DDS 581-1
1 July 1984

CALCULATION AND USE OF ANCHORING NOMOGRAPHS

CONTENTS

References

(a) Naval Ships' Technical Manual, Chapter 581, Anchors and Anchoring, NAVSEA S9086-TV-STM-000
(b) D'Arcangelo, A. (editor), Ship Design and Construction, New York, Society of Naval Architects and Marine Engineers, 1969
(c) Taylor, D.W., The Speed and Power of Ships, Washington, D.C., U.S. Government Printing Office, 1943

581-1-a. General

This Design Data Sheet provides the equations and the procedures followed by Naval Sea Systems Command (NAVSEA) to construct and use ship anchoring nomographs, which are in consonance with References (a) and (b). The criteria used for designing anchoring systems are based on a ship being capable of anchoring in conditions up to a maximum of 70 knots of wind, 4 knots of current and 240 feet of water. To anchor a ship under varying conditions of wind, current and depth of water up to the design criteria, it is necessary to know the required length of anchor chain and the horizontal distance from the ship to anchor; anchoring nomographs provide this data. Also needed are correction factors to determine how much additional chain must be let out for a sloped bottom and the subsequent increase in horizontal distance. Accuracy is very important in developing and reproducing nomographs.

Ordinary duplicating machines make distorted and generally inaccurate copies. Therefore, as a check for accuracy, a benchmark (⊕) will be drawn in three of the corners of each nomograph, to form a 6-8-10 inch triangle. A note in the nomograph instructions will state that the benchmarks must scale to within 1/16 inch for the chart to be usable.

581-1-b. Definition of Major Terms

1. Anchor chain catenary is the curve the anchor chain takes from the hawsepipe to anchor when the anchor is on the bottom. The curve takes its shape from the weight of the anchor chain and the loading due to the ship's resistance.

Note: The length of chain from the hawsepipe to the anchor is sometimes called Scope. Scope is not a ratio of length to depth.

2. Maximum holding power of the anchor is the maximum horizontal force the anchor can hold in firm sand. The maximum anchor holding power for various types of anchors is provided in the tables of Appendix A.

3. Bottom slope is the angle (α) of the ocean bottom to the horizontal.

4. Depth of water is the vertical distance from the water surface to the ocean bottom.

5. Ship's resistance is the total load on the ship due to wind and current and is equal to the sum of these forces.

6. Wind force is the load on the ship due to the force of the wind on the frontal area above the design waterline. For ships with the anchors forward, the wind force is calculated for wind coming straight towards the bow; for stern anchors, it is calculated towards the stern.

7. Current force is the sum of the skin friction force and the propeller drag force. For ships with anchors forward, the current force is calculated with the current coming straight towards the bow; for stern anchors, it is calculated toward the stern.

8. Skin friction force is the load on the ship's hull due to the force of the current.

9. Propeller drag force is the load on the ship's propellers due to the force of the current.

581-1-c. Calculations

The nomographs are derived from the following formulas. The calculation forms provided in Appendix B arrange these formulas into a convenient format. To construct the nomographs it is necessary to compute a data base using these forms. Examples of the finished nomographs are provided in Appendix C.

1. Wind Force

A formula used to calculate the force in pounds of the wind on the ship. Calculations are computed in 10 knot increments from 0 to 70 knots.

$$F_W = 0.004\ (A)\ (V^2)$$

where:

0.004 = constant, which takes into account the barometric pressure, temperature, humidity, and drag coefficient of a nonstreamlined structure

A = projected frontal area (square feet)

V = wind velocity (knots)

2. Current Force

A formula used to calculate the force in pounds of the current on the ship. Calculations are computed in 1/2 knot increments from 0 to 4 knots.

$$F_c = F_s + F_p$$

where:

F_s = skin friction force

$$F_s = (f)\ (S)\ (V^{1.825})$$

f = constant, from Table 4 of Section 40, Chapter 7.2 of Reference (c)

= .009 average

1.825 = constant, from Table 4 of Section 40, Chapter 7.2 of Reference (c)

V = current velocity (knots)

S = wetted surface (square feet)

$$S = 15.5\ (\Delta L)^{1/2}$$

15.5 = constant, from Figure 20 of Section 25, Chapter 4.1 of Reference (c)

Δ = design displacement (long tons)

L = length between perpendiculars (feet)

F_p = propeller drag force

$$F_p = 3.17\ Ncv^2\ (Ap)$$

3.17 = constant, based on a factor of 2.85 (which changes knots squared to feet squared per second squared) times 1.1 which is the drag coefficient for flat circular plates

N = number of propellers

v = current velocity (knots)

c = constant; varies as a factor of projected area of the propeller blades minus the hub divided by the disc area of the propeller (usually varies between 0.5 and 0.80)

Ap = disc area of the propeller (square feet)

Note: Model data may be used as a substitute for F_s and F_p subject to Naval Sea Systems Command's approval.

