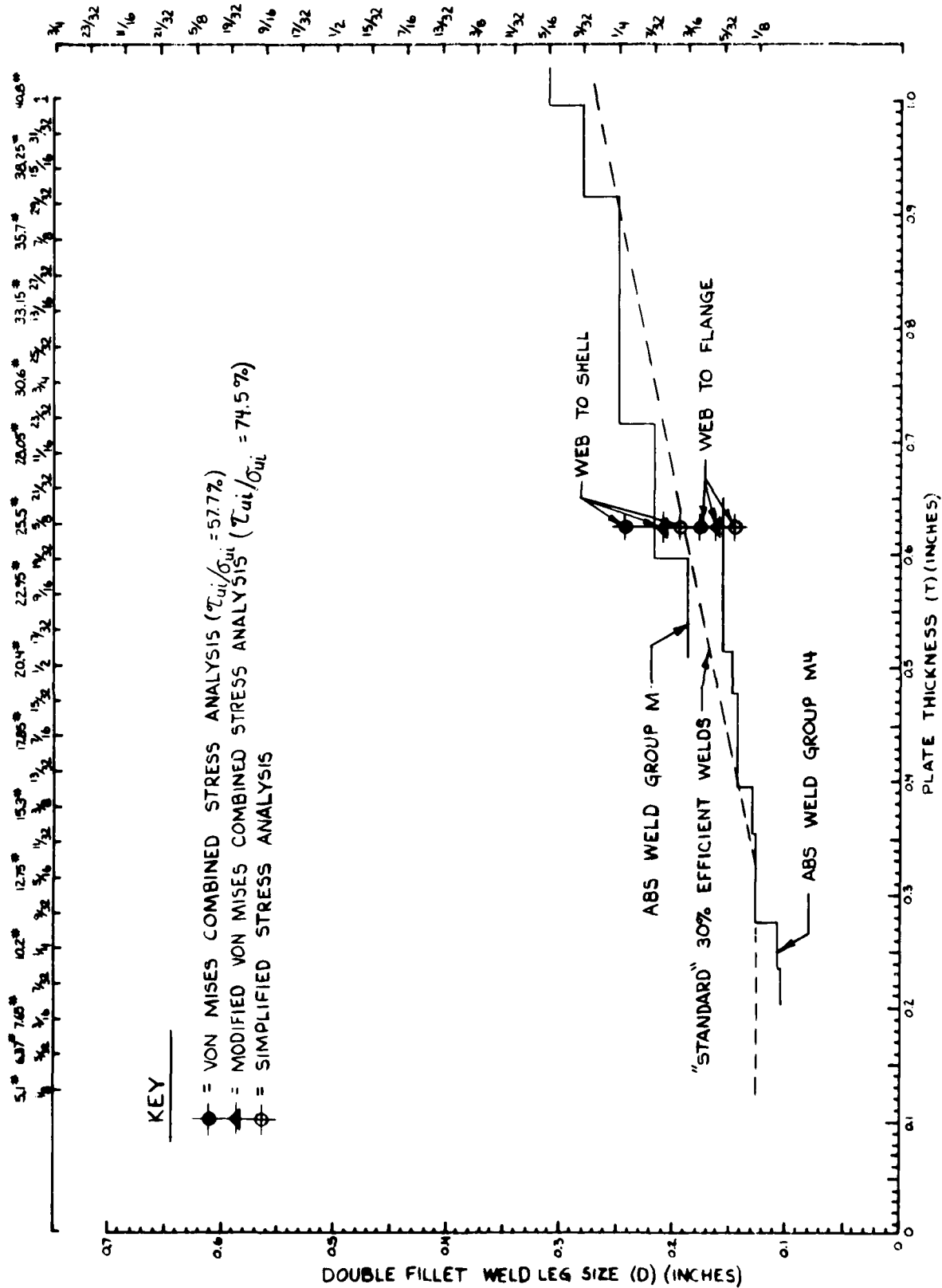
$$D = 0.668 (0.09340") + 0.085" = 0.1474"$$

For web to shell connection,

$$\tau_r = \frac{1}{27,944 \text{ \#/in}^2} [182.40 \text{ \#/in.} + 4293.26 \text{ \#/in.}] = 0.1601 \text{ in.}$$

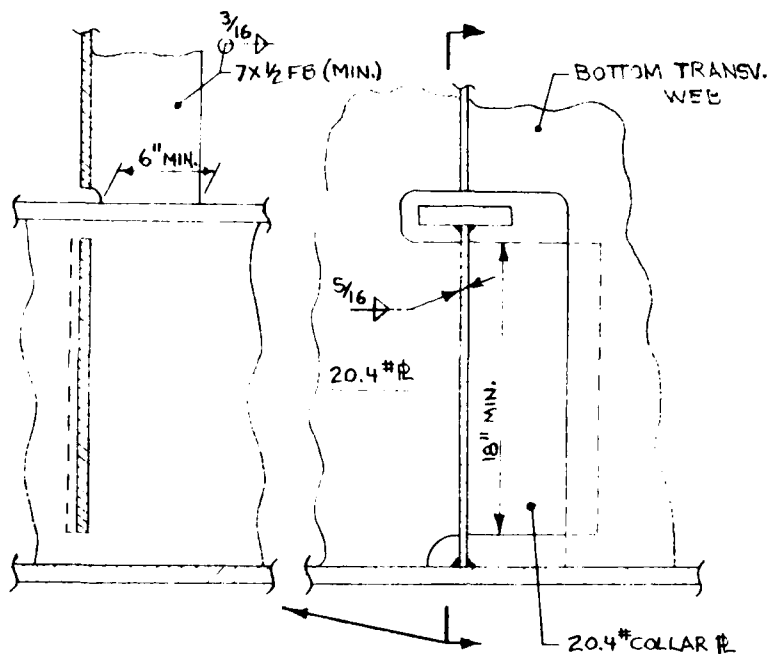
$$D = 0.668 (0.1601") + 0.085" = 0.1920"$$

From the comparison on the next page, this procedure matches the existing ABS rule tables much better than the von Mises combined stress analysis does. Hence, it should be sufficiently conservative for normal use. Also, the web to flange welds are not as highly loaded as the web to shell welds, so some further reduction in the former weld size would appear feasible if these welds were not already at the minimum acceptable size (see Section 5.5).



COMPARISON OF CALCULATED AND TABULAR WELD SIZES FOR BOTTOM LONGITUDINALS OF CYLINDRICAL TANKS

# CONNECTION OF BOTTOM LONGITUDINALS TO SUPPORTING STRUCTURE



SECTION LOOKING FORWARD

The most significant load on this connection is due to the secondary load on the longitudinals. From page E-13, the local force on the supporting structure is  $2 \times 90,090\#$ . There will also be shear forces in the bottom transverse webs which vary in magnitude at each longitudinal location. The maximum design shear stress from the latter forces is 12,320 PSI for mild steel webs (see page E-22). An acceptable total shear stress in mild steel webs is 24,976 PSI (see page E-22). Hence, an allowable local shear stress for the longitudinal reactions is:

$$24,976 - 12,320 = 12,656 \text{ PSI.}$$

If both the flat bar and the collar plates are omitted, the required local girder web thickness is:

$$T_r = \frac{2 \times 90,090\#}{18" \times 12,656 \text{ PSI}} = 0.7909".$$

Since this is obviously unacceptable, collar plates are required, and the required local girder web and collar plate thickness is:

$$T_r = \frac{2 \times 90,090\#}{2 \times 18" \times 12,656 \text{ PSI}} = 0.3955",$$

and the required weld is:

$$D = 0.628 (0.3955") + 0.085" = 0.3334".$$

Since the required weld is still greater than that normally provided (matching periphery weld), the flat bars should also be provided. The equivalent weld size provided by all three welds is approximately:

$$D = \frac{6" \times 0.1875" + 2 \times 18" \times 0.3125"}{2 \times 18"} = 0.3438" > 0.3334".$$

#### CONNECTION OF DECK LONGITUDINALS TO SUPPORTING STRUCTURE

Secondary load is a hydrostatic head of eight feet:

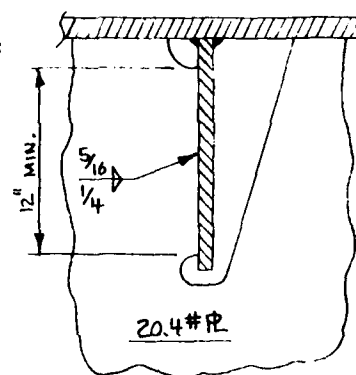
$$8 \text{ Ft} \times 64 \text{ #/Ft}^3 \times 3 \text{ Ft} \times 13.125 \text{ Ft} = 20,160 \#.$$

Using same procedure as bottom longitudinals, required local girder web thickness is:

$$T_r = \frac{20,160 \text{ #}}{12" \times 12,656 \text{ PSI}} = 0.1327",$$

and required weld is:

$$D = 0.628 (0.1327") + 0.085" = 0.1683" < 0.2812".$$



SECTION LKG. FWD

The provided weld is adequate without collars or flat bars for this local load. However, it should be rechecked when other local loads (such as those from deck mounted foundations) are present.

APPENDIX F

CALCULATIONS FOR VANGUARD CLASS CONTAINERSHIP

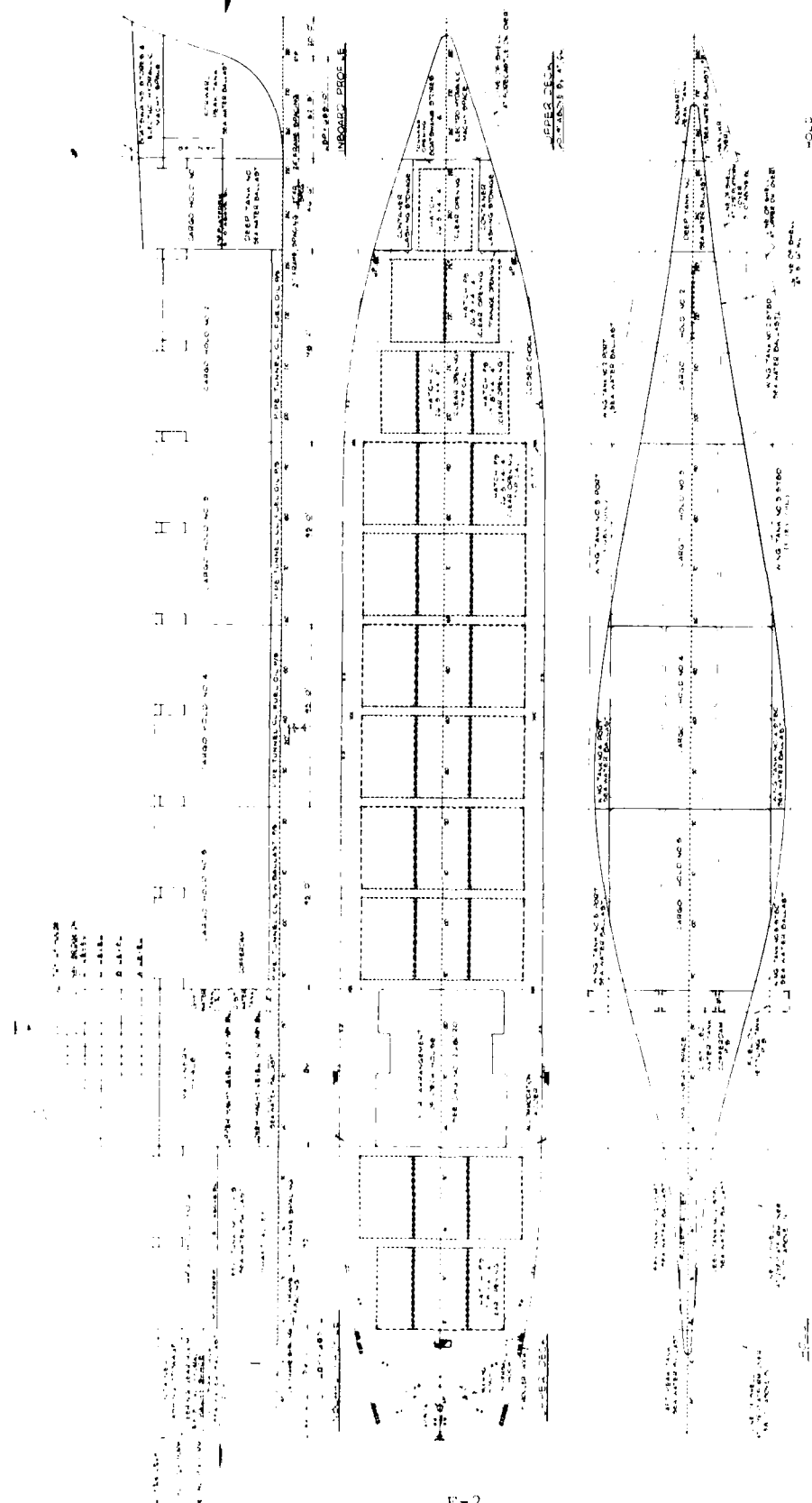
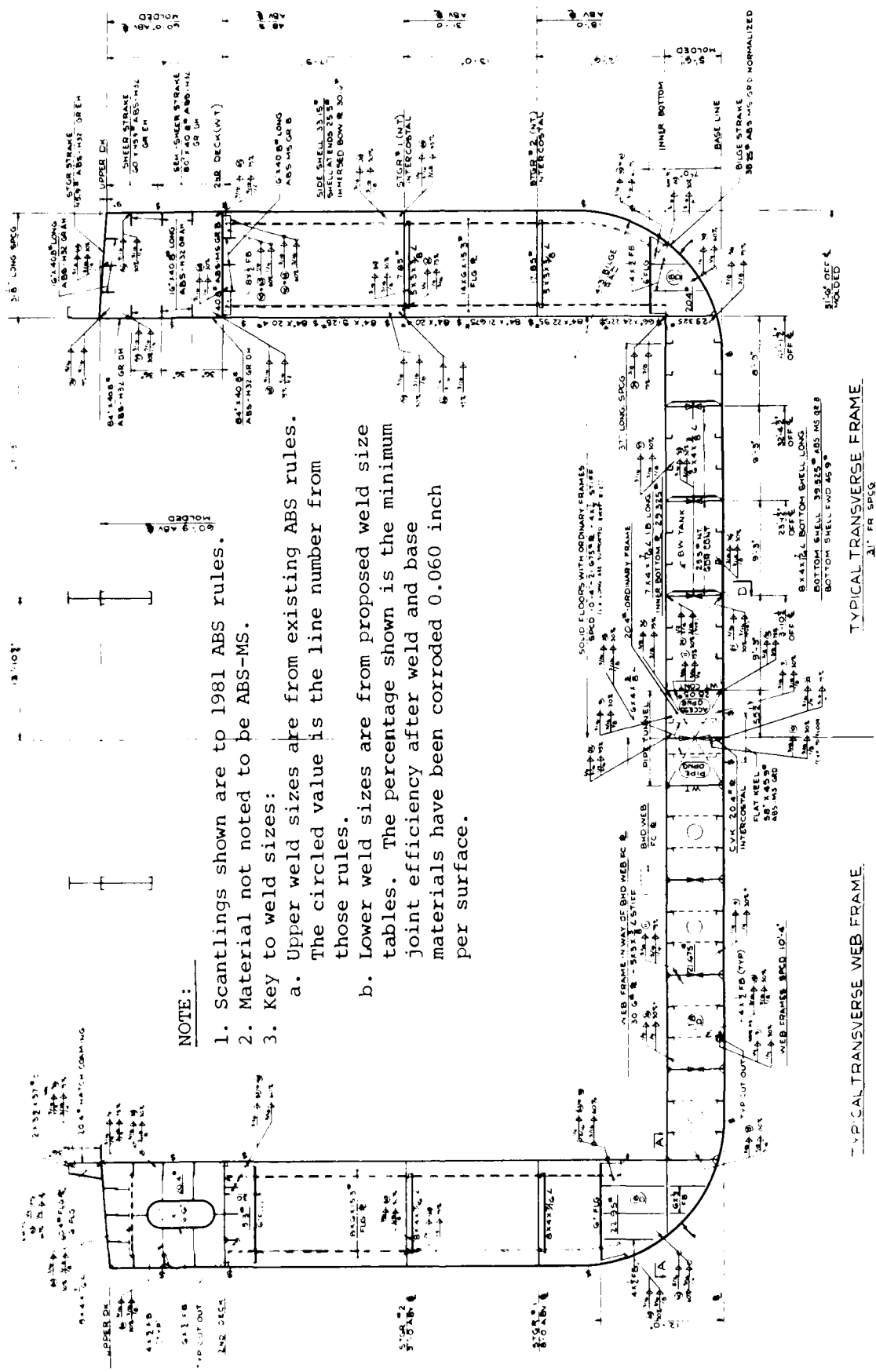


