DESIGN DATA SHEET
DEPARTMENT OF THE NAVY
NAVAL SEA SYSTEMS COMMAND

DDS 100-1

15 MAY 1984

Supersedes DDS 100-1, dated 15 November 1982

REINFORCEMENT OF OPENINGS IN STRUCTURE OF SURFACE SHIPS, OTHER THAN IN PROTECTIVE PLATING.

CONTENTS

100-1-a. Reference

(a) Gen. Spec. and applicable Det. Spec., Sect. 100 - Lightening, drain, and air holes.

100-1-b. Introduction

1. These design data have been prepared for guidance in designing reinforcement around openings in structural members of naval ships. Such openings are made:

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

Every opening in a stressed area of a structural member causes stress concentrations. If opening is large in proportion to width of member, or too near an edge, stress concentration is increased. If size or location of opening is such as to unduly impair the strength of an important member, measures should be taken to reduce the stress in way of the hole. This may be done:

(d) By changing location of opening. For example, in a beam, locate holes near neutral axis.
(e) By changing shape of opening.
(f) By fitting an insert plate around opening.
(g) By fitting a reinforcing ring around opening. The purpose of such reinforcement is to concentrate extra material around opening, close enough to plane of plate so that it will deform with loaded plate, thus absorbing energy and reducing strains around opening. The rules below deal with this type of reinforcement.

100-1-c. Scope of these rules

1. General rule for reinforcement of holes is currently stated in reference (a) as follows:

> 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 and main transverse bulkheads shall be considered to be of this type.
>
> Lightening holes shall not normally be reinforced.

In amplification of this rule, lightening holes in longitudinals, transverses, and stiffeners shall be reinforced if their clear depth is greater than 35 percent of the web depth, the length of the hole exceeds twice its own depth, or if they are unfavorably located.

2. The rules below are not applicable to:

(a) Openings in protective plating.
(b) Door openings, except in special cases.
(c) Bolted plate and manhole openings.
(d) Airport openings.
(e) Openings for main sea chests not normal to shell. Sketches and calculations (as required) for the proposed method of reinforcement shall be forwarded for NAVSEA-approval.
(f) Holes in webs of stiffening members where maximum clear depth of hole exceeds 50 percent of web depth. Where an excessive hole dimension is required, the web depth shall be increased, or heavier reinforcing shall be installed as approved by Supervisor of Shipbuilding.

3. Range of sizes concerned.- The formulas given below apply to openings having a maximum clear dimension, after reinforcement, exceeding 5 inches (with a lower limit for holes in webs of stiffening members, as stated below), but not more than 120 inches. Reinforcement of larger openings shall be as shown on contract plans. For webs of stiffening members (longitudinals, transverses, and stiffeners), openings of 5 inches and less in maximum clear depth shall be reinforced if this dimension exceeds 40 percent of web depth of member.

100-1-d. Formulas for reinforcing ring sizes

1. For openings in strength envelope (that is, in outside plating, uppermost strength deck, innerbottom, and their associated longitudinal framing), and for other strength decks within the midship three-fifths length; also for strength deck stringer plating forward and aft, where reinforcement is required:

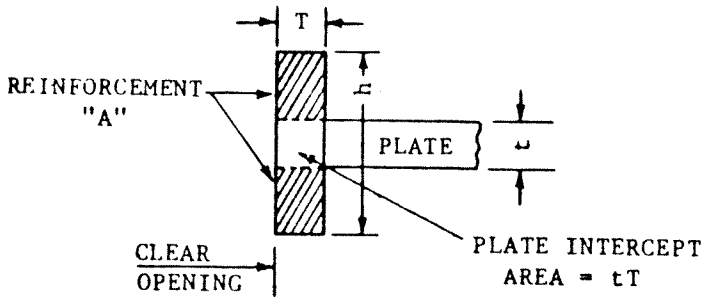


FIGURE 1.

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" (cut-back of plate because of presence of reinforcing ring).