3. Ship's Resistance

A formula used to calculate the resistance force on the ship in pounds.

$$R = F_w + F_c$$

where the maximum ship's resistance equals

$$R\ (max) = F_w\ (70\ kts) + F_c\ (4\ kts)$$

4. Required length of anchor chain

A formula used to calculate the required length of anchor chain. Calculations are computed for values up to the maximum amount of chain onboard.

$$S_c = \frac{R}{W_s} \sinh \left(\frac{W_s\ X}{R}\right)$$

W_s = weight per foot of chain (in water)

R = ship's resistance

X = horizontal distance from the anchor to the ship

5. Depth of Water

A formula to calculate the vertical distance from the water surface at the anchorage.

$$y = \frac{R}{W_s} \cosh \frac{W_s\ X}{R} - 1$$

= vertical distance from the water surface to the ocean bottom

6. Bottom Slope Angle

A formula to calculate the bottom slope angle. Calculations are computed for values up to 40 degrees for all values of ship's resistance.

$$\alpha = \arctan \frac{(W_S \; S_C)}{R}$$

α = bottom slope angle calculated up to 40 degrees for all values of R

Note: The equations for the required length of anchor chain (scope), depth of water, and bottom slope angle are the catenary equations. Approximations of these equations are available; however, the approximations will not give exact answers. Although there are other forms of the catenary equations the ones used in this design data sheet are the most useful for this application.

581-1-d. Procedure for Developing the Ship Anchoring Nomograph

The Ship Anchoring Nomograph enables the user to determine the required amount of anchor chain for varying values of wind and current at anchorage depth. The Ship Anchoring Nomograph has scales for wind, current, ship's resistance, depth of water and required length of anchor chain.

1. Current Scale

To plot the Current Scale start at the left hand side of the page and plot, to any convenient scale, on a vertical line, current force values in pounds in 1/2 knot increments from 0 to 4 knots. Plot the 0 point at the bottom of the scale (see example in Figure 1).

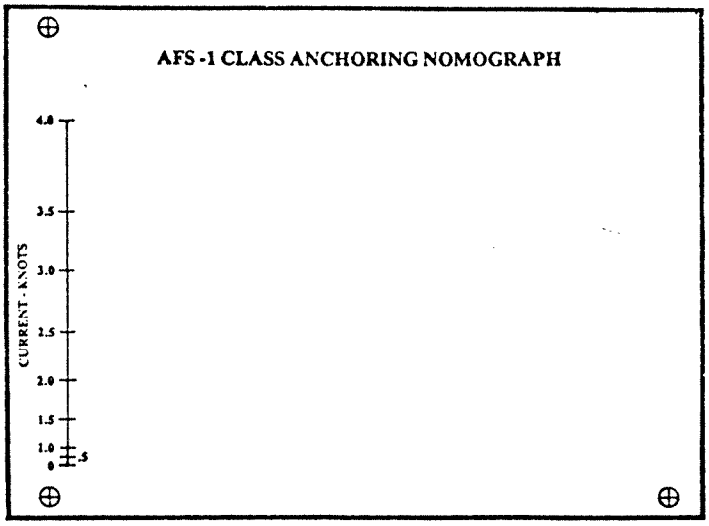


Figure 1

2. Ship's Resistance Scale

To plot the Ship's Resistance Scale, start in the center of the page and plot, to any convenient scale, on a vertical line, the ship's resistance value in pounds from 0 to either the maximum holding power of the anchor or the maximum ship's resistance, whichever is less. Plot the 0 point at the top of the scale (see example in Figure 2).