FIGURE F-1  
GENERAL ARRANGEMENT DRAWINGS OF VANGUARD CLASS CONTAINERSHIP

21' 4" X 42' 0" HATCH COVER

21' 4" X 42' 0" HATCH COVER



NOTE:

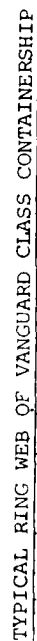
1. Scantlings shown are to 1981 ABS rules.
2. Material not noted to be ABS-MS.
3. Key to weld sizes:
  - a. Upper weld sizes are from existing ABS rules.
  - b. Lower weld sizes are from proposed weld size tables. The percentage shown is the minimum joint efficiency after weld and base materials have been corroded 0.060 inch per surface.

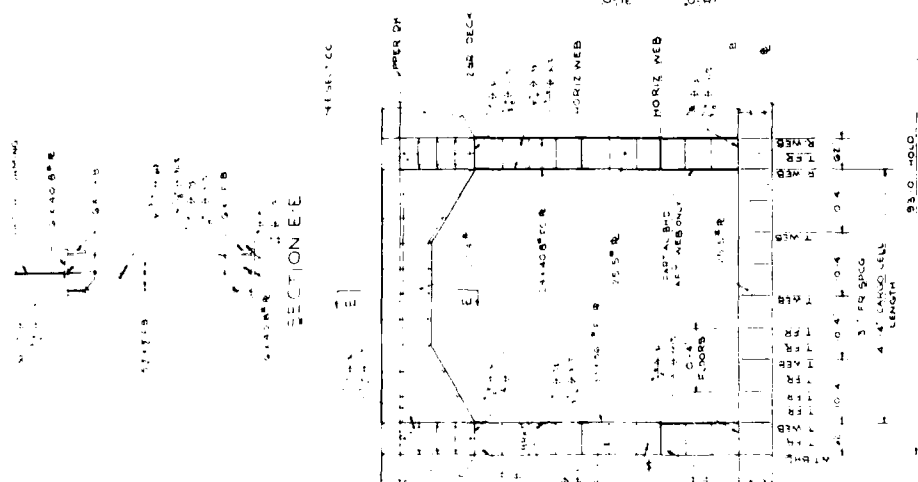
TYPICAL TRANSVERSE WEB FRAME

TYPICAL TRANSVERSE FRAME

FIGURE F-2

MIDSHIP SECTION OF VANGUARD CLASS CONTAINERSHIP





SECTION D-D  
3'-0" GIRDERS

TYPICAL TRANSVERSE BULKHEAD AND GIRDERS OF VANGUARD CLASS CONTAINERSHIP

FIGURE F-4

93 0 -GOLD-

LENGTH

TABLE F-1

## LENGTHS AND WEIGHTS OF ALTERED WELDS FOR VANGUARD CLASS CONTAINERSHIP

| STRUCTURAL CONNECTION                          | Length<br>(Feet) | Number | Total Length<br>of Double<br>Fillet Welds<br>(Feet) | Design Weld<br>Size<br>(Inches) |                    | Weight of Design<br>Welds<br>(Pounds) |          |
|------------------------------------------------|------------------|--------|-----------------------------------------------------|---------------------------------|--------------------|---------------------------------------|----------|
|                                                |                  |        |                                                     | Existing                        | Proposed           | Existing                              | Proposed |
| Long'ls, to Dk, Long'l Bhd, & Shell            | 470.17           | 18     | 8,463                                               | 5/16                            | $\frac{5/16}{1/4}$ | 2,810                                 | 2,304    |
| Long'ls to 2nd Dk                              | 470.17           | 6      | 2,821                                               | 5/16                            | 1/4                | 937                                   | 599      |
| 2nd Dk to Long'l Bhd & Shell                   | 470.17           | 4      | 1,881                                               | 9/16                            | $\frac{9/16}{1/2}$ | 2,024                                 | 1,811    |
| Strgr. No. 1 & 2 to Bhd & Shell                | 470.17           | 8      | 3,761                                               | $\frac{1/4}{3/16}$              | 3/16               | 624                                   | 450      |
| Long'ls to I.B. & Bottom Shell                 | 470.17           | 32     | 15,045                                              | 3/16                            | $\frac{3/16}{1/8}$ | 1,798                                 | 1,299    |
| Side Girders to Innerbottom                    | 470.17           | 6      | 2,821                                               | $\frac{1/4}{3/16}$              | 3/16               | 468                                   | 337      |
| Long'l Hatch Gird Web to Dk                    | 449.50           | 2      | 899                                                 | 3/16                            | $\frac{3/16}{1/8}$ | 107                                   | 78       |
| Long'l Hatch Gird Web to Flg                   | 484.37           | 2      | 969                                                 | 3/16                            | $\frac{3/16}{1/8}$ | 116                                   | 84       |
| Long'l Hatch Gird Fc Pl to Dk                  | 41.33            | 38     | 1,570                                               | 5/16                            | 1/4                | 521                                   | 334      |
| Long'l Hatch Gird Fc Pl to Flg                 | 45.0             | 38     | 1,710                                               | 5/16                            | 1/4                | 568                                   | 363      |
| Long'l Hatch Gird to Box Gird                  | 14.67            | 86     | 1,262                                               | 5/16                            | $\frac{5/16}{1/4}$ | 419                                   | 344      |
| Long'l Hatch Gird Web Stiff                    | 7.58             | 342    | 2,592                                               | 3/16                            | $\frac{3/16}{1/8}$ | 310                                   | 224      |
| Stiff on Diaph                                 | 17.0             | 24     | 408                                                 | 3/16                            | $\frac{3/16}{1/8}$ | 49                                    | 35       |
| SUBTOTAL-Long'l Str of Cargo Sect              | -                | -      | 44,202                                              | 0.267 Avg                       | 0.234 Avg          | 10,751                                | 8,262    |
| Transv Fr to Shell (132 Fr)                    | 44.0             | 264    | 11,616                                              | 3/16                            | $\frac{3/16}{1/8}$ | 1,388                                 | 1,003    |
| Transv Fr to Bhd                               | 43.25            | 264    | 11,418                                              | 3/16                            | $\frac{3/16}{1/8}$ | 1,365                                 | 986      |
| Stiff to Strgr No. 1 & 2                       | 7.5              | 528    | 3,960                                               | 3/16                            | $\frac{3/16}{1/8}$ | 473                                   | 342      |
| Strgr Stiff End Conn                           | 0.583            | 1,056  | 616                                                 | 1/4                             | $\frac{1/4}{3/16}$ | 131                                   | 102      |
| Stiff on Bilge Brackets                        | 8.5              | 264    | 2,244                                               | 3/16                            | $\frac{3/16}{1/8}$ | 268                                   | 194      |
| Stiff on D.B. Side Gird (92 Fr)                | 5.25             | 552    | 2,898                                               | 3/16                            | $\frac{3/16}{1/8}$ | 346                                   | 250      |
| Docking Floor to Side Gird                     | 5.0              | 184    | 920                                                 | 5/16                            | $\frac{5/16}{1/4}$ | 305                                   | 250      |
| Docking Floor to I.B., Shell & CVK             | 14.5             | 184    | 2,668                                               | 3/16                            | $\frac{3/16}{1/8}$ | 319                                   | 230      |
| Stiff on Docking Floor                         | 5.25             | 184    | 966                                                 | 3/16                            | $\frac{3/16}{1/8}$ | 115                                   | 83       |
| Solid Floor to Long'l Bhd (40 Fr)              | 4.25             | 80     | 340                                                 | 3/8                             | $\frac{3/8}{5/16}$ | 163                                   | 138      |
| Solid Floor to Side Gird                       | 4.75             | 640    | 3,040                                               | 5/16                            | $\frac{5/16}{1/4}$ | 1,009                                 | 828      |
| CVK to Solid Floor                             | 4.75             | 80     | 380                                                 | 3/16                            | $\frac{3/16}{1/8}$ | 45                                    | 33       |
| Stiff on Solid Floor & Long                    | 5.25             | 720    | 3,780                                               | 3/16                            | $\frac{3/16}{1/8}$ | 452                                   | 326      |
| SUBTOTAL-132 Transv Fr-40<br>With Solid Floors | -                | -      | 44,846                                              | 0.205 Avg                       | 0.177 Avg          | 6,379                                 | 4,765    |

TABLE F-1 (Cont'd)

| STRUCTURAL CONNECTION         | Length<br>(Feet) | Number | Total Length<br>of Double<br>Fillet Welds<br>(Feet) | Design Weld<br>Size<br>(Inches) |                    | Weight of Design<br>Welds<br>(Pounds) |          |
|-------------------------------|------------------|--------|-----------------------------------------------------|---------------------------------|--------------------|---------------------------------------|----------|
|                               |                  |        |                                                     | Existing                        | Proposed           | Existing                              | Proposed |
| Web IWO Box Girder Inc. A.O.  | 52.25            | 74     | 3,866                                               | 3/16                            | $\frac{3/16}{1/8}$ | 462                                   | 334      |
| Stiff on Web IWO Box Girder   | 23.25            | 74     | 1,721                                               | 3/16                            | $\frac{3/16}{1/8}$ | 206                                   | 149      |
| Transv Fr to Shell & Long Bhd | 38.75            | 148    | 5,735                                               | 3/16                            | $\frac{3/16}{1/8}$ | 686                                   | 495      |
| Stiff to Strgr No. 1 & 2      | 7.0              | 148    | 1,036                                               | 3/16                            | $\frac{3/16}{1/8}$ | 124                                   | 89       |
| Bilge Brkt to Shell & Bhd     | 21.75            | 74     | 1,610                                               | 5/16                            | $\frac{5/16}{1/4}$ | 535                                   | 438      |
| Stiff on Bilge Brkt           | 22.0             | 74     | 1,628                                               | 3/16                            | $\frac{3/16}{1/8}$ | 195                                   | 141      |
| Frame to Bilge Brkt           | 3.25             | 148    | 481                                                 | $\frac{1/4}{3/16}$              | 3/16               | 80                                    | 57       |
| Brkts IWO I.B.                | 8.5              | 148    | 1,258                                               | 5/16                            | $\frac{5/16}{1/4}$ | 418                                   | 343      |
| Floor to Long Bhd             | 4.25             | 74     | 315                                                 | 3/8                             | $\frac{3/8}{5/16}$ | 151                                   | 128      |
| Floor to Side Girders         | 4.75             | 592    | 2,812                                               | 5/16                            | $\frac{5/16}{1/4}$ | 934                                   | 766      |
| C.V.K. to Floor               | 4.75             | 74     | 352                                                 | 3/16                            | $\frac{3/16}{1/8}$ | 42                                    | 30       |
| Stiff to Floor & Long's       | 5.25             | 666    | 3,496                                               | 3/16                            | $\frac{3/16}{1/8}$ | 418                                   | 302      |
| SUBTOTAL-37 Transv Web Fr     | -                | -      | 24,310                                              | 0.227 Avg                       | 0.199 Avg          | 4,251                                 | 3,272    |