Values of A for various hole proportions are as follows:

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

when 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.
b = transverse dimension (normal to a), in inches, of clear opening after reinforcement.
a = longitudinal dimension, 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 should not exceed 16T, and preferably be not greater than 8T, particularly in the case of shell reinforcements.
h shall not be 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 x 1/4 inch. Values of A may also be derived from the graph, Figure 2.

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

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

For square openings, with rounded corners,

$$A = \frac{12(1.4W)t}{0.4W + 100} = \frac{16.8\ Wt}{1.4W + 100}$$

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 subparagraph 100-1-d-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.

100-1-e. Miscellaneous requirements

1. Insofar as practicable, holes and reinforcing rings should conform to the following limitations.

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

(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) should be circular.

(c) Reinforcing ring should be placed symmetrically with respect to plate except that for usual reinforcement of outside plating there shall be no protrusion of reinforcing ring beyond outboard face of shell other than that required for the welded joint.

(d) Reinforcing ring should be of same material as 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, of physical properties equal to or better than the reinforced plate, instead of a shaped flat bar, will be acceptable.

(e) The welded joint which connects ring to plate should be 100 percent efficient.

100-1-f. Examples of use of the graph (Fig. 2)

The equation for the graph is:

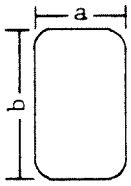
$$Ao, \text{ (chart value for area of reinforcement)} = \frac{24KT}{K + 100}$$

(a) Take K = b, D, 1.4W, or (0.4W + L), depending on shape and location of the opening, as discussed in the statement of the formulas, subparagraphs 100-1-d-1 and 100-1-d-2.

(b) Allow for proportions and location by use of a multiplier, as indicated below:

For holes in longitudinal strength members:

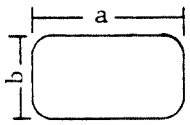
Example 1: When b is equal to, or greater than, 2a, use reinforcement = 1.25 Ao.



Given: K = b = 20 in.; a = 8 in.; t = 3/8 in.; then Ao = 1.50;

Reinforcement = 1.25 x 1.50 = 1.88 sq. in.

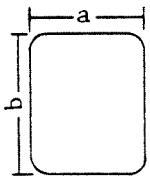
Example 2: When b is equal to, or less than, a/2, use reinforcement = 0.75 Ao.



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

Reinforcement = 0.75 x 1.50 = 1.12 sq. in.

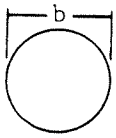
Example 3: For intermediate proportions, use reinforcement = Ao.



Given: K = b = 20 in.; a = 15 in.; t = 3/8 in.;

Reinforcement = Ao = 1.50 sq. in.

Example 4:

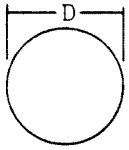


Given: Round hole, K = b = 20 in.; t = 3/8 in.;

Reinforcement = Ao = 1.50 sq. in.

For holes in transverse framing.- Use 1/2 of Ao for reinforcement.

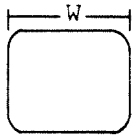
Example 5: For circular openings:



Given: K = D = 20 in.; t = 3/8 in.; then Ao = 1.50;

Reinforcement = 1/2 x 1.50 = 0.75 sq. in.

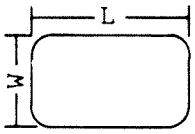
Example 6: For square opening, with rounded corners:



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

Reinforcement = 1/2 x 1.97 = 0.99 sq. in.

Example 7: For oblong opening, with rounded corners:



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

Reinforcement = 1/2 x 2.48 = 1.24 sq. in.