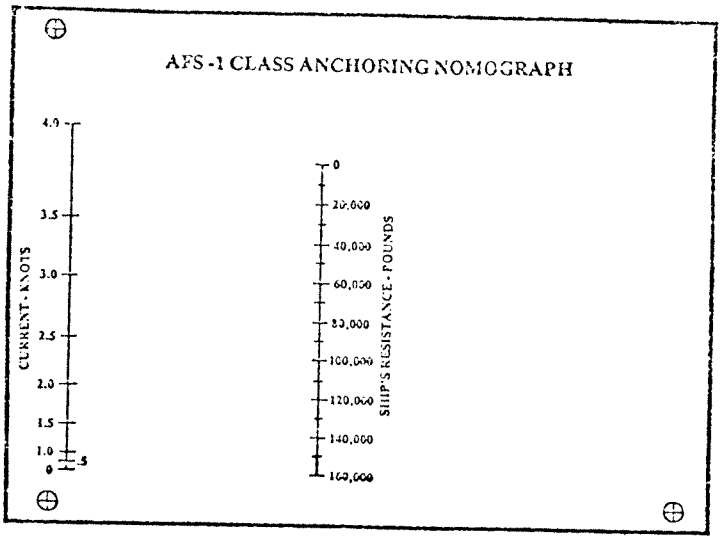


Figure 2

3. Wind Scale

To plot the Wind Scale, first determine the scale's location by the following graphical means (refer to Figure 3). Draw a line from the 0 knot point on the Current Scale to the 0 pound point on the Ship's Resistance Scale. Draw a second line from the 4 knots point on the Current Scale to the pound value for 4 knots of current on the Ship's Resistance Scale. The intersection of the first and second lines is the 0 knot point on the Wind Scale. Draw a third line from a point on the Ship's Resistance Scale equal to 70 knots of wind plus some pound value of current (such as 2 or 3 knots) to that value of the current on the Current Scale. Draw a fourth line from the 0 knot point on Current Scale to the pound value of 70 knots on the Ship's Resistance Scale. The intersection of the third and fourth lines is the 70 knot point on the Wind Scale and lies directly below the 0 knot point of the Wind Scale. Draw a vertical line between these two points. This is the Wind Scale.

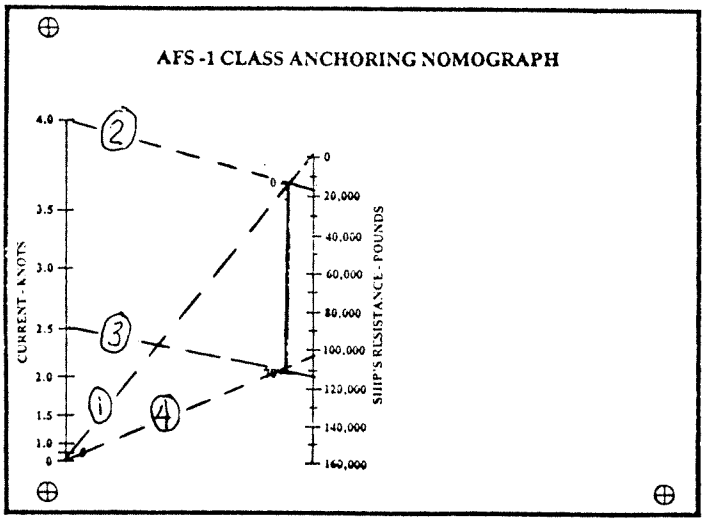


Figure 3

Graduate the Wind Scale in 10-knot increments by finding the pound values for the wind on the Ship's Resistance Scale and drawing lines from these values to the 0 point on the Current Scale. The intersections with the Wind Scale are the values for wind (see example in Figure 4).