TABLE F-1 (Cont'd)

| STRUCTURAL CONNECTION                             | Length<br>(Feet) | Number | Total Length<br>of Double<br>Fillet Welds<br>(Feet) | Design Weld<br>Size<br>(Inches) |                        | Weight of Design<br>Welds<br>(Pounds) |          |
|---------------------------------------------------|------------------|--------|-----------------------------------------------------|---------------------------------|------------------------|---------------------------------------|----------|
|                                                   |                  |        |                                                     | Existing                        | Proposed               | Existing                              | Proposed |
| Deck Transv to Deck                               | 82.0             | 10     | 820                                                 | 1/4                             | $\frac{1/4}{3/16}$     | 174                                   | 136      |
| Deck Transv to FC P <sub>L</sub>                  | 82.0             | 10     | 820                                                 | 1/4                             | $\frac{1/4}{3/16}$     | 174                                   | 136      |
| Deck Transv to Long'l Box G. P <sub>L</sub>       | 12.0             | 20     | 240                                                 | $\frac{1/2}{7/16}$              | 7/16                   | 180                                   | 156      |
| Web IWO Box Girder Inc. A.O.                      | 52.25            | 20     | 1,045                                               | $\frac{1/4}{3/16}$              | 3/16                   | 173                                   | 125      |
| Stiff on Web IWO Box Gird                         | 23.25            | 20     | 465                                                 | 3/16                            | $\frac{3/16}{1/8}$     | 56                                    | 40       |
| Side Transv to Shell & Long'l Bhd                 | 100.5            | 20     | 2,010                                               | 3/16                            | $\frac{3/16}{1/8}$     | 240                                   | 174      |
| Side Transv to 2nd Deck                           | 7.25             | 20     | 145                                                 | 5/16                            | $\frac{5/16}{1/4}$     | 48                                    | 39       |
| Side Transv Stiffeners                            | 44.0             | 60     | 2,640                                               | 3/16                            | $\frac{3/16}{1/8}$     | 316                                   | 228      |
| Brkts (Dk Transv-Side Transv)                     | 16.0             | 20     | 320                                                 | 5/16                            | $\frac{5/16}{1/4}$     | 106                                   | 87       |
| Brkt FC P <sub>L</sub> 's (Dk Transv-Side Transv) | 12.0             | 20     | 240                                                 | 3/16                            | $\frac{3/16}{1/8}$     | 29                                    | 21       |
| Brkts & FC P <sub>L</sub> 's (I.B.-Side Transv)   | 28.0             | 10     | 280                                                 | 3/16                            | $\frac{3/16}{1/8}$     | 33                                    | 24       |
| Brkt Stiffeners                                   | 21.0             | 30     | 630                                                 | 3/16                            | $\frac{3/16}{1/8}$     | 75                                    | 54       |
| Floor to Shell, IB & Long                         | 38.88            | 40     | 1,555                                               | $\frac{3/8}{5/16}$              | 5/16                   | 630                                   | 516      |
| Floor to Long Bhd                                 | 4.25             | 20     | 85                                                  | $\frac{9/16}{1/2}$              | 1/2                    | 82                                    | 72       |
| Floor to Side Girders                             | 4.75             | 160    | 760                                                 | $\frac{3/8}{5/16}$              | $\frac{7/16}{3/8}$ (2) | 308                                   | 429      |
| C.V.K. to Floor                                   | 4.75             | 20     | 95                                                  | 3/16                            | $\frac{3/16}{1/8}$     | 11                                    | 8        |
| Stiff to Floor & Long'l's                         | 5.25             | 180    | 945                                                 | 3/16                            | $\frac{3/16}{1/8}$     | 113                                   | 82       |
| FC P <sub>L</sub> to Horiz Web                    | 78               | 20     | 1,560                                               | 3/16                            | $\frac{3/16}{1/8}$     | 186                                   | 135      |
| Horiz Web Stiffeners                              | 5.0              | 150    | 750                                                 | 3/16                            | $\frac{3/16}{1/8}$     | 90                                    | 65       |
| Horiz Web to Vert Web & Long'l Bhd                | 5.0              | 60     | 300                                                 | 3/8                             | $\frac{3/8}{5/16}$     | 143                                   | 122      |
| Vert Web to FC P <sub>L</sub> 's & Part Bhd       | 43.0             | 20     | 860                                                 | $\frac{1/4}{3/16}$              | 3/16                   | 143                                   | 103      |
| Vert Web to 2nd Dk & I.B.                         | 5.0              | 20     | 100                                                 | 7/16                            | $\frac{7/16}{3/8}$     | 65                                    | 56       |
| Diaph to Dk & Transv Box G                        | 27.5             | 30     | 825                                                 | 3/16                            | $\frac{3/16}{1/8}$     | 99                                    | 71       |
| Diaph Stiffeners                                  | 17.0             | 30     | 510                                                 | 3/16                            | $\frac{3/16}{1/8}$     | 61                                    | 44       |
| Vert Web Stiffeners                               | 6.33             | 140    | 886                                                 | 3/16                            | $\frac{3/16}{1/8}$     | 106                                   | 76       |
| Partial Bhd Periphery                             | 89.5             | 5      | 448                                                 | 3/16                            | $\frac{3/16}{1/8}$     | 54                                    | 39       |
| Partial Bhd Stiffeners                            | 11.5             | 120    | 1,380                                               | 3/16                            | $\frac{3/16}{1/8}$     | 165                                   | 119      |
| SUBTOTAL-10 Ring Webs                             | -                | -      | 20,714                                              | 0.234 Avg                       | 0.212 Avg              | 3,860                                 | 3,157    |

TABLE F-1 (Cont'd)

| STRUCTURAL CONNECTION                                       | Length<br>(Feet) | Number | Total Length<br>of Double<br>Fillet Welds<br>(Feet) | Design Weld<br>Size<br>(Inches) |                        | Weight of Design<br>Welds<br>(Pounds) |          |
|-------------------------------------------------------------|------------------|--------|-----------------------------------------------------|---------------------------------|------------------------|---------------------------------------|----------|
|                                                             |                  |        |                                                     | Existing                        | Proposed               | Existing                              | Proposed |
| Deck Transv to Deck                                         | 82.0             | 14     | 1,148                                               | 1/4                             | <u>1/4</u><br>3/16     | 244                                   | 191      |
| Deck Transv to FC P <sub>L</sub>                            | 82.0             | 14     | 1,148                                               | 1/4                             | <u>1/4</u><br>3/16     | 244                                   | 191      |
| Deck Transv to Long Bhd                                     | 12.0             | 28     | 336                                                 | <u>1/2</u><br>7/16              | 7/16                   | 252                                   | 218      |
| Web IWO Box Girder Inc. A.O.                                | 52.25            | 14     | 732                                                 | <u>1/4</u><br>3/16              | 3/16                   | 122                                   | 87       |
| Stiff on Web IWO Box Gird                                   | 23.25            | 14     | 326                                                 | 3/16                            | <u>3/16</u><br>1/8     | 39                                    | 28       |
| Bhd Stiff to P <sub>L</sub>                                 | 43.25            | 210    | 9,082                                               | 3/16                            | <u>3/16</u><br>1/8     | 1,086                                 | 784      |
| Stiff to Floor & Long's                                     | 5.25             | 126    | 662                                                 | 3/16                            | <u>3/16</u><br>1/8     | 79                                    | 57       |
| C.V.K. to Floor                                             | 4.75             | 14     | 66                                                  | 3/16                            | <u>3/16</u><br>1/8     | 8                                     | 6        |
| Floor to Long. Bhd                                          | 5.0              | 14     | 70                                                  | 7/16                            | <u>7/16</u><br>3/8     | 46                                    | 40       |
| Horiz Web to Bhd                                            | 64.0             | 14     | 896                                                 | 3/16                            | <u>3/16</u><br>1/8     | 107                                   | 77       |
| Face Plate to Horiz Web                                     | 82.0             | 14     | 1,148                                               | 3/16                            | <u>3/16</u><br>1/8     | 137                                   | 99       |
| Stiff on Horiz Web                                          | 4.0              | 252    | 1,008                                               | 3/16                            | <u>3/16</u><br>1/8     | 120                                   | 87       |
| Horiz Web & Collar P <sub>L</sub> to Bhd Stiff              | 2.0              | 336    | 672                                                 | 3/16                            | <u>3/16</u><br>1/8     | 80                                    | 58       |
| Vert Web to Bhd                                             | 28.5             | 14     | 399                                                 | 3/16                            | <u>1/4</u><br>3/16 (2) | 48                                    | 66       |
| Vert Web to FC P <sub>L</sub>                               | 43.0             | 14     | 602                                                 | 1/4                             | <u>1/4</u><br>3/16     | 128                                   | 100      |
| Vert Web to 2nd Dk & I.B.                                   | 5.0              | 28     | 140                                                 | <u>9/16</u><br>1/2              | 1/2                    | 135                                   | 119      |
| Vert Web Stiff                                              | 6.33             | 196    | 1,241                                               | 3/16                            | <u>3/16</u><br>1/8     | 148                                   | 107      |
| Diaph to Dk & Transv Box Girder                             | 27.5             | 42     | 1,155                                               | 3/16                            | <u>3/16</u><br>1/8     | 138                                   | 100      |
| Diaph Stiffeners                                            | 17.0             | 42     | 714                                                 | 3/16                            | <u>3/16</u><br>1/8     | 85                                    | 62       |
| Bhd Periphery                                               | 7.5              | 28     | 210                                                 | 5/16                            | <u>5/16</u><br>1/4     | 70                                    | 57       |
| SUBTOTAL-7 Bhds                                             | -                | -      | 21,755                                              | 0.212 Avg                       | 0.185 Avg              | 3,316                                 | 2,534    |
| SUBTOTAL-All Cargo Sect. Structure                          | -                | -      | 155,827                                             | 0.232 Avg                       | 0.204 Avg              | 28,557                                | 21,990   |
| ESTIMATE FOR BOW, STERN,<br>MACHINERY SPACE & DECKHOUSE (1) | -                | -      | 35,840                                              | 0.232 Avg                       | 0.204 Avg              | 6,559                                 | 5,071    |
| TOTAL                                                       | -                | -      | 191,667                                             | 0.232 Avg                       | 0.204 Avg              | 35,116                                | 27,061   |

## NOTES:

(1) The 470.17 foot long cargo section is assumed to be essentially prismatic. Therefore, the length and weight estimates for the cargo section should be slightly high. This is compensated for by deliberately underestimating weld lengths and weights for the bow, stern, machinery space, and deckhouse.

(2) Proposed weld sizes which are increased from existing values are highlighted by reference to this note.

TABLE F-2  
LENGTHS AND WEIGHTS OF UNALTERED WELDS FOR VANGUARD CLASS CONTAINERSHIP

| STRUCTURAL CONNECTION                           | Length<br>(Feet) | Number | Total Length<br>of Double<br>Fillet Welds<br>(Feet) | Design Weld<br>Size<br>(Inches) | Weight of Design<br>Welds<br>(Pounds) |
|-------------------------------------------------|------------------|--------|-----------------------------------------------------|---------------------------------|---------------------------------------|
| Inbd. Hatch Coaming to Dk & to<br>Face Plate    | 392.67           | 4      | 1571                                                | $\frac{5}{16}$<br>$\frac{1}{4}$ | 428                                   |
| Outbd Hatch Coaming to Dk & to<br>Channel       | 413.33           | 4      | 1653                                                | $\frac{5}{16}$<br>$\frac{1}{4}$ | 450                                   |
| Long. Bhd. to Deck                              | 470.17           | 2      | 940                                                 | 9/16                            | 1011                                  |
| Inner Bottom to Long'l. Bhd.                    | 470.17           | 2      | 940                                                 | 3/8                             | 449                                   |
| Long. Bhd. to Shell                             | 470.17           | 2      | 940                                                 | 3/8                             | 449                                   |
| N.T. Girders to Shell                           | 470.17           | 6      | 2821                                                | 3/16                            | 337                                   |
| W.T. Girders to Shell & I.B.                    | 470.17           | 4      | 1881                                                | 3/8                             | 899                                   |
| C.V.K. to I.B.                                  | 470.17           | 1      | 470                                                 | $\frac{1}{4}$<br>$\frac{3}{16}$ | 78                                    |
| C.V.K. to Shell                                 | 470.17           | 1      | 470                                                 | $\frac{5}{16}$<br>$\frac{1}{4}$ | 128                                   |
| SUBTOTAL-LONG'L. STR. OF CARGO SECT             | -                | -      | 11,686                                              | 0.326 Avg.                      | 4,229                                 |
| Transv. Frame End Conn.                         | 1.833            | 1056   | 1936                                                | 3/16                            | 231                                   |
| Clips at 2nd Dk.                                | 2.833            | 528    | 1496                                                | 1/4                             | 318                                   |
| Bilge Brackets                                  | 12.25            | 264    | 3234                                                | 1/4                             | 687                                   |
| Solid Floors to Shell, I.B. & Long.             | 38.88            | 160    | 6221                                                | 1/4                             | 1322                                  |
| SUBTOTAL-132 TRANSV. FR-40 WITH<br>SOLID FLOORS | -                | -      | 12,887                                              | 0.242 Avg.                      | 2,558                                 |
| Hatch Coaming Brackets                          | 5.25             | 74     | 388                                                 | 1/4                             | 82                                    |
| Header Below 2nd Dk.                            | 18.33            | 74     | 1356                                                | 3/16                            | 162                                   |
| Strgr. No. 1 & 2 Stiff. End Conn.               | 0.833            | 296    | 247                                                 | 1/4                             | 52                                    |
| Floor to Shell, I.B., & Long.                   | 38.88            | 148    | 5754                                                | 1/4                             | 1223                                  |
| SUBTOTAL-37 TRANSV. WEB FR.                     | -                | -      | 7,745                                               | 0.240 Avg.                      | 1,519                                 |
| Hatch Coaming to Dk. & to Channel               | 82.0             | 20     | 1640                                                | $\frac{5}{16}$<br>$\frac{1}{4}$ | 447                                   |
| Hatch Coaming Brackets                          | 5.25             | 100    | 525                                                 | 1/4                             | 112                                   |
| Stiff. on Transv. Box Girder                    | 82.0             | 30     | 2460                                                | 3/16                            | 294                                   |
| Strgr. No. 1 & 2 to Transv. Web                 | 18.75            | 40     | 750                                                 | 5/16                            | 249                                   |
| SUBTOTAL-10 RING WEBS                           | -                | -      | 5,375                                               | 0.246 Avg.                      | 1,102                                 |

