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MIL-STD-2189 (SH)
SECTION 100-1
22 JANUARY 1988

MILITARY STANDARD

DESIGN METHODS FOR NAVAL SHIPBOARD SYSTEMS
SECTION 100-1
REINFORCEMENT OF OPENINGS IN STRUCTURE OF SURFACE SHIPS OTHER THAN IN PROTECTIVE PLATING

AMSC N/A FSC 1990

DEPARTMENT OF THE NAVY
NAVAL SEA SYSTEMS COMMAND

Washington, DC 20362-51O1

Design Methods for Naval Shipboard Systems
Reinforcement of Openings in Structure of Surface Ships, Other Than in Protective Plating

1. This Military Standard is approved for use by the Naval Sea Systems Command, Department of the Navy, and is available for use by all Departments and Agencies of the Department of Defense.

2. Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this document should be addressed to: Commander, Naval Sea Systems Command, SEA 5523, Department of the Navy, Washington, DC 20362-5101 by using the self-addressed standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this document or by letter.

FOREUORD

Purpose The purpose of this standard is to set forth design methods for shipboard components or systems as designated in the title.

Background. The design methods presented in this standard were formerly presented in a design data sheet (DDS), number 100-1, issued by the U.S. Naval Sea Systems Command. It is now being published as a military standard to promote its wider availability throughout the Department of Defense.

CONTENTS

FIGURES

1. GENERAL AND SCOPE

1.1 General. The procedures established by MIL-STD-2189(SH) are applicable. This section and the basic standard are to be considered as an Integral single document.

1.2 Scope. This standard has been prepared to set forth design methods for reinforcement around openings in structural members of naval ships. Such openings are made for the following purposes:

(a) To lighten members.
(b) For access or inspection.
(c) To allow passage of wiring, piping, and ventilation ducts.

2. REFERENCED DOCUMENTS

Not applicable.

3. DEFINITIONS

Not applicable.

4. GENERAL REQUIREMENTS

4.1 Criteria to establish need for reinforcement. criteria are specified in 4.1.1 through 4.1.3.

4.1.1 Strength impairment. If the size or location of an opening impairs the strength of an important structural member, it shall be reinforced. Openings in longitudinal strength structure or main transverse bulkheads are considered to be of this nature.

4.1.2 Lightening holes. Lightening holes need not normally be reinforced, but lightening holes in longitudinal, transverses, or stiffeners shall be reinforced if their clear depth is greater than 35 percent of the web depth, if the length of the hole exceeds its own depth, or if they are unfavorably located.

4.1.3 Size ranges. This standard and the formulas given herein apply to openings that have a maximum clear dimension, after reinforcement, that exceeds 5 inches but does not exceed 120 inches. Reinforcements of larger openings are usually shown on applicable contract drawings, but for webs of stiffening members (longitudinal, transverses, and stiffeners), Openings of 5 inches or less in maximum clear depth shall be reinforced if this dimension exceeds 40 percent of the web depth of the member.

4.2 Overall requirements, Openings and reinforcement of openings shall conform to the following criteria to minimize their adverse effect on structural strength.

4.2.1 Openings. Every opening in a stressed area of a structural member causes stress concentrations. If the opening is large in proportion to the width of the member, or too near an edge, stress concentration is increased. if the size or location of an opening is such as to impair the strength of a member below its required factor of safety, measures shall be taken to reduce the stress in way of the hole. This may be done:

(a) By changing the location of the opening. For example, in a beam, holes are best located near the neutral axis.
(b) By changing the shape of the opening.
(c) By fitting an insert plate around the opening.
(d) By fitting a reinforcing ring around the opening.

The purpose of such reinforcement is to concentrate extra material around the opening and close enough to the plane of the plate that it will deform with the loaded plate, thus absorbing energy and reducing strains around the opening. The rules in this standard deal with this latter type of reinforcement.

4.2.2 Reinforcements. Insofar as practicable, holes and reinforcing rings shall conform to the following:

(a) Radii of corners of reinforced openings shall be in accordance with applicable specifications. Where corner radii are not specified for square or oblong reinforced openings in structural members, they shall be at least one-eighth of the clear dimension described as follows:

    (1) In longitudinal members, normal to the longitudinal axis of the hull.
    (2) In transverse members, normal to the neutral axis of the member.

(b) Small openings (maximum dimension less than 10t, where t is the thickness of the plating) shall be circular.
(c) The reinforcing ring shall be placed symmetrically with respect to the plate except that for usual reinforcement of outside plating there shall be no protrusion of reinforcing ring beyond the outboard face of the shell other than that required for the welded joint.
(d) The reinforcing ring shall be of the same material as the plating. For special-treatment steel rings, it is realized that forming of the material may cause some change in physical properties. The use of tubing (instead of a shaped flat bar) of physical properties equal to or better than those of the reinforced plate is acceptable in such a case.
(e) The welded joint which connects the ring to the plate shall be 100 percent efficient.