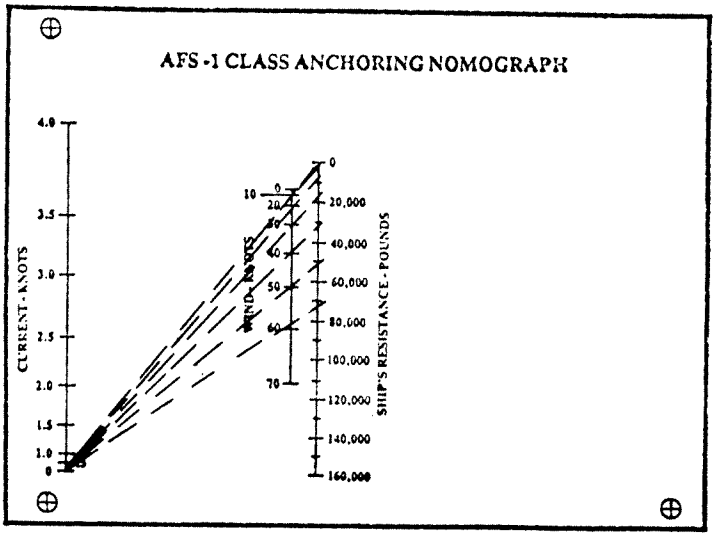


Figure 4

4. Required Length of Anchor Chain Scale

To plot the Required Length of Anchor Chain Scale, start at the right hand side of the page and plot on a vertical line a sequence of squared numbers from 0 to the squared value of the maximum amount of chain onboard. Plot the 0 point at the bottom of the scale. Label the values on the scale as the square root of the numbers plotted (see example in Figure 5).

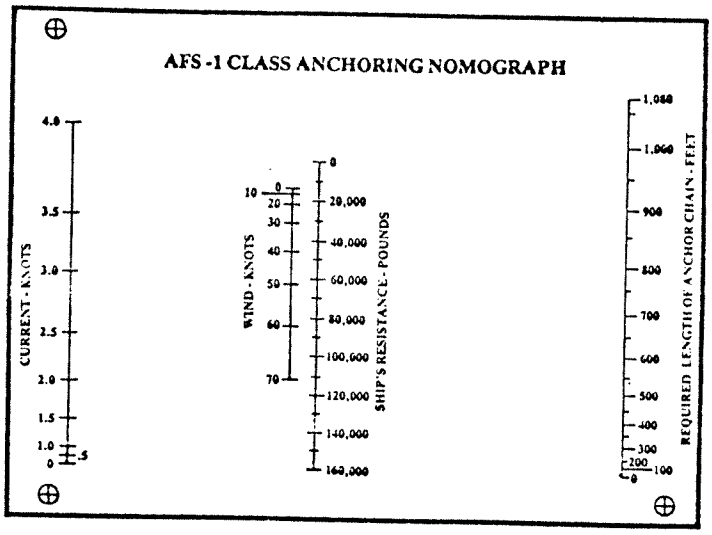


Figure 5

5. Depth of Water Scale

Note: Before plotting the Depth of Water Scale, an adjustment shall be made in the data obtained for the values of y and S_c to account for the vertical distance from the waterline to the hawsepipe. For ships with topside anchors, the depth used is equal to the value for the depth of water plus the vertical distance, however, the depth is plotted as the value for the depth of water. For ships with both a topside anchor and a bottom anchor, the Depth of Water Scale is plotted for the topside anchor. A nomograph note informs the user that to use the nomograph with the bottom anchor, the user shall subtract whatever the vertical distance from the hawsepipe to the keel is from the water depth at the anchorage and use the difference as the value for the Depth of Water Scale.

To plot the Depth of Water Scale select any three ships resistances from the data base and find the values for S_c for a y of 240 feet. Draw lines between the three values of ship's resistances on the Ship's Resistance Scale to the respective values of scope on the Required Length of Anchor Chain Scale. The three lines will intersect at a point. Draw a straight line from this intersection to the 0 point on the Required Length of Anchor Chain Scale.

The line just drawn is the Depth of Water Scale and the intersection is the 240 foot point (see example in Figure 6). Graduate the Depth of Water Scale by using the above procedure for the remaining depths. Use increments of 10 feet up to 100 feet increments from over 100 feet to 240 feet (see example in Figure 7).