TABLE F-2 (Cont'd)

| STRUCTURAL CONNECTION                                   | Length<br>(Feet) | Number | Total Length<br>of Double<br>Fillet Welds<br>(Feet) | Design Weld<br>Size<br>(Inches) | Weight of Design<br>Welds<br>(Pounds) |
|---------------------------------------------------------|------------------|--------|-----------------------------------------------------|---------------------------------|---------------------------------------|
| Hatch Coaming to Dk. & to Channel                       | 82.0             | 20     | 1640                                                | $\frac{5}{16}$<br>$\frac{1}{4}$ | 447                                   |
| Hatch Coaming Brackets                                  | 5.25             | 100    | 525                                                 | $\frac{1}{4}$                   | 112                                   |
| Stiff. on Transv. Box Girder                            | 82.0             | 42     | 3444                                                | $\frac{3}{16}$                  | 412                                   |
| Bhd. Periphery Inc. Collar Plates                       | 163.5            | 7      | 1144                                                | $\frac{1}{4}$<br>$\frac{3}{16}$ | 190                                   |
| Bhd. Periphery                                          | 60               | 7      | 420                                                 | $\frac{1}{4}$                   | 89                                    |
| Bhd. Periphery                                          | 45               | 7      | 315                                                 | $\frac{5}{16}$<br>$\frac{1}{4}$ | 86                                    |
| Bhd. Periphery                                          | 142.25           | 7      | 996                                                 | $\frac{5}{16}$                  | 331                                   |
| Bhd. Periphery Inc. Collar Plates                       | 387              | 7      | 2709                                                | $\frac{3}{8}$<br>$\frac{5}{16}$ | 1097                                  |
| Horiz. Web to Vert. Webs &<br>Long. Bhd.                | 5.0              | 84     | 420                                                 | $\frac{5}{16}$                  | 139                                   |
| Collar Pl. to Horiz. Webs                               | 1.25             | 336    | 420                                                 | $\frac{1}{4}$                   | 89                                    |
| Strgr. No. 1 & 2 to Transv. Web                         | 18.75            | 28     | 525                                                 | $\frac{5}{16}$                  | 174                                   |
| Vert. Web to Bhd.                                       | 14.5             | 14     | 203                                                 | $\frac{1}{4}$<br>$\frac{3}{16}$ | 34                                    |
| SUBTOTAL - 7 BRDS.                                      | -                | -      | 12,761                                              | 0.272 Avg.                      | 3,200                                 |
| SUBTOTAL - ALL CARGO SECTION STRUCT.                    | -                | -      | 50,454                                              | 0.271 Avg.                      | 12,608                                |
| ESTIMATE FOR BOW, STERN, MACHY,<br>SPACE, AND DECKHOUSE | -                | -      | 11,604                                              | 0.271 Avg.                      | 2,898                                 |
| TOTAL                                                   | -                | -      | 62,058                                              | 0.271 Avg.                      | 15,506                                |

# MIDSHIP SECTION - 1981 ABS RULES

(Terms are as defined in ABS Rules unless noted otherwise)

## Principal Dimensions

LOA 725'-0"  
 B 103'-0"  
 D 60'-0"  
 Values at scantling draft:  
 d 34'-0"  
 LWL 702'-0"  
 LBP 687'-6"

## Weights (Long Tons)

|                         |               |
|-------------------------|---------------|
| Light Ship              | 12,500        |
| Fuel Oil                | 3,300         |
| D.O. & L.O.             | 30            |
| Fresh water             | 300           |
| Crew & Stores           | 50            |
| Cargo                   | 19,740        |
| Clean Ballast           | 2,580         |
| <u>TOTAL DEADWEIGHT</u> | <u>26,000</u> |
| <br>DISPLACEMENT        | <br>38,500    |
| (at scantling draft)    |               |

## REQUIRED SECTION MODULUS - MILD STEEL

Section 2.1 Scantling length =  $L = 0.97 \times \text{LWL} = 680.94'$

Section 6.3.1(a)  $SM = M_t / f_p$

$$f_p = 10.56 - \frac{790-L}{845} = 10.431 \text{ LT/in}^2$$

Section 6.3.1(b)  $C_1 = 0.01441 \left[ 10.75 - \left( \frac{984-L}{328} \right)^{1.5} \right] = 0.14211$

$$C_b = \frac{\text{Displacement} \times 35 \text{ ft}^3/\text{LT}}{L \times B \times d} = 0.56507 \text{ (use minimum value of 0.60 for this section)}$$

$$\text{Min. SM} = 0.01 C_1 L^2 B (C_b + 0.70) = 88,231 \text{ in}^2 \text{ ft}$$

Section 6.3.2 (a)  $C_{st} = \left[ 0.275 + \frac{690-L}{16,400} \right] 10^{-3} = 0.27555 \times 10^{-3}$

$$C_b = 0.64 \text{ (minimum value for this section)}$$

$$M_{sw} = C_{st} L^{2.5} B (C_b + 0.5) = 391,485 \text{ Ft-LT}$$

Section 6.3.2(b)  $C_b = 0.64 \text{ (minimum value for this section)}$

$$K_b = 1.4 - 0.5 C_b = 1.08$$

$$C_2 = \left[ 6.53 C_b + 0.57 \right] 10^{-4} = 4.7492 \times 10^{-4}$$

$$H_e = 0.0181 L + 11.535 = 23.860 \text{ Ft}$$

$$M_w = C_2 L^2 B H_e K_b = 584,480 \text{ Ft-LT}$$

$$M_t = M_{sw} + M_w = 975,965 \text{ Ft-LT}$$

$$SM = M_t / f_p = 93,564 \text{ in}^2 \text{ Ft (96 and 93\% of 1970 ABS Rules Deck and Baseline values)}$$

#### REQUIRED MOMENT OF INERTIA AND SECTION MODULUS - H32 STEEL

$$\text{Section 6.13.2} \quad I_{H32} = L \times SM / 34.1 = 1,868,372 \text{ in}^2 \text{ Ft}^2$$

$$\text{Section 6.13.3} \quad Q = 0.78050 \text{ (see page E-11)}$$

$$SM_{H32} = Q(SM) = 73,027 \text{ in}^2 \text{ Ft}$$

#### SCANTLINGS

Use H32 material in deck.

Reduce main deck and shear strake from 56.1# to 45.9#  $\bar{L}$

Reduce longitudinal bulkhead from 56.1# to 40.8#

Reduce main deck longitudinals from 51.0# to 40.8#

Resulting properties:

$$I = 2,774,384 \text{ in}^2 \text{ ft}^2 > 1,868,372 \text{ in}^2 \text{ ft}^2$$

$$SM_{dk} = 74,890 \text{ in}^2 \text{ ft} > 73,027 \text{ in}^2 \text{ ft}$$

$$SM_{\bar{L}} = 120,867 \text{ in}^2 \text{ ft} > 93,564 \text{ in}^2 \text{ ft}$$

Neutral axis is 22.954 Ft above  $\bar{L}$

#### MAXIMUM HULL GIRDER SHEARING FORCE

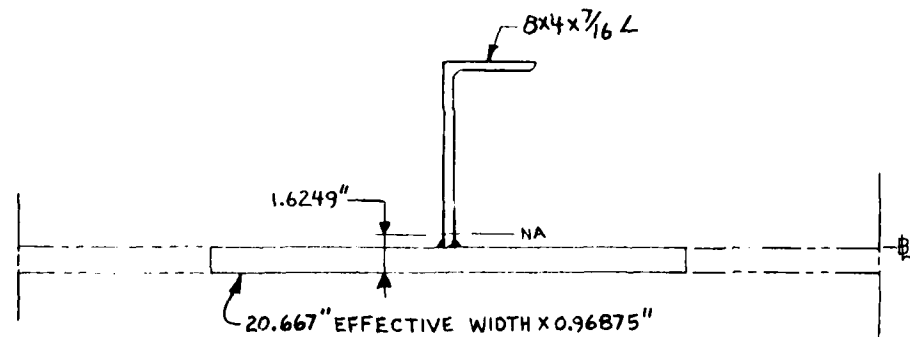
$$\text{Section 6.3.3(a)} \quad V_p = F_{sw} + F_w$$

$$\text{Section 6.3.3(b)} \quad V_p = 5.0 M_{sw}/L + 2.6 M_w/L = 5106.3 \text{ LT}$$

# SIMPLIFIED STRESS ANALYSIS FOR BOTTOM LONGITUDINALS

Bottom longitudinals are rolled 8" x 4" x 7/16" mild steel angles with 37" spacing on 39.525# mild steel bottom plate and spans of 5'-2".

Section 3.9 Effective plate width =  $(5.167' \times 12"/')/3 = 20.667"$



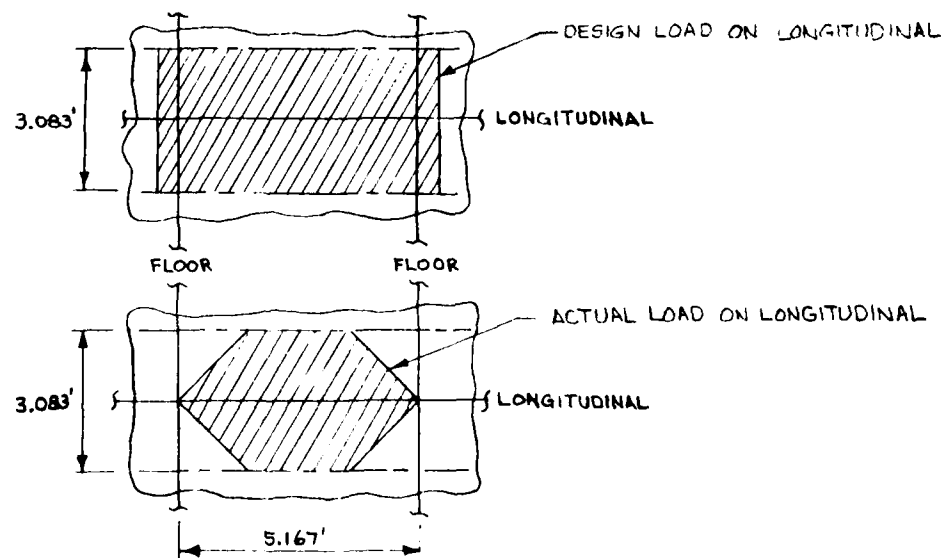
Section 7.3.8  $c = 1.30$   
 $h = \frac{2}{3} \times 60 \text{ Ft} = 40 \text{ Ft}$   
 $L = \text{Span} = 6 \text{ Ft minimum}$   
 $s = \text{Spacing} = 3.083 \text{ Ft}$

Design Load on Longitudinal=

$$64\#/ \text{Ft}^3 \times 40 \text{ Ft} \times 6 \text{ Ft} \times 3.083 \text{ Ft} = 47,355\#$$

Actual Load on Longitudinal=

$$64\#/ \text{Ft}^3 \times 40 \text{ Ft} \left[ 5.167 \text{ Ft} \times 3.083 \text{ Ft} - \frac{4}{2} \left( \frac{3.083 \text{ Ft}}{2} \right)^2 \right] = 28,614\#$$



Design stresses for container ship mild steel bottom structure

Section 6.3.1(a)  $\sigma_p = 10.431 \text{ Lt/in}^2 = 23,365 \text{ PSI}$

Section 7.3.3 and  
Page E-23

$$\sigma_s = 15,610/1.30 = 12,008 \text{ PSI}$$

$$\sigma_T = 35,373 \text{ PSI}$$

Section 6.3.3

$$\tau_p = 6.75 \text{ Lt/in}^2 = 15,120 \text{ PSI}$$

Use 60% of  $\sigma_s$

$$\tau_s = 0.6 (12,008) = 7,205 \text{ PSI}$$

$$\tau_T = 22,325 \text{ PSI}$$

Primary Strength Values,  $V_p = 5106.3 \text{ LT} = 11,438,112\#$

$$(AY)_p = 9.497 \text{ in. Ft}^2$$

$$I_p = 2,774,384 \text{ in}^2 \text{ Ft}^2$$

Secondary Strength Values, Design  $V_s = 23,677\#$

$$\text{Actual } V_s = 14,307\#$$

$$(AY)_s = 22.834 \text{ in}^2$$

$$I_s = 164.87 \text{ in}^4$$

$$T_r = \frac{1}{\tau_T} \left[ \frac{V_p (AY)_p}{I_p} + \frac{V_s (AY)_s}{I_s} \right]$$

$$D = 0.628 (T_r) + 0.085" \text{ for mild steel.}$$

$$\text{For design load, } T_r = \frac{1}{22,325 \text{ \#/in}^2} [39.2 \text{ \#/in.} + 3279.2 \text{ \#/in.}] = 0.14864 \text{ in.}$$

$$D = 0.628 (0.14864") + 0.085" = 0.1783" > 0.1562" \text{ N.G.}$$

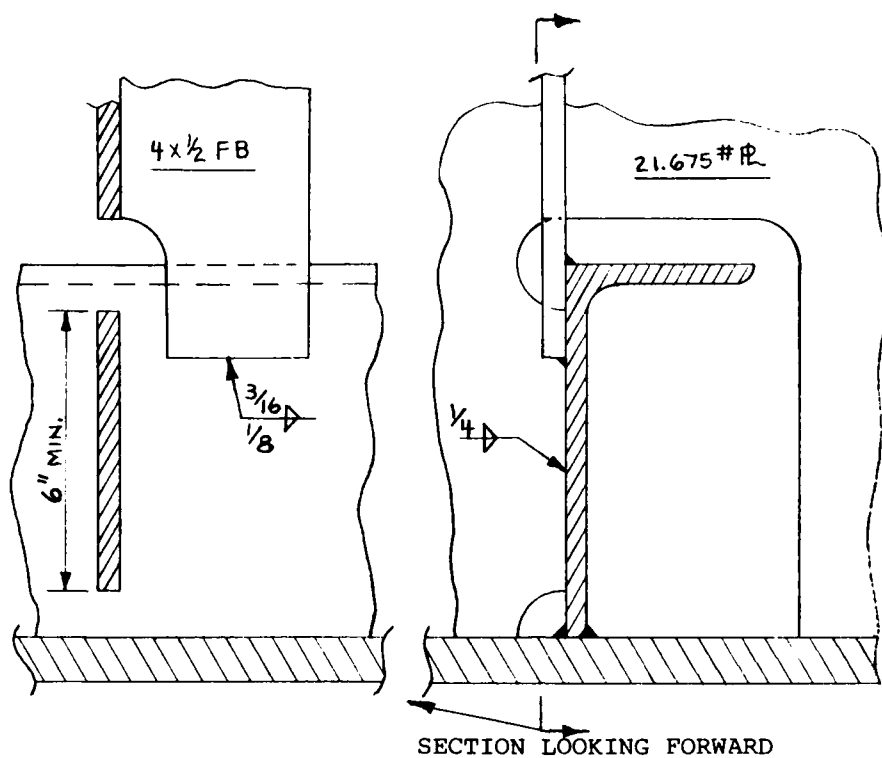
$$\text{For actual load, } T_r = \frac{1}{22,325 \text{ \#/in}^2} [39.2 \text{ \#/in.} + 1981.5 \text{ \#/in.}] = 0.090513 \text{ in.}$$

$$D = 0.628 (0.090513") + 0.085" = 0.1418" < 0.1562" \text{ OK}$$

NOTE: The difference between the actual and design values primarily accounts for that portion of the load on the bottom shell plating which would be transferred directly into the floors rather than through the longitudinals and then into the floors. This correction is more important to an analysis of shear forces (as required here) than to an analysis of bending moments in the member (as required by normal ABS Rule design procedures) because the load removed is near the ends of the span. The conservative values specified by ABS for an analysis of bending moments also helps to ensure that the longitudinal selected

will have sufficient inertia to prevent premature buckling of the bottom shell. This design requirement does not put a significant load on the weld connection. Hence, there should be no significant problem with using a lower load for the shear stress analysis of the weld connection than that used for a bending stress analysis when sizing the longitudinal.