4.3 Formulas for reinforcing-ring sizes.

4.3.1. Openings in strength envelope. For openings in the strength envelope (that is, in outside plating, uppermost strength deck, inner bottom, and their associated longitudinal framing), for other strength decks within the midship three-fifths length, and for strength deck stringer plating forward and aft, where reinforcement is required the following formulas apply (see figure 1).

Minimum cross-sectional area of reinforcing ring = A + tT

Where:

A is the reinforcement (see shaded area of sketch), tT is the "plate intercept area" (cutback of plate because of presence of reinforcing ring).

Values of A for various hole proportions are as follows:

If b is equal to or greater than 2a, $A = \frac{30bt}{b + 100}$

If b is equal to or less than a/2, $A = \frac{18bt}{b + 100}$

For intermediate proportions, $A = \frac{24bt}{b + 100}$

Where:

t = thickness of plating to be reinforced, in inches.
a = longitudinal dimension, in inches, of clear opening after reinforcement.
b = transverse dimension (normal to a), in inches, of clear opening after reinforcement.
T = thickness of reinforcing bar ring, This shall preferably be not less than t, and shall be not less than 1/4 inch.
h = depth of ring. This shall not exceed 16T, and shall preferably be not greater than 8T, particularly in the case of shell reinforcements. Dimension h shall be not less than t + 1-1/4 inches.

Based on the foregoing requirements, the minimum dimensions of cross-section of reinforcing ring, anywhere in the ship, will be (t + 1-1/4) inches by 1/4 inch. Values of A may also be derived from the graph shown on figure 2.

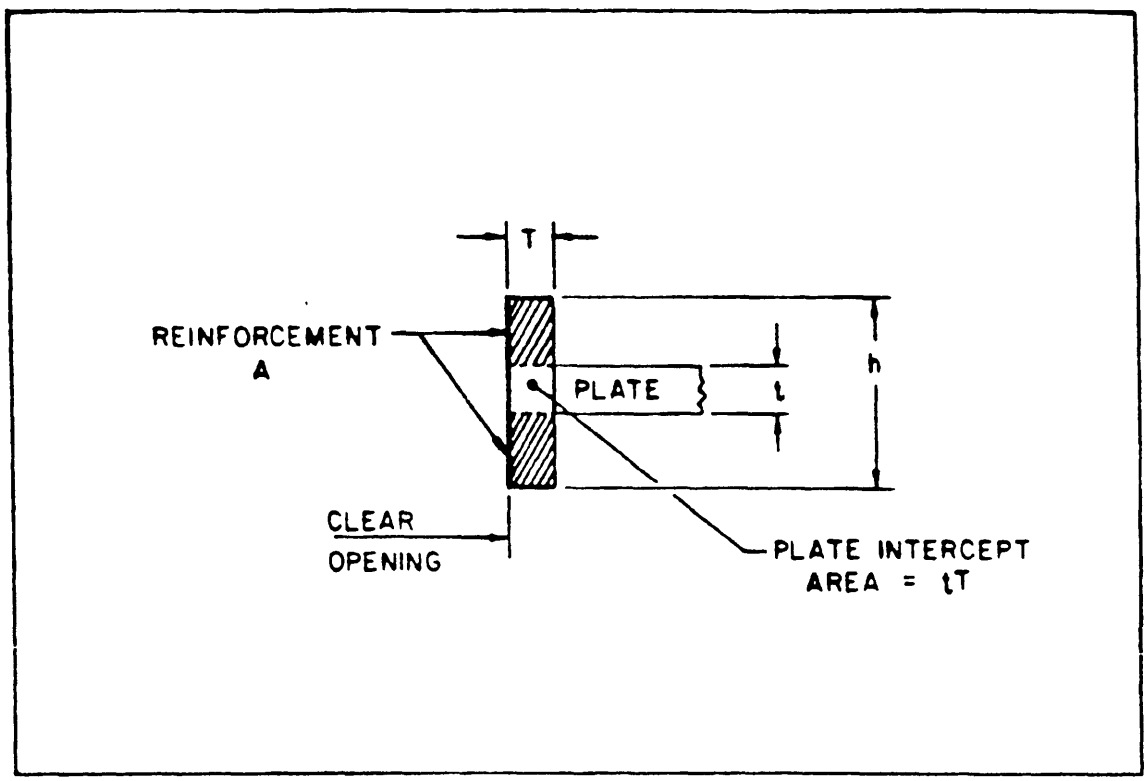

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FIGURE 1. Cross-section of plate.