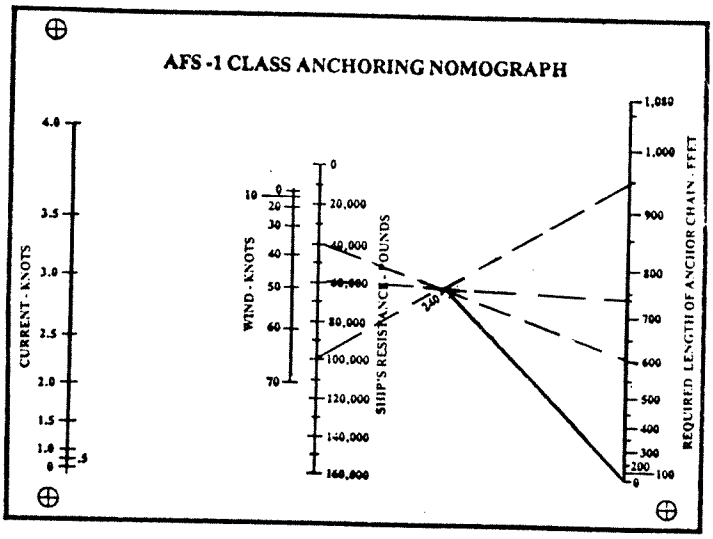


Figure 6

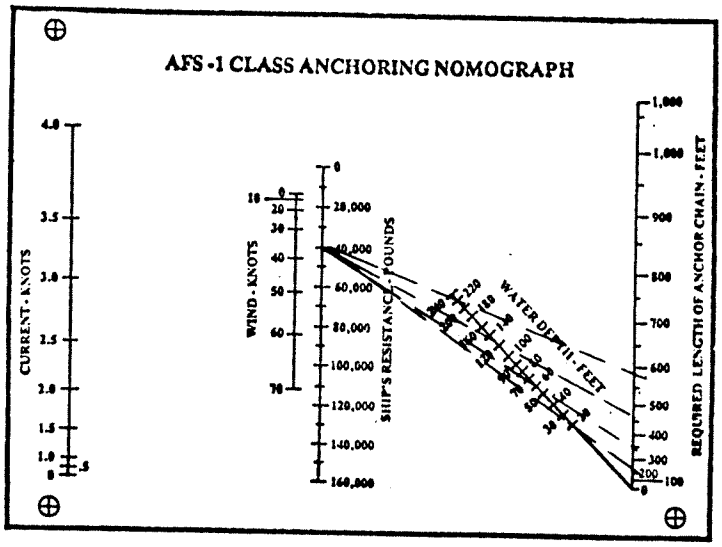


Figure 7

Note: Some construction lines are omitted for clarity.

581-1-e. Procedure for Developing the Distance From Ship to Anchor Nomograph

The ship to anchor nomograph enables the user to determine the horizontal distance from the ship's hawsepipe to the anchor for the conditions used in the Ship Anchoring Nomograph. The Ship to Anchor Nomograph has scales for ship's resistance, depth of water and distance from ship to anchor.

1. Ship's Resistance Scale

To plot the Ship's Resistance Scale, start at the left hand side of the page and plot on a vertical two cycle logarithmic scale the ship resistance values in pounds. The lowest ship's resistance value is plotted at the bottom of the scale (see example in Figure 8).

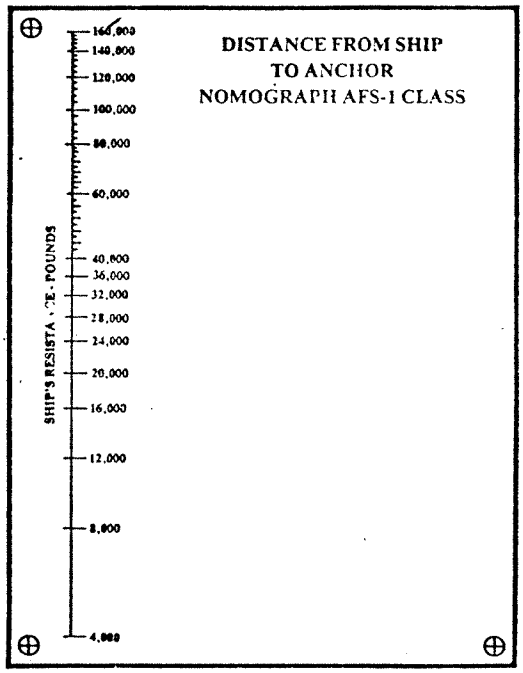


Figure 8

2. Distance from Ship to Anchor Scale

To plot the Distance from Ship to Anchor Scale start at the right hand side of the page and plot on vertical four cycle logarithmic scale the values of x in feet. The shortest distance from ship to anchor value is plotted at the top of the scale (see example in Figure 9).