# CONNECTION OF BOTTOM LONGITUDINALS TO SUPPORTING STRUCTURE



From Section 7.3.8 of ABS rules, design head is  $\frac{2}{3} \times 60' = 40'$ , and minimum design span is 6'. Actual span is 5.17' and spacing is 3.083'. Total design load on connection is:

$$40 \text{ Ft} \times 64 \text{ \#/Ft}^3 \times 6 \text{ Ft} \times 3.083 \text{ Ft} = 47,355 \text{ \#}.$$

Chapter 7 of the ABS rules does not give allowable stresses for double bottom floors. Therefore, a total allowable shear stress of 24,976 PSI from page E-22 will be used. Based on a grillage analysis of the double bottom structure, the maximum shear stress in the floors is 3698 PSI. Hence, an allowable shear stress for this local connection is:  $24,976 - 3698 = 21,278$  PSI. The required local floor thickness is then:

$$T_r = \frac{47,355 \text{ \#}}{6" \times 21,278 \text{ PSI}} = 0.3709",$$

and the required weld is:

$$D = 0.628 (0.3709") + 0.085" = 0.3179".$$

The equivalent weld size provided is approximately:

$$D = \frac{6" \times 0.25" + 5" \times 0.15625"}{6"} = 0.3802" > 0.3179" \text{ OK.}$$

In this case, collar plates are not required; the web and flat bar connections are adequate. However, if the flat bars are eliminated for any reason, the weld of the floor to the longitudinals should be increased, collar plates added, or the design load could possibly be reduced as discussed on pages F-14 and F-15.

## DOUBLE-BOTTOM GIRDERS

Design load for bottom structure  
is head of  $2/3 \times 60' = 40'$ .

Design pressure =

$$40 \text{ Ft} \times 64 \text{ #/Ft}^3 = 2560 \text{ #/Ft}^2$$

Total load =

$$2560 \text{ #/Ft}^2 \times 82.25' \times 41.33' = 8,702,445\#$$

Check weight of containers

$$11.86 \text{ LT/CONT.} \times 9 \text{ athw} \times 7 \text{ high} \times 2 \text{ rows} =$$

$$1494.36 \text{ LT} = 3,347,366\#$$

Does not govern even if dynamic effects  
were included.

Grillage will be essentially simply  
supported along longitudinal edges  
and fixed along athwartship edges.

Using Schade's grillage analysis  
(Trans. SNAME 1941)

$$a = 82.25'$$

$$S_a = 5.167'$$

$$I_{na} = 127,676 \text{ in}^4$$

$$I_{pa} = 114,454 \text{ in}^4$$

$$i_a = 2059.3 \text{ in}^3$$

$$A_a = 35.06 \text{ in.}$$

$$r_a = 37.475 \text{ in.}$$

$$b = 41.33'$$

$$S_b = 9.25'$$

$$I_{nb} = 220,449 \text{ in}^4$$

$$I_{pb} = 204,779 \text{ in}^4$$

$$i_b = 1986.0 \text{ in}^3$$

$$A_b = 41.25 \text{ in}^2$$

$$r_b = 37.827 \text{ in.}$$

$$\eta = \sqrt{\frac{I_{pa}}{I_{na}} \frac{I_{pb}}{I_{nb}}} = 0.9125 \quad \rho = a/b \sqrt{\frac{i_b}{i_a}} = 1.972$$

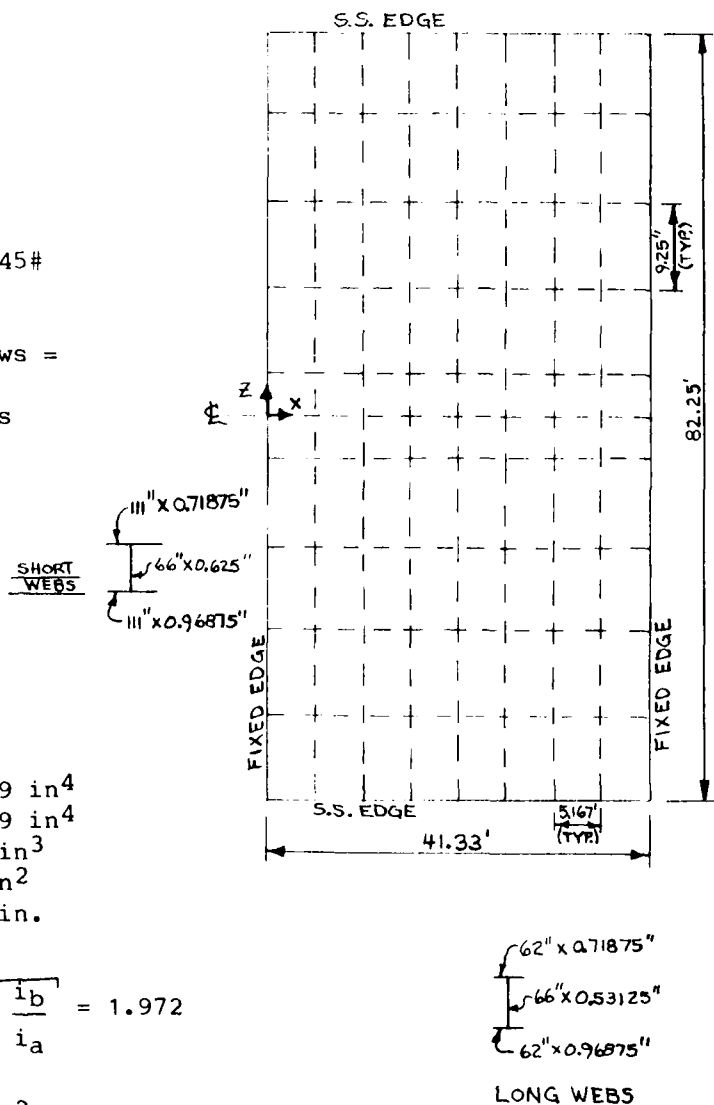
$$\text{From Figure 6, } K = 0.0930 \text{ and } \sigma_x = K \frac{pb^2}{i_b} r_b = 7746 \text{ PSI}$$

From Figure 9, maximum shear stress in short webs,  $K = 0.513$  and

$$\tau = K \frac{pb}{A_b} \frac{I_{nb}}{i_b} = 12,172 \text{ PSI}$$

From Figure 8, maximum shear stress in long webs,  $K = 0.235$  and

$$\tau = K \frac{pb}{A_a} \frac{I_{na}}{\sqrt[4]{i_a^3 i_b}} = 3698 \text{ PSI}$$



APPENDIX G

CALCULATIONS FOR CRESCENT CLASS ORE/BULK/OIL CARRIER

AD-A162 485

UPDATING OF FILLET WELD STRENGTH PARAMETERS FOR  
COMMERCIAL SHIPBUILDING(U) R P KRUMPEN ET AL. APR 83  
BA-117960 SSC-323 DTICG23-81-C-20030

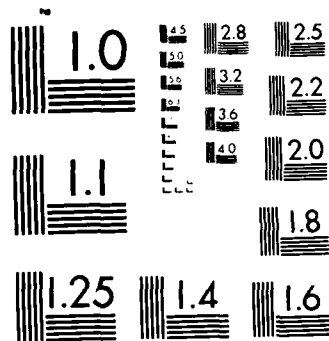
3/3

UNCLASSIFIED

F/G 13/8

NL





MICROCOPY RESOLUTION TEST CHART  
NATIONAL BUREAU OF STANDARDS-1963-A

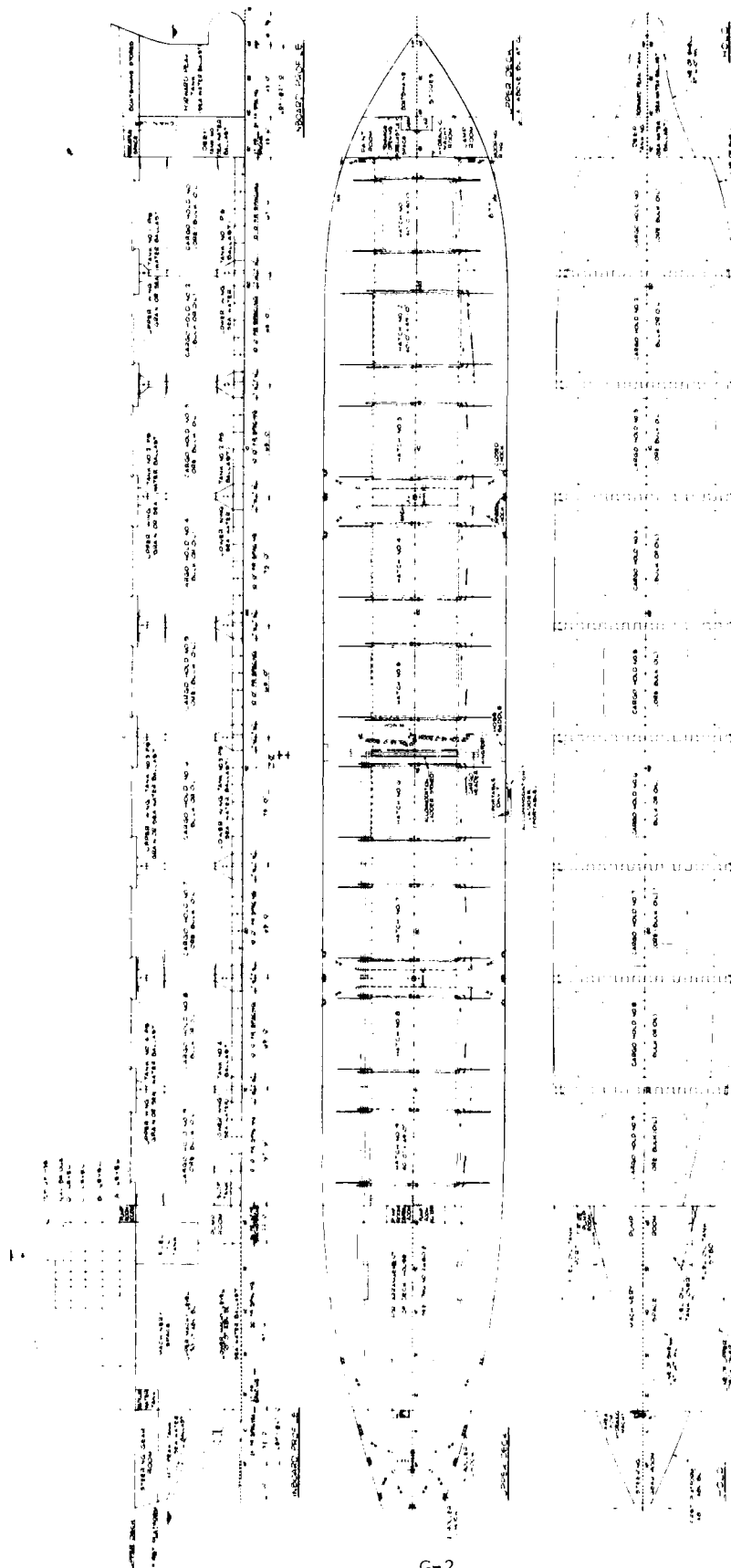


FIGURE G-1  
GENERAL ARRANGEMENT DRAWINGS OF CRESCENT CLASS ORE/BULK/OIL CARRIER

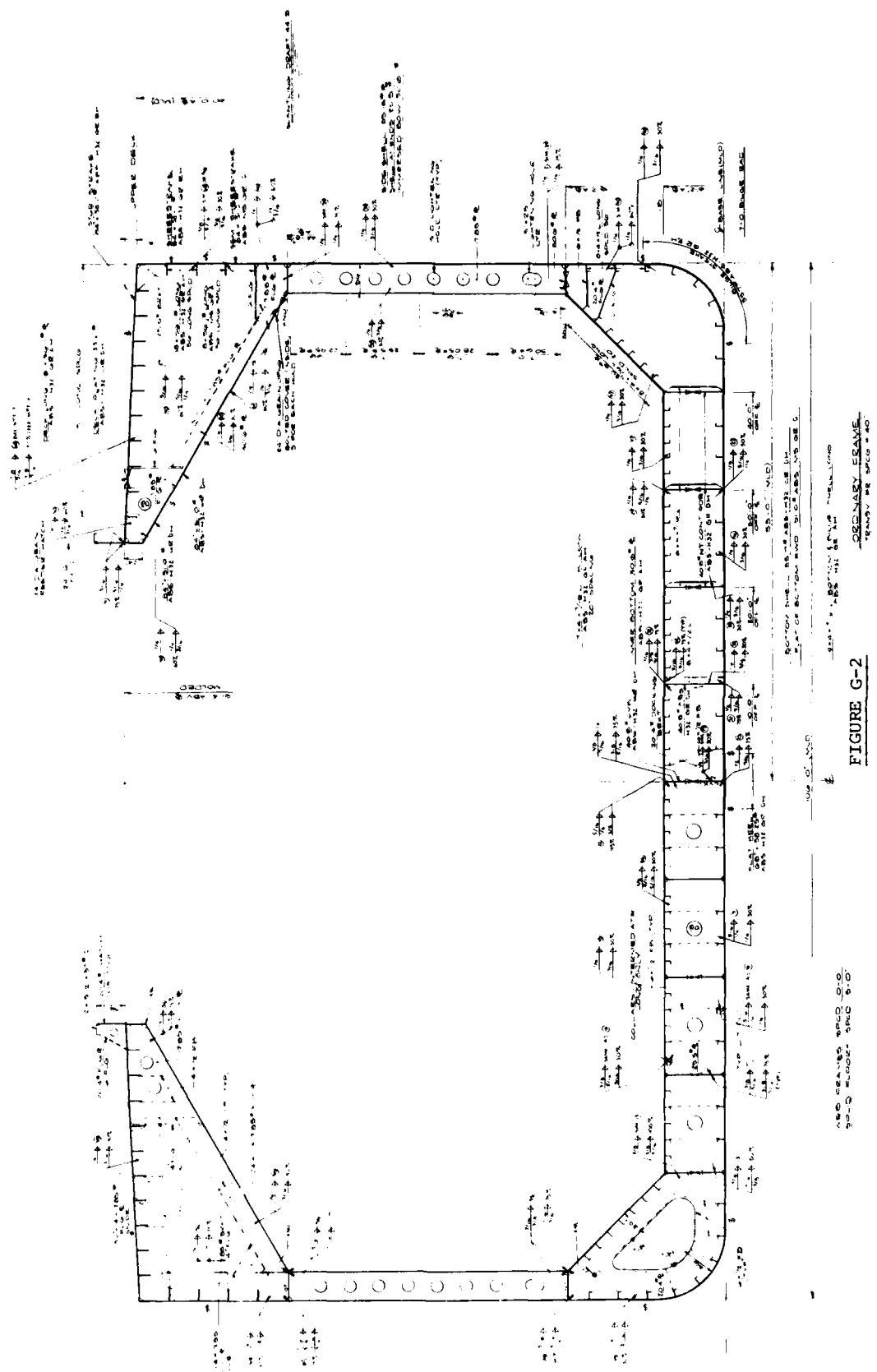


FIGURE G-2  
CRESCENT CLASS ORE/BULK/OIL CARRIER

NOTE:

1. Scantlings shown are to 1981 ABS rules.
2. Material not noted to be ABS-MS.
3. All scantlings shown apply to .4L midship length except as noted.
4. Key to weld sizes:
  - a. Upper weld sizes are from existing ABS rules.  
The circled value is the line number from those rules.
  - b. Lower weld sizes are from proposed weld size tables.  
The percentage shown is the minimum joint efficiency after  
weld and base materials have been corroded 0.060 inch per surface.
5. Weld for 1.375" plating requires ABS approval. Since plating is only  
3% thicker than the maximum value for which a weld is specified  
(1.34") the next larger weld size  
(11/32 or  $\frac{3}{8}$ /<sub>5/16</sub>) is used.
6. Weld determined from 30% efficiency for H32 material:  
$$D = 0.3 \times 0.668(T - 0.12) + 0.085" = 0.3365" \text{ or } 11/32 \text{ or } \frac{3}{8}/_{5/16}$$
7. Minimum weld size for oil carriers is used (1/4" for ABS welds and  
3/16" for proposed welds).