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

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

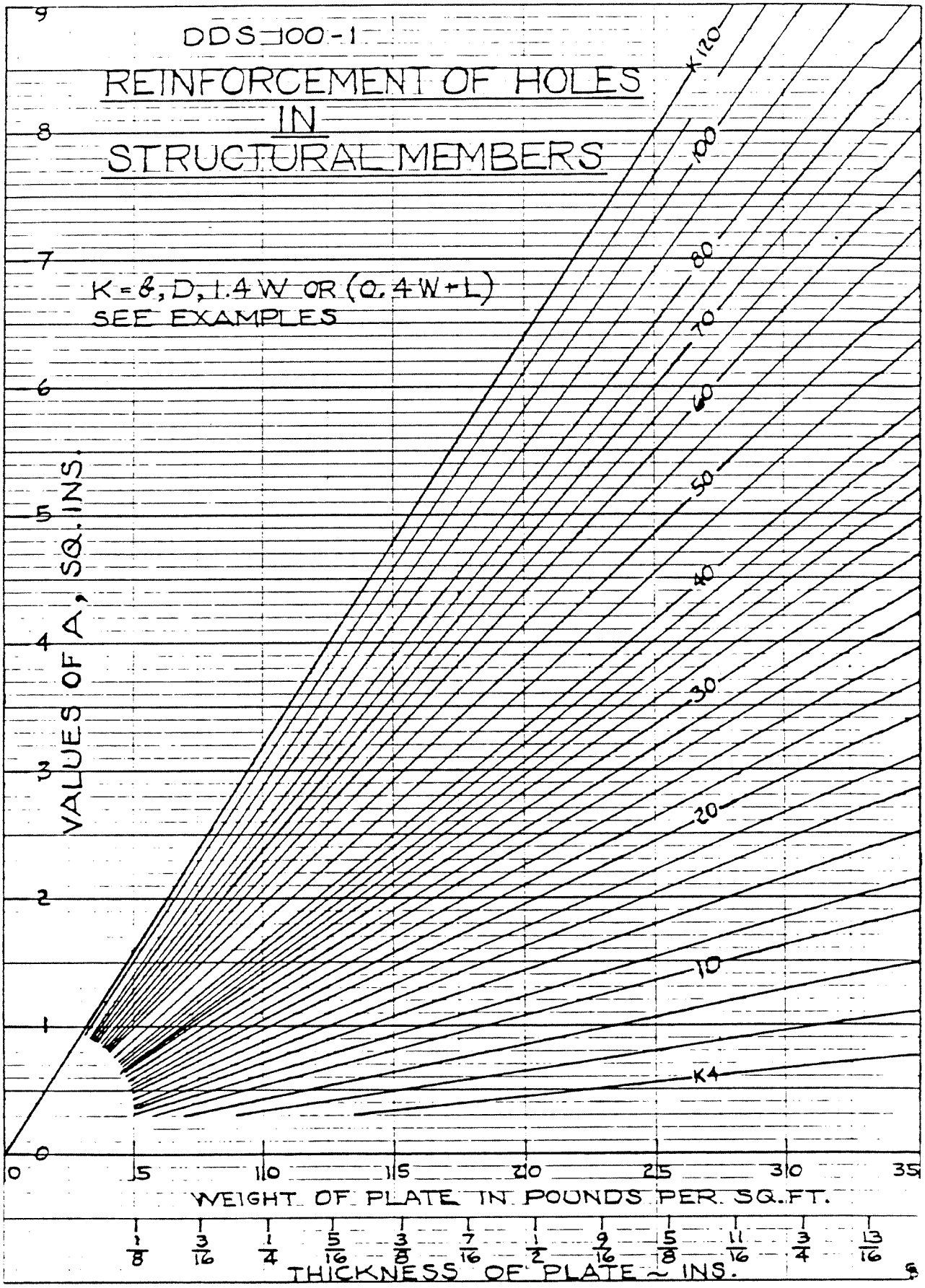

DDS 100-1
REINFORCEMENT OF HOLES IN STRUCTURAL MEMBERS
K = 6, D, 1.4W OR (0.4W + L)
SEE EXAMPLES
K 120
100
80
70
60
50
40
30
20
10
K4
VALUES OF A, SQ. INS.
0
1
2
3
4
5
6
7
8
9
0
5
10
15
20
25
30
35
WEIGHT OF PLATE IN POUNDS PER SQ. FT.
1/8
3/16
1/4
5/16
3/8
7/16
1/2
9/16
5/8
11/16
3/4
13/16
THICKNESS OF PLATE ~ INS.

FIGURE 2.