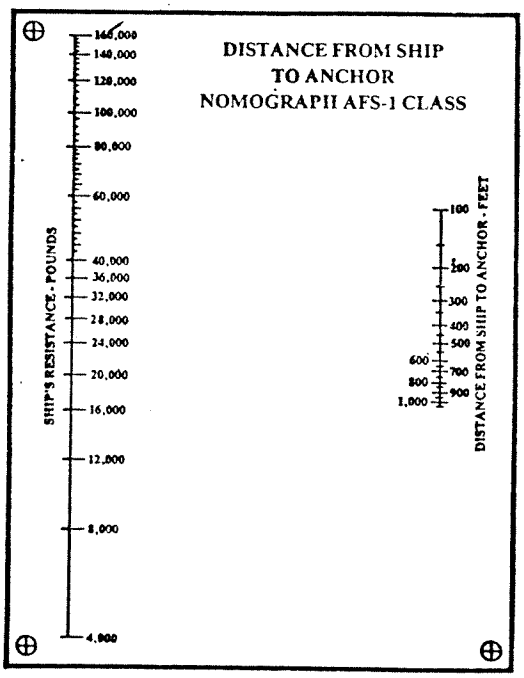


Figure 9

3. Depth of Water Scale

See note in paragraph 581-1-d-5 Note which applies here.

To plot the Depth of Water Scale, first determine the scale's location by the following graphical means. Draw a line from any value of ship's resistance on the Ship's Resistance Scale to the corresponding calculated value for x on the Distance from ship to Anchor Scale for a depth of 240 feet. Repeat this process for another value of Ship's Resistance. The intersection of the first and second lines is the 240 foot-pound on the Depth of Water Scale. Draw a third line from any value of ship's resistance on the Ship's Resistance Scale to the corresponding calculated value for x on the Distance from Ship to Anchor Scale for a depth of 20 feet. Repeat this process for another value of Ship's Resistance. The intersection of the third and fourth lines is the 20 foot point on the Depth of Water Scale and lies directly above the 240 foot point. Draw a vertical line between these two points. This is the depth of Water Scale (see example in Figure 10).

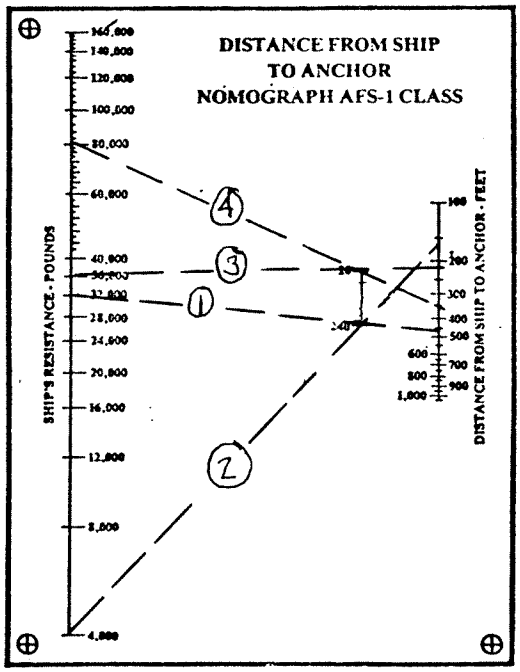


Figure 10

Graduate the Depth of Water Scale by finding using the above procedure for the remaining depths (see example in Figure 11).

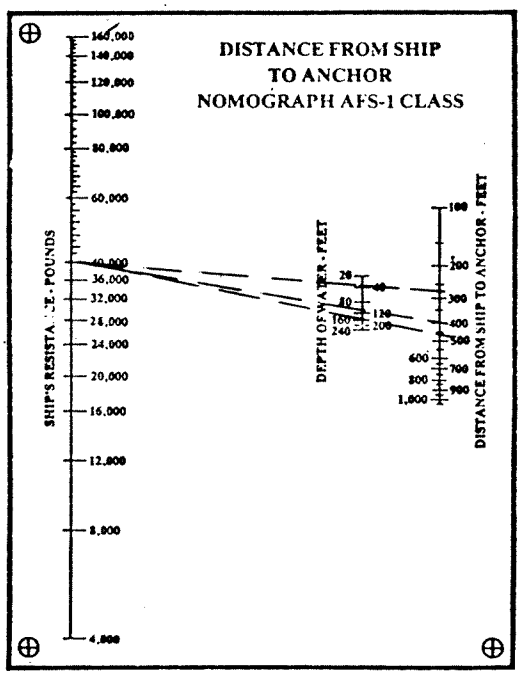


Figure 11

Note: Some construction lines are omitted for clarity.