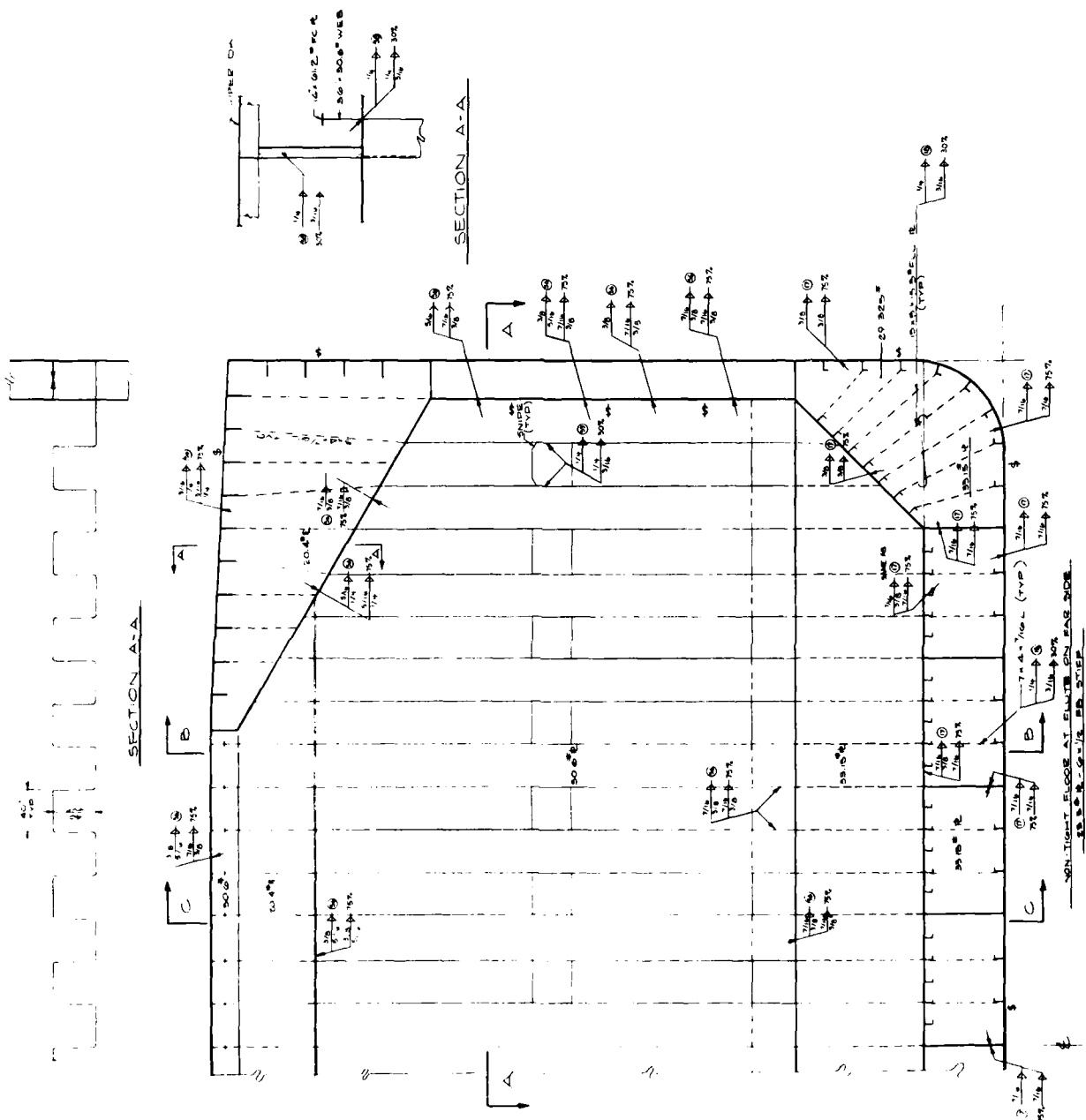
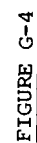


FIGURE G-3  
TYPICAL TRANSVERSE WT BULKHEAD OF CRESCENT CLASS ORE/BULK/OIL CARRIER



G- 6

TABLE G-1

## LENGTHS AND WEIGHTS OF ALTERED WELDS FOR CRESCENT CLASS ORE/BULK/OIL CARRIER

| Item                                         | Length<br>(Feet) | Number<br>Both<br>Sides | Double Fillet<br>Weld<br>Length<br>(Feet) | Weld<br>Size<br>(Inches) |                        | Weld<br>Weight<br>(Pounds) |          |
|----------------------------------------------|------------------|-------------------------|-------------------------------------------|--------------------------|------------------------|----------------------------|----------|
|                                              |                  |                         |                                           | Existing                 | Proposed               | Existing                   | Proposed |
| Stringer R (16'-2" ABL) to<br>Side Shell     | 610              | 2                       | 1,220                                     | 5/16                     | $\frac{5/16}{1/4}$     | 405                        | 332      |
| Long'l's. to Hopper Side R                   | 610              | 14                      | 8,540                                     | 1/4                      | 3/16                   | 1,815                      | 1,021    |
| Inner Bottom Long'l's. to Inner<br>Bottom R  | 610              | 40                      | 24,400                                    | 1/4                      | 3/16                   | 5,185                      | 2,917    |
| Bottom & Bilge Long'l's. to R                | 610              | 32                      | 19,520                                    | 1/4                      | 3/16                   | 4,148                      | 2,333    |
| Side Girders (N.T.) to Inner<br>Bottom       | 610              | 6                       | 3,660                                     | 1/4                      | $\frac{5/16}{1/4} (2)$ | 778                        | 997      |
| Side Girders (N.T.) to Bottom<br>Shell       | 610              | 6                       | 3,660                                     | 1/4                      | $\frac{5/16}{1/4} (2)$ | 778                        | 997      |
| Side Girders (W.T.) to Inner<br>Bottom       | 610              | 2                       | 1,220                                     | $\frac{7/16}{3/8}$       | 9/16 (2)               | 689                        | 1,312    |
| Side Girders (W.T.) to Bottom<br>Shell       | 610              | 2                       | 1,220                                     | 1/2                      | 9/16 (2)               | 1,037                      | 1,312    |
| C.V.K. to Inner Bottom                       | 610              | 1                       | 610                                       | $\frac{5/16}{1/4}$       | 3/8 (2)                | 166                        | 292      |
| C.V.K. to Bottom Shell                       | 610              | 1                       | 610                                       | 1/2                      | 9/16 (2)               | 519                        | 656      |
| SUBTOTAL-Long'l's. Struct. Cargo.<br>Section | -                | -                       | 64,660                                    | 0.266 avg                | 0.235 avg              | 15,520                     | 12,169   |

TABLE G-1, LENGTHS AND WEIGHTS OF ALTERED WELDS FOR CRESCENT CLASS ORE/BULK/OIL CARRIER (Cont'd)

| Item                                            | Length<br>(Feet) | Number<br>Both<br>Sides | Double Fillet<br>Weld<br>Length<br>(Feet) | Weld<br>Size<br>(Inches) |                    | Weld<br>Weight<br>(Pounds) |          |
|-------------------------------------------------|------------------|-------------------------|-------------------------------------------|--------------------------|--------------------|----------------------------|----------|
|                                                 |                  |                         |                                           | Existing                 | Proposed           | Existing                   | Proposed |
| Brkt-Upper Dk to Transv Fr (Inbd )              | 12.5             | 196                     | 2,450                                     | 1/4                      | $\frac{1/4}{3/16}$ | 521                        | 407      |
| Brkt-Upper Dk to Shell R                        | 4.0              | 196                     | 784                                       | 5/16                     | $\frac{5/16}{1/4}$ | 260                        | 213      |
| Brkt-Shell to Transv Fr (46' ABL)               | 6.75             | 196                     | 1,323                                     | 1/4                      | $\frac{1/4}{3/16}$ | 281                        | 220      |
| Transv Fr to Slanting Wing Tank R               | 20.5             | 196                     | 4,018                                     | 1/4                      | 3/16               | 854                        | 480      |
| Transv Fr to Shell R                            | 28.0             | 196                     | 5,488                                     | 1/4                      | 3/16               | 1,166                      | 656      |
| Transv Fr to Cargo Side Bhd                     | 28.0             | 196                     | 5,488                                     | 1/4                      | 3/16               | 1,166                      | 656      |
| Stiff to Side Girders (I.B.)                    | 5.75             | 736                     | 4,232                                     | 1/4                      | 3/16               | 899                        | 506      |
| Docking Brkt to I.B., C.V.K<br>& Bottom R       | 10.0             | 196                     | 1,960                                     | 1/4                      | 3/16               | 417                        | 234      |
| Slanting Wing Tank Stiffs.<br>(End Connections) | 2.5              | 392                     | 980                                       | 1/4                      | $\frac{1/4}{3/16}$ | 208                        | 163      |
| SUBTOTAL-98 Ordinary Transv Fr                  | -                | -                       | 26,723                                    | 0.252 avg                | 0.197 avg          | 5,772                      | 3,535    |

TABLE G-1, LENGTHS AND WEIGHTS OF ALTERED WELDS FOR CRESCENT CLASS ORE/BULK/OIL CARRIER (Cont'd)

| Item                                           | Length<br>(Feet) | Number<br>Both<br>Sides | Double Fillet<br>Weld<br>Length<br>(Feet) | Weld<br>Size<br>(Inches) |                    | Weld<br>Weight<br>(Pounds) |          |
|------------------------------------------------|------------------|-------------------------|-------------------------------------------|--------------------------|--------------------|----------------------------|----------|
|                                                |                  |                         |                                           | Existing                 | Proposed           | Existing                   | Proposed |
| Transv Fr to Dk R                              | 15.0             | 112                     | 1,680                                     | 1/4                      | 3/16               | 357                        | 201      |
| Transv Fr to Sheer & Semi Sheer<br>Strake      | 9.25             | 112                     | 1,036                                     | 1/4                      | 3/16               | 220                        | 124      |
| Transv Fr to Slanting Wing Tank<br>R           | 17.0             | 112                     | 1,904                                     | 1/4                      | 3/16               | 405                        | 228      |
| Transv Fr to Shell R                           | 36.0             | 112                     | 4,032                                     | 1/4                      | 3/16               | 857                        | 482      |
| Transv Fr to Cargo Side Bhd                    | 28.0             | 112                     | 3,136                                     | 1/4                      | 3/16               | 666                        | 375      |
| Floor (Brkts) to Bilge Strake<br>& Bottom R    | 47.5             | 112                     | 5,320                                     | $\frac{5/16}{1/4}$       | 1/4                | 1,448                      | 1,131    |
| Floors to Inner Bottom &<br>Hopper Sides       | 36               | 112                     | 4,032                                     | $\frac{3/8}{5/16}$       | 5/16               | 1,633                      | 1,339    |
| Floors to Outbd Side Girder                    | 5.5              | 112                     | 616                                       | 3/8                      | $\frac{3/8}{5/16}$ | 295                        | 250      |
| Floors to Outbd Side Girder                    | 5.5              | 112                     | 616                                       | 7/16                     | $\frac{7/16}{3/8}$ | 401                        | 348      |
| Stiffeners to Floor R (Bilge)                  | 45.0             | 112                     | 5,040                                     | 1/4                      | 3/16               | 1,071                      | 602      |
| Stiffeners to Floor R (Except<br>Lower Stools) | 5.0              | 640                     | 3,200                                     | 1/4                      | 3/16               | 680                        | 382      |
| Stiff to N.T. Floors of Webs<br>@Lower Stools  | 5.0              | 320                     | 1,600                                     | 1/4                      | $\frac{1/4}{3/16}$ | 340                        | 266      |
| Bottom & Bilge Long's to Floors                | 0.42             | 1,792                   | 753                                       | $\frac{5/16}{1/4}$       | 1/4                | 205                        | 160      |
| Inner Bottom Long's to Floors                  | 0.33             | 3,024                   | 998                                       | $\frac{3/8}{5/16}$       | 5/16               | 404                        | 332      |
| Inner Bottom Long's to Collars<br>@Floors      | 0.33             | 1,344                   | 444                                       | $\frac{3/8}{5/16}$       | 5/16               | 180                        | 147      |
| Slanting Wing Tank Stiffs<br>(End Connections) | 3.0              | 224                     | 672                                       | 1/4                      | $\frac{1/4}{3/16}$ | 143                        | 112      |
| SUBTOTAL-56 Web Frames                         | -                | -                       | 35,079                                    | 0.279 avg                | 0.233 avg          | 9,305                      | 6,478    |