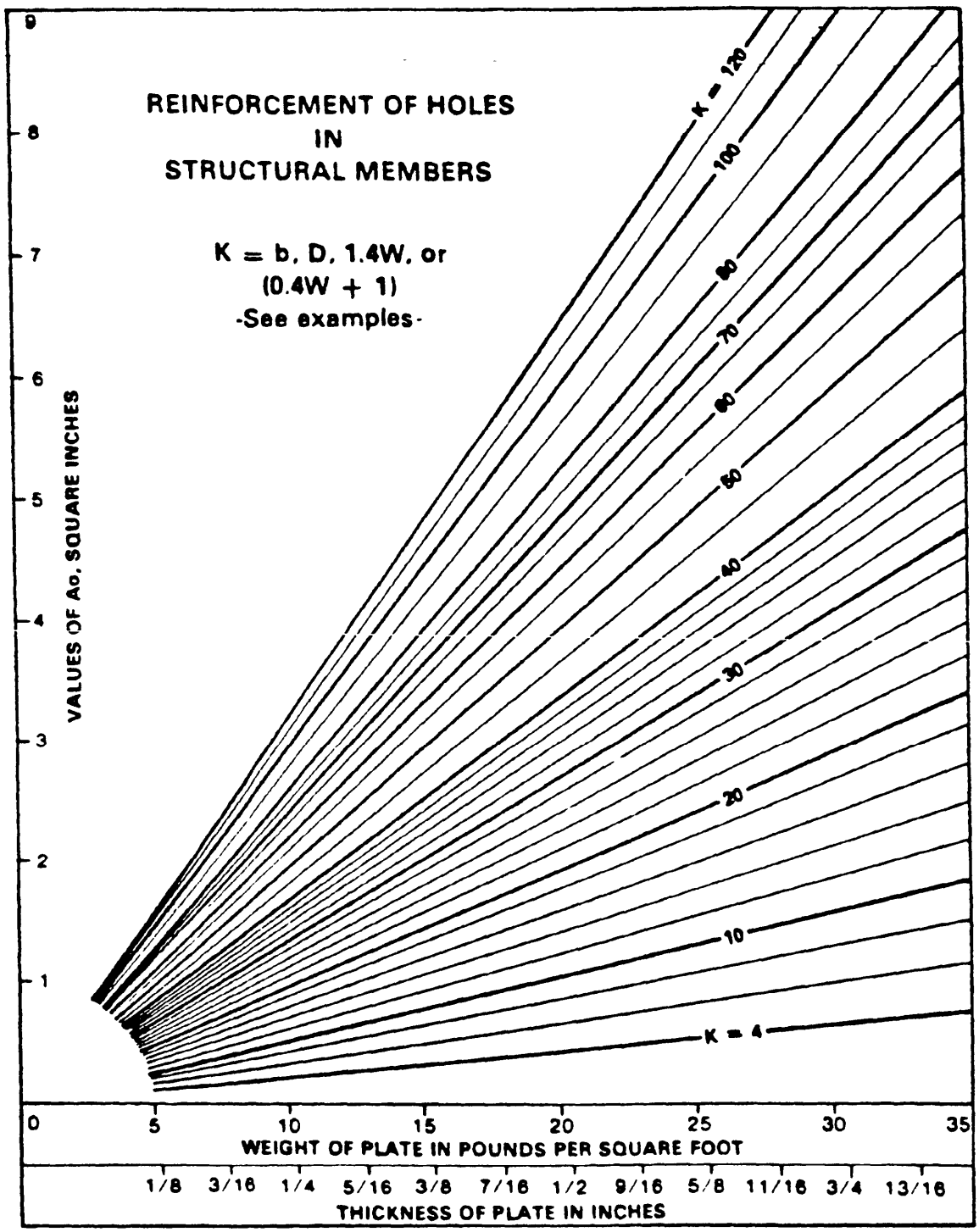

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FIGURE 2. Reinforcement of holes in structural members.

4.3.2 openings in transverse framing and bulkhead plating. For reinforced openings in transverse framing and bulkhead plating, the minimum cross-sectional area of the reinforcement shall be:

For circular openings, $A = \frac{12rDt}{D + 100}$

For square openings, with rounded corners,

$$A = \frac{12(1.4W)t}{1.4W + 100} = \frac{16.8\ Wt}{1.4W + 100}$$

For oblong openings, with rounded corners,

$$A = \frac{12(0.4W + L)t}{0.4W + L + 100}$$

A, t, T, and h are defined in 4.3.1.

D, W, and L are clear dimensions after reinforcement, all in inches, and have the following meanings:

D = diameter of circular opening.
W = distance across a square opening or smaller dimension of an oblong opening.
L = larger dimension of an oblong opening.