TABLE G-1, LENGTHS AND WEIGHTS OF ALTERED WELDS FOR CRESCENT CLASS ORE/BULK/OIL CARRIER (Cont'd)

| Item                                      | Length<br>(Feet) | Number<br>Both<br>Sides | Double Fillet<br>Weld<br>Length<br>(Feet) | Weld<br>Size<br>(Inches) |                    | Weld<br>Weight<br>(Pounds) |          |
|-------------------------------------------|------------------|-------------------------|-------------------------------------------|--------------------------|--------------------|----------------------------|----------|
|                                           |                  |                         |                                           | Existing                 | Proposed           | Existing                   | Proposed |
| Brkts (Floor-Side Fr) to Side<br>Shell R  | 8.0              | 98                      | 784                                       | 1/4                      | 3/16               | 167                        | 94       |
| Brkts to Bilge PL & Floors to<br>Bottom R | 47.5             | 98                      | 4,655                                     | $\frac{5/16}{1/4}$       | 1/4                | 1,267                      | 989      |
| Floors to Inner Bottom &<br>Hopper Sides  | 36               | 98                      | 3,528                                     | $\frac{3/8}{5/16}$       | 5/16               | 1,429                      | 1,171    |
| Floors to Outbd Side Girder               | 5.5              | 98                      | 539                                       | 3/8                      | $\frac{3/8}{5/16}$ | 258                        | 218      |
| Floors to Outbd Side Girder               | 5.5              | 98                      | 539                                       | 7/16                     | $\frac{7/16}{3/8}$ | 351                        | 304      |
| Stiffeners to Floor R (Bilge)             | 45.0             | 98                      | 4,410                                     | 1/4                      | 3/16               | 937                        | 527      |
| Stiffeners to Floor R                     | 5.0              | 784                     | 3,920                                     | 1/4                      | 3/16               | 833                        | 469      |
| Bottom & Bilge Long's to Floors           | 0.42             | 1,568                   | 659                                       | $\frac{5/16}{1/4}$       | 1/4                | 179                        | 140      |
| Inner Bottom Long's to Floors             | 0.33             | 2,646                   | 873                                       | $\frac{3/8}{5/16}$       | 5/16               | 354                        | 290      |
| Inner Bottom Long's to Collars<br>@Floors | 0.33             | 1,176                   | 388                                       | $\frac{3/8}{5/16}$       | 5/16               | 157                        | 129      |
| SUBTOTAL-49 Solid Floors                  | -                | -                       | 20,295                                    | 0.293 avg                | 0.251 avg          | 5,932                      | 4,331    |

TABLE G-1, LENGTHS AND WEIGHTS OF ALTERED WELDS FOR CRESCENT CLASS ORE/BULK/OIL CARRIER (Cont'd)

| Item                                           | Length<br>(Feet) | Number<br>Both<br>Sides | Double Fillet<br>Weld<br>Length<br>(Feet) | Weld<br>Size<br>(Inches)        |                                     | Weld<br>Weight<br>(Pounds) |          |
|------------------------------------------------|------------------|-------------------------|-------------------------------------------|---------------------------------|-------------------------------------|----------------------------|----------|
|                                                |                  |                         |                                           | Existing                        | Proposed                            | Existing                   | Proposed |
| Upper Stool R to Deck R                        | 49.0             | 20                      | 980                                       | $\frac{3}{8}$<br>$\frac{5}{16}$ | $\frac{7}{16}$<br>$\frac{3}{8}$ (2) | 397                        | 553      |
| Stiffeners to Bhd R (Upper Wing Area)          | 80.0             | 20                      | 1,600                                     | 1/4                             | 3/16                                | 340                        | 191      |
| Stiff to Diaph R Within Upper Stool            | 6.5              | 340                     | 2,210                                     | 1/4                             | 3/16                                | 470                        | 264      |
| Diaph R (Upper Stool) to Transv R Stiff        | 3.0              | 300                     | 900                                       | 5/16                            | $\frac{5}{16}$<br>$\frac{1}{4}$     | 299                        | 245      |
| Brkt (Upper Stool) to Rolled R                 | 3.5              | 300                     | 1,050                                     | 5/16                            | $\frac{5}{16}$<br>$\frac{1}{4}$     | 349                        | 286      |
| Brkt (Upper Stool) to Dk R & Tank Overhead R   | 6.5              | 300                     | 1,950                                     | 1/4                             | 3/16                                | 414                        | 233      |
| Tank Overhead R and Chock to Transv R Stiff    | 49.0             | 40                      | 1,960                                     | 7/16                            | $\frac{7}{16}$<br>$\frac{3}{8}$     | 1,276                      | 1,106    |
| Tripping Stiffener to Bhd R                    | 8.0              | 150                     | 1,200                                     | 1/4                             | $\frac{1}{4}$<br>$\frac{3}{16}$     | 255                        | 199      |
| Stiffeners to W.T. Floor                       | 5.0              | 160                     | 800                                       | 1/4                             | 3/16                                | 170                        | 96       |
| Stiffeners to W.T. Floor (Bilge Area)          | 53.0             | 20                      | 1,060                                     | 1/4                             | 3/16                                | 225                        | 127      |
| W.T. Floor to Inner Bottom R                   | 40.0             | 20                      | 800                                       | $\frac{7}{16}$<br>$\frac{3}{8}$ | 7/16 (2)                            | 452                        | 521      |
| Inner Bottom Long's to W.T. Floors & Collar R  | 3.38             | 400                     | 1,352                                     | $\frac{7}{16}$<br>$\frac{3}{8}$ | 7/16 (2)                            | 763                        | 880      |
| Long'l Portion of Bhd Flutes to Upper Stool    | 3.33             | 210                     | 699                                       | $\frac{3}{8}$<br>$\frac{5}{16}$ | $\frac{7}{16}$<br>$\frac{3}{8}$ (2) | 283                        | 395      |
| Brkt to R and Stiff (Lower Stool)              | 14.75            | 200                     | 2,950                                     | 5/16                            | $\frac{5}{16}$<br>$\frac{1}{4}$     | 979                        | 803      |
| Stiffeners to R (Lower Stool)                  | 8.75             | 360                     | 3,150                                     | 1/4                             | 3/16                                | 669                        | 377      |
| Diaphs Above Long'l G's to R (Lower Stool)     | 27.0             | 90                      | 2,430                                     | $\frac{3}{8}$<br>$\frac{5}{16}$ | $\frac{5}{16}$<br>$\frac{1}{4}$     | 984                        | 662      |
| Stiff on Diaphs Above Long'l G's (Lower Stool) | 38.0             | 90                      | 3,420                                     | 1/4                             | 3/16                                | 727                        | 409      |
| Bhd Periphery to Cargo Side Bhd                | 5.5              | 20                      | 110                                       | 5/16                            | $\frac{7}{16}$<br>$\frac{3}{8}$ (2) | 37                         | 62       |
| Bhd Periphery to Cargo Side Bhd                | 7.5              | 20                      | 150                                       | $\frac{3}{8}$<br>$\frac{5}{16}$ | $\frac{7}{16}$<br>$\frac{3}{8}$ (2) | 61                         | 85       |
| Bhd Periphery to Cargo Side Bhd                | 7.5              | 20                      | 150                                       | 3/8                             | $\frac{7}{16}$<br>$\frac{3}{8}$ (2) | 72                         | 85       |
| SUBTOTAL - 10 Bulkheads                        | -                | -                       | 28,921                                    | 0.306 avg                       | 0.278 avg                           | 9,222                      | 7,579    |

TABLE G-1, LENGTHS AND WEIGHTS OF ALTERED WELDS FOR CRESCENT CLASS ORE/BULK/OIL CARRIER (Cont'd)

| Item                                                     | Length<br>(Feet) | Number<br>Both<br>Sides | Double Fillet<br>Weld<br>Length<br>(Feet) | Weld<br>Size<br>(Inches) |                    | Weld<br>Weight<br>(Pounds) |          |
|----------------------------------------------------------|------------------|-------------------------|-------------------------------------------|--------------------------|--------------------|----------------------------|----------|
|                                                          |                  |                         |                                           | Existing                 | Proposed           | Existing                   | Proposed |
| Transv Fr to Slanting Wing Tank R                        | 17.0             | 20                      | 340                                       | 1/4                      | <u>1/4</u><br>3/16 | 72                         | 56       |
| Transv Fr to Shell R                                     | 36.0             | 20                      | 720                                       | 1/4                      | 3/16               | 153                        | 86       |
| Transv Fr to Cargo Side Bhd                              | 28.0             | 20                      | 560                                       | 1/4                      | 3/16               | 119                        | 67       |
| Floors (Brkts) to Bilge Strake &<br>Bottom R             | 47.5             | 20                      | 950                                       | <u>5/16</u><br>1/4       | 1/4                | 259                        | 202      |
| Floors to Inner Bottom & Hopper<br>Sides                 | 36               | 20                      | 720                                       | <u>3/8</u><br>5/16       | 5/16               | 292                        | 239      |
| Floors to Outbd Side Girder                              | 5.5              | 20                      | 110                                       | 3/8                      | <u>3/8</u><br>5/16 | 53                         | 45       |
| Floors to Outbd Side Girder                              | 5.5              | 20                      | 110                                       | 7/16                     | <u>7/16</u><br>3/8 | 72                         | 62       |
| Stiffeners to Floor R (Bilge)                            | 45.0             | 20                      | 900                                       | 1/4                      | 3/16               | 191                        | 108      |
| Stiffeners to Floor R                                    | 5.0              | 160                     | 800                                       | 1/4                      | 3/16               | 170                        | 96       |
| Bottom and Bilge Long's to<br>Floors                     | 0.42             | 320                     | 134                                       | <u>5/16</u><br>1/4       | 1/4                | 36                         | 28       |
| Inner Bottom Long's to Floors                            | 0.33             | 540                     | 178                                       | <u>3/8</u><br>5/16       | 5/16               | 72                         | 59       |
| Inner Bottom Long's to<br>Collars @ Floors               | 0.33             | 240                     | 79                                        | <u>3/8</u><br>5/16       | 5/16               | 32                         | 26       |
| SUBTOTAL-10 Transv Bhd Fr                                | -                | -                       | 5,601                                     | 0.283 avg                | 0.237 avg          | 1,521                      | 1,074    |
| SUBTOTAL-ALL CARGO SECTION<br>STRUCTURE                  | -                | -                       | 181,279                                   | 0.277 avg                | 0.239 avg          | 47,272                     | 35,166   |
| ESTIMATE FOR BOW, STERN, AND<br>DECKHOUSE <sup>(1)</sup> | -                | -                       | 32,630                                    | 0.277 avg                | 0.239 avg          | 8,512                      | 6,337    |
| TOTALS                                                   | -                | -                       | 213,909                                   | 0.277 avg                | 0.239 avg          | 55,784                     | 41,503   |

## NOTES:

- (1) The 610 foot long cargo section is assumed to be prismatic. Therefore, the length and weight estimates for the cargo section should be slightly high. This is compensated for by deliberately underestimating weld lengths and weights for the bow, stern, and deckhouse.
- (2) Proposed weld sizes which are increased from existing values are highlighted by reference to this note.

TABLE G-2

## LENGTHS AND WEIGHTS OF UNALTERED WELDS FOR CRESCENT CLASS ORE/BULK/OIL CARRIER

| Item                                                      | Length<br>(Feet) | Number | Total Length<br>of Double<br>Fillet Welds<br>(Feet) | Design Weld<br>Size<br>(Inches) | Weight of<br>Design Welds<br>(Pounds) |
|-----------------------------------------------------------|------------------|--------|-----------------------------------------------------|---------------------------------|---------------------------------------|
| Long'l. Hatch Coaming to Upper Dk.                        | 40.0             | 18     | 720                                                 | $\frac{5}{16}$<br>$\frac{1}{4}$ | 196                                   |
| Deck Long'l's to Deck R                                   | 610.0            | 20     | 12,200                                              | $\frac{3}{8}$<br>$\frac{5}{16}$ | 4,942                                 |
| Long'l's to Shearstrake & Semi-Shearstrake                | 610.0            | 8      | 4,880                                               | $\frac{3}{8}$<br>$\frac{5}{16}$ | 1,977                                 |
| Stringer 44'-8-5/8" ABL to Shell                          | 610.0            | 2      | 1,220                                               | $\frac{7}{16}$<br>$\frac{3}{8}$ | 689                                   |
| Cargo Side Bhd to Stringer<br>44'-8-5/8" ABL              | 610.0            | 2      | 1,220                                               | 5/16                            | 405                                   |
| Cargo Side Bhd to Stringer<br>16'-2" ABL                  | 610.0            | 2      | 1,220                                               | $\frac{7}{16}$<br>$\frac{3}{8}$ | 689                                   |
| SUBTOTAL-LONG'L STRUCT CARGO SECT                         | -                | -      | 21,460                                              | 0.349 Avg.                      | 8,898                                 |
| Side Fr. & Brkt. to Stringer<br>44'-8-5/8" ABL            | 5.0              | 196    | 980                                                 | 1/4                             | 208                                   |
| Side Fr. to Stringer 16'-2" ABL                           | 2.5              | 196    | 490                                                 | 1/4                             | 104                                   |
| Fig R (20.4#) to Lower Side Shell<br>& Hopper Side        | 10.4             | 196    | 2,038                                               | 1/4                             | 433                                   |
| W.T. Side Girder Stiffener to<br>Inner Bottom             | 1.0              | 196    | 196                                                 | 5/16                            | 65                                    |
| SUBTOTAL-98 ORDINARY TRANSV. FR.                          | -                | -      | 3,704                                               | 0.254 Avg.                      | 810                                   |
| Transv. Fr. Brkt. (upper Dk.<br>to Slanting Wing Tank)    | 20.0             | 112    | 2,240                                               | 1/4                             | 476                                   |
| Brkt. (Side Shell Stiff. to<br>Slanting Wing Tank Stiff.) | 5.75             | 112    | 644                                                 | 1/4                             | 137                                   |
| Side Fr. & Brkt. to Stringer<br>44'-8-5/8" ABL            | 5.0              | 112    | 560                                                 | 1/4                             | 119                                   |
| Side Fr. to Stringer<br>16'-2" ABL                        | 2.25             | 112    | 252                                                 | 1/4                             | 54                                    |
| Floors to Side Girders & C.V.K.                           | 11.0             | 392    | 4,312                                               | $\frac{3}{8}$<br>$\frac{5}{16}$ | 1,747                                 |
| SUBTOTAL-56 WEB FRAMES                                    | -                | -      | 8,008                                               | 0.305 Avg.                      | 2,533                                 |

TABLE G-2 (Cont'd)

| Item                                                        | Length<br>(Feet) | Number | Total Length<br>of Double<br>Fillet Welds<br>(Feet) | Design Weld<br>Size<br>(Inches) | Weight of<br>Design Welds<br>(Pounds) |
|-------------------------------------------------------------|------------------|--------|-----------------------------------------------------|---------------------------------|---------------------------------------|
| Wing Tank Bhd PL Periphery                                  | 79.25            | 20     | 1,585                                               | $\frac{5}{16}$<br>$\frac{1}{4}$ | 432                                   |
| W.T. Bhd PL to Upper Stool PL                               | 140.0            | 10     | 1,400                                               | $\frac{3}{8}$<br>$\frac{5}{16}$ | 567                                   |
| W.T. Bhd PL to Slanting Wing<br>Tank PL                     | 30.8             | 20     | 616                                                 | $\frac{7}{16}$<br>$\frac{3}{8}$ | 348                                   |
| W.T. Bhd PL to Cargo Side Bhd                               | 7.0              | 20     | 140                                                 | $\frac{7}{16}$<br>$\frac{3}{8}$ | 79                                    |
| Bhd PL to Lower Side Shell,<br>Hopper Side & Lower Stringer | 25.0             | 20     | 500                                                 | $\frac{3}{8}$                   | 239                                   |
| Floors to Bottom Shell<br>& Bilge PL                        | 58.25            | 20     | 1,165                                               | $\frac{7}{16}$                  | 758                                   |
| Floors to Side Girders & C.V.K.                             | 12.33            | 90     | 1,110                                               | $\frac{7}{16}$                  | 722                                   |
| Shedder PL to Bhd                                           | 9.0              | 300    | 2,700                                               | $\frac{7}{16}$<br>$\frac{3}{8}$ | 1,524                                 |
| W.T. Bhd PL to Lower Stool PL                               | 196.67           | 10     | 1,967                                               | $\frac{7}{16}$<br>$\frac{3}{8}$ | 1,110                                 |
| Upper Stool Diaph. PL Periphery                             | 31.75            | 170    | 5,398                                               | $\frac{1}{4}$                   | 1,147                                 |
| SUBTOTAL-10 BHDS                                            | -                | -      | 16,581                                              | 0.351 Avg.                      | 6,926                                 |
| Brkt. - Upper Dk to Transv. Fr.<br>(Inboard)                | 20.2             | 20     | 404                                                 | $\frac{1}{4}$                   | 86                                    |
| Transv. Fr. to Stringer<br>44'-18-5/8" ABL                  | 5.0              | 20     | 100                                                 | $\frac{1}{4}$                   | 21                                    |
| Transv. Fr. to Stringer<br>16'-2" ABL                       | 2.0              | 20     | 40                                                  | $\frac{1}{4}$                   | 9                                     |
| Floors to Side Girders & C.V.K.                             | 5.5              | 140    | 770                                                 | $\frac{3}{8}$<br>$\frac{5}{16}$ | 312                                   |
| SUBTOTAL-10 TRANSV. BHD. FRs.                               | -                | -      | 1,314                                               | 0.310 Avg.                      | 428                                   |
| Floors to Side Girders & C.V.K.                             | 5.5              | 686    | 3,773                                               | $\frac{3}{8}$<br>$\frac{5}{16}$ | 1,528                                 |
| SUBTOTAL-SOLID FLOORS                                       | -                | -      | 3,773                                               | 0.344 Avg.                      | 1,528                                 |
| Dk PL Periphery @ Hatch Opening<br>Trans. Edge              | 49.0             | 18     | 882                                                 | $\frac{3}{8}$<br>$\frac{5}{16}$ | 357                                   |
| Transv. Hatch Coaming                                       | 49.0             | 18     | 882                                                 | $\frac{5}{16}$<br>$\frac{1}{4}$ | 240                                   |
| SUBTOTAL-MISC.                                              | -                | -      | 1,764                                               | 0.315 Avg.                      | 597                                   |
| SUBTOTAL-ALL CARGO SECTION STRUCT.                          | -                | -      | (56,604)                                            | (0.336)                         | (21,720)                              |
| ESTIMATE FOR BOW, STERN, AND<br>DECKHOUSE                   | -                | -      | 10,189                                              | 0.336 Avg.                      | 3,911                                 |
| TOTALS                                                      | -                | -      | 66,793                                              | 0.336 Avg.                      | 25,631                                |

# MIDSHIP SECTION - 1981 ABS RULES

(Terms are as defined in ABS Rules unless noted otherwise)

## Principal Dimensions

LOA 871'-0"  
 B 106'-0"  
 D 60'-0"  
 Values at scantling draft:  
 d 44'-3"  
 LWL 847'-9"  
 LBP 827'-0"

## Weights (Long Tons)

|                                      |               |
|--------------------------------------|---------------|
| Light Ship                           | 17,400        |
| Fuel Oil                             | 3,300         |
| D.O. & L.O.                          | 50            |
| Fresh water                          | 280           |
| Crew & Stores                        | 50            |
| Cargo                                | 69,520        |
| <u>TOTAL DEADWEIGHT</u>              | <u>73,200</u> |
| DISPLACEMENT<br>(at scantling draft) | 90,600        |

## REQUIRED SECTION MODULUS - MILD STEEL

Section 2.1 Scantling length =  $L = 0.97 \times \text{LWL} = 822.32'$

Section 6.3.1(a)  $SM = M_t / f_p$

$$f_p = 10.56 - \frac{L-790}{2045} = 10.576 \text{ LT/in}^2$$

Section 6.3.1(b)  $C_1 = 0.01441 \left[ 10.75 - \left( \frac{984-L}{328} \right)^{1.5} \right] = 0.14992$

$$C_b = \frac{\text{Displacement} \times 35 \text{ ft}^3/\text{LT}}{L \times B \times d} = 0.82212$$

$$\text{Min. } SM = 0.01C_1 L^2 B (C_b + 0.70) = 163,567 \text{ in}^2 \text{ ft}^2$$

Section 6.3.2 (a)  $C_{st} = \left[ 0.275 - \frac{L-820}{11,600} \right] 10^{-3} = 0.27480 \times 10^{-3}$

$$M_{sw} = C_{st} L^{2.5} B (C_b + 0.5) = 746,785 \text{ Ft-LT}$$

Section 6.3.2(b)  $K_b = 1.0$

$$C_2 = [6.53 C_b + 0.57] 10^{-4} = 5.9384 \times 10^{-4}$$

$$H_e = [4.5L - 0.00216L^2 + 335] 10^{-2} = 25.748 \text{ Ft}$$

$$M_w = C_2 L^2 B H_e K_b = 1,095,975 \text{ Ft-LT}$$

$$M_t = M_{sw} + M_w = 1,842,760 \text{ Ft-LT}$$

$$SM = M_t/f_p = 174,240 \text{ in}^2 \text{ Ft (96 and 91\% of 1970 ABS Rules Deck and Baseline values)}$$

#### REQUIRED MOMENT OF INERTIA AND SECTION MODULUS - H32 STEEL

$$\text{Section 6.13.2} \quad I_{H32} = L \times SM/34.1 = 4,201,790 \text{ in}^2 \text{ Ft}^2$$

$$\text{Section 6.13.3} \quad Q = 0.78050 \text{ (see page E-11)}$$

$$SM_{H32} = Q(SM) = 135,994 \text{ in}^2 \text{ Ft}$$

#### SCANTLINGS

Use H32 material in deck and bottom structure with mild steel elsewhere.

Reduce 61.2# deck and sheer strake to 58.65#

Resulting properties:

$$I = 4,427,616 \text{ in}^2 \text{ ft}^2 > 4,201,790 \text{ in}^2 \text{ ft}^2$$

$$SM_{dk} = 140,980 \text{ in}^2 \text{ ft} > 135,994 \text{ in}^2 \text{ ft}$$

$$SM_{\bar{L}} = 154,844 \text{ in}^2 \text{ ft} > 135,994 \text{ in}^2 \text{ ft}$$

Neutral axis is 28.594 Ft above  $\bar{L}$

#### MAXIMUM HULL GIRDER SHEARING FORCE

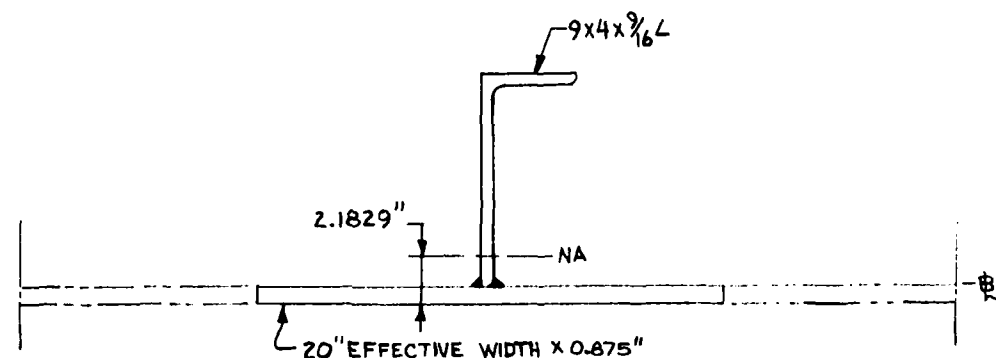
$$\text{Section 6.3.3(a)} \quad V_p = F_{sw} + F_w$$

$$\text{Section 6.3.3(b)} \quad V_p = 5.0 M_{sw}/L + 2.6 M_w/L = 8006.0 \text{ LT}$$

# SIMPLIFIED STRESS ANALYSIS FOR BOTTOM LONGITUDINALS

Bottom longitudinals are rolled 9" x 4" x 9/16" AH 32 angles with 40" spacing on 35.7# DH 32 bottom plate and spans of 5'-0".

Section 3.9 Effective plate width =  $(5' \times 12"/')/3 = 20"$



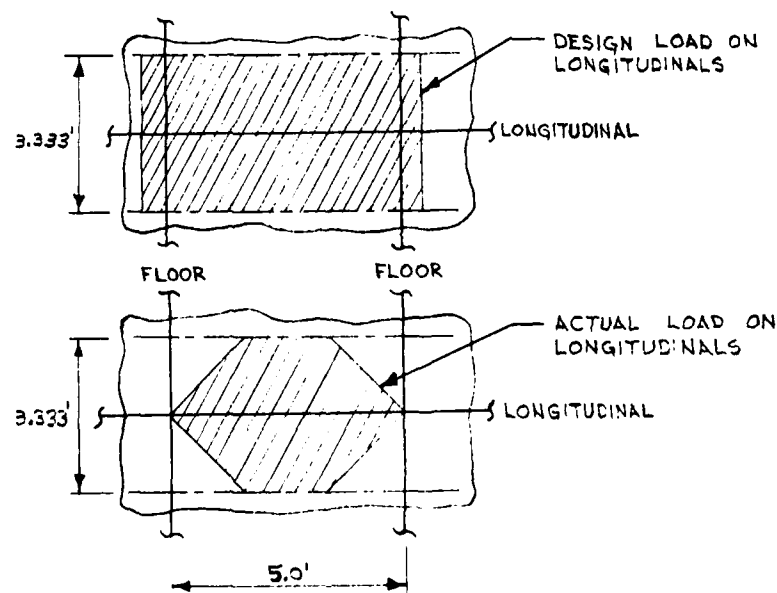
Section 7.3.8  $c = 1.30$   
 $h = 44.25$  Ft  
 $L = \text{Span} = 6$  Ft minimum  
 $s = \text{Spacing} = 3.333$  Ft

Design Load on Longitudinal=

$$64\#/Ft^3 \times 44.25 \text{ Ft} \times 6 \text{ Ft} \times 3.333 \text{ Ft} = 56,634\#$$

Actual Load on Longitudinal=

$$64\#/Ft^3 \times 44.25 \text{ Ft} \left[ 5 \text{ Ft} \times 3.333 \text{ Ft} - \frac{4}{2} \left( \frac{3.333 \text{ Ft}}{2} \right)^2 \right] = 31,465\#$$



Design stresses for O/B/O H32 bottom structure

Section 6.3.1(a)  
and 6.13.3

$$\sigma_p = 10.576 \text{ Lt/in}^2 / 0.7805 = 30,353 \text{ PSI}$$

Section 7.3.8 and  
Page E-24

$$\sigma_s = 15,610 / (1.30 \times 0.7805) = 15,385 \text{ PSI}$$

$$\sigma_T = 45,738 \text{ PSI}$$

Section 6.3.3 &  
6.13.3

$$\tau_p = 6.75 \text{ Lt/in}^2 / 0.7805 = 19,372 \text{ PSI}$$

Use 60% of  $\sigma_s$

$$\tau_s = 0.6 (15,385) = 9,231 \text{ PSI}$$

$$\tau_T = 28,603 \text{ PSI}$$

Primary Strength Values,  $V_p = 8006.0 \text{ LT} = 17,933,440\#$   
 $(AY)_p = 16.404 \text{ in. Ft}^2$   
 $I_p = 4,427,616 \text{ in}^2 \text{ Ft}^2$

Secondary Strength Values, Design  $V_s = 28,317\#$   
 Actual  $V_s = 15,733\#$   
 $(AY)_s = 30.544 \text{ in}^2$   
 $I_s = 246.7 \text{ in}^4$

$$T_r = \frac{1}{\tau_T} \left[ \frac{V_p (AY)_p}{I_p} + \frac{V_s (AY)_s}{I_s} \right]$$

$D = 0.668 (T_r) + 0.085"$  for H32 steel.

For design load,  $T_r = \frac{1}{28,603 \text{ \#/in}^2} [66.4 \text{ \#/in.} + 3505.9 \text{ \#/in.}] = 0.12489 \text{ in.}$

$$D = 0.668 (0.12489") + 0.085" = 0.1684" < 0.1875" \text{ OK}$$

For actual load,  $T_r = \frac{1}{28,603 \text{ \#/in}^2} [66.4 \text{ \#/in.} + 1947.9 \text{ \#/in.}] = 0.070423 \text{ in.}$

$$D = 0.668 (0.070423") + 0.085" = 0.1320" < 0.1875" \text{ OK}$$

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**END**

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