5. DETAILED REQUIREMENTS

5.1 Examples of use of the graph (see figure 2). The equation for the graph is as foliows:

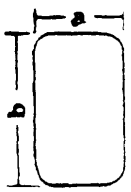
Ac (graph value for area of reinforcement) = $\frac{24KT'}{K + 100}$

(a) Take K : b, D, 1.4w, or (0.4W + L), depending on shape and location of the opening, as described in 4.3.1 and 4.3.2.

(b) Allow for proportions and location by use of a muitlpier, as indicated by the examples.

For holes in longitudinal strength members see examples through 4

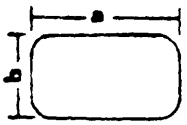
Example 1: When b iss equal to, or g-eater than, 2a, use reinforcement = 1.25 Ao.



Given: K = b = 20 Inches; a = 8 Inches; t = 3/8 inch; then Ao = 1.50;

Reinforcement = 1.25 X 1.50 = 1.88 square inches.

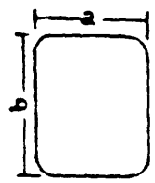
Example 2: When b is equal to, or less than, a/2, use reinforcement = 0.75 Ao.



Given: K = b = 20 inches; a = 50 inches; t = 3/8 inch; then Ao = 1.50;

Reinforcement = 0.75 X 1.50 = 1.12 square inches.

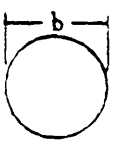
Example 3: For intermediate proportions, use reinforcement = Ao.



Given: K = b = 20 inches; a = 15 inches; t = 3/8 inch;

Reinforcement = Ao = 1.50 square inches.

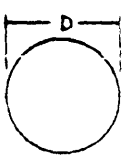
Example 4: Given: Round hole, K = b = 20 inches; t = 3/8 inch;



Reinforcement = Ao = 1.50 square inches

For holes in transverse framing, use 1/2 of Ao for reinforcement, as in examples 5 through 7.

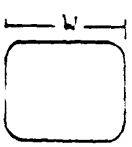
Example 5: For circular openings·



Given: K = D = 20 inches; t = 3/8 inch; then Ao = 1.50;

Reinforcement = 1/2 X 1.50 = 0.75 square inch.

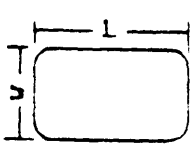
Example 6: For square opening, with rounded corners:



Given: W = 20 inches; t = 3/8 inch; then K = 1.4W = 28, and Ao = 1.97;

Reinforcement = 1/2 X 1.97 = 0.99 square inch.

Example 7: For oblong opening, with rounded corners:



Given: W = 20 inches; L = 30 inches; t = 3/8 inch; then K = (0.4W + L) = 38, Ao = 2.48;

Reinforcement = 1/2 X 2.48 = 1.24 square inches.

(c) Cross-sectional area of reinforcing ring equals tT + reinforcement;

Where, t = plate thickness; T = ring thickness.

6. NOTES

6.1 Intended use. This standard is for use in specifying reinforcement around openings in structural members of naval ships.

6.2 Nonapplicability. This standard is not applicable to:

(a) Openings in protective plating.
(b) Conventional door openings.
(c) Bolted plate and manhole openings.
(d) Airport openings.
(e) Openings for main sea chests not normal to the shell. Sketches and calculations (as required) for the proposed method of reinforcement of these are usually the subject of special approval.
(f) Holes in webs of stiffening members where the maximum clear depth of hole exceeds SO percent of the web depth. Where an excessive hole dimension is required, the web depth should be increased, or heavier reinforcing should be installed.

6.3 Subject term (key word) listing.

Holes
Hulls (marine)
Strength (mechanics)

-Preparing activity:
Navy - SH
(Project 1990-N060)

STANDARDIZATION DOCUMENT IMPROVEMENT PROPOSAL

(See Instructions – Reverse Side)

1. DOCUMENT NUMBER	2 DOCUMENT TITLE
MIL-STD-2189(SH)	SECTION 100-1 (See box 6)

3a. NAME OF SUBMITTING ORGANIZATION	4 TYPE OF ORGANIZATION *(Mark one)*
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	☐ OTHER *(Specify)*:

5 PROBLEM AREAS

a. Paragraph Number and Wording:

b. Recommended Wording:

c. Reason/Rationale for Recommendation:

6 REMARKS Document identification:
MIL-STD-2189(SH) Design Methods for Naval Shipboard Systems; Section 100-1, Reinforcement of Openings in Structure of Surface Ships Other Than in Protective Plating.

7a. NAME OF SUBMITTER *(Last, First, MI)* – Optional	b. WORK TELEPHONE NUMBER *(Include Area Code)* – Optional
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