581-1-f. Procedure for Developing the Bottom Slope Correction Factor

Additional chain must be let out to account for sloping bottoms (see Figure 12). Use Y_2 for the correction factor, α , for the angle of the bottom slope, Y_1 for the depth at anchorage, and Y_3 for the maximum depth of the catenary. The total of X_1 and X_2 is the distance from ship to the anchor. The total of S_1 and S_2 is the total required length of anchor chain for X_1 and X_2. A Bottom Slope Nomograph is used to find α the angle of the bottom with the horizontal. This angle is used with the Ship Correction Factor Curves to determine the value for Y_2. The procedure for using the correction factor is shown in the example in Appendix C.

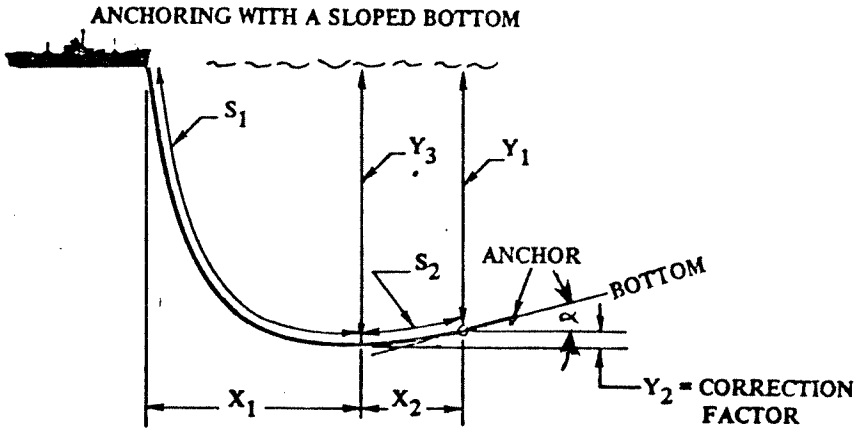


Figure 12

Bottom Slope Nomograph

The Bottom Slope Nomograph is the trigonometric function for tangent α . Using the horizontal distance as the abscissas and the difference in depth as the ordinate calculate bottom slope up to 40 degrees.

1. Difference in Bottom Depth Scale

To plot the Difference in Bottom Depth Scale start at the left-hand side of the page and plot on a vertical line the values for difference in depth in 5 foot increments at any convenient scale. Plot the 0 point at the bottom of the scale (see example in Figure 13).

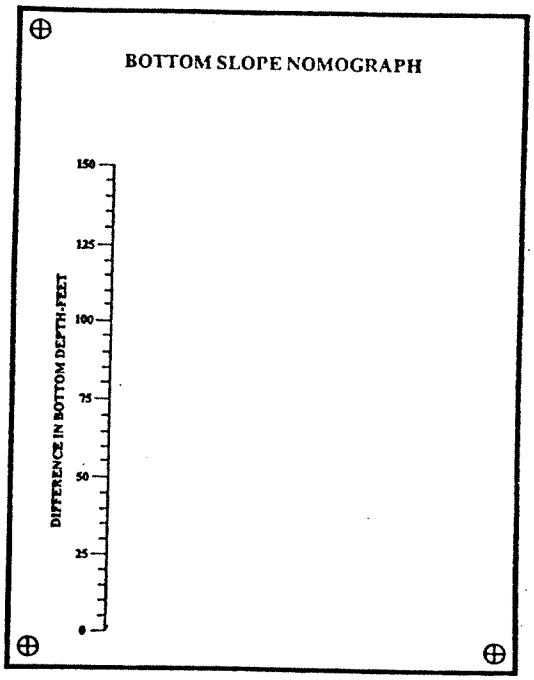


Figure 13

2. Horizontal Distance Scale

To plot the Horizontal Distance Scale start at the right hand side of the page and plot on a vertical line the values for horizontal distance in 5 foot increments at any convenient scale. Plot the 0 point at the top of the scale (see example in Figure 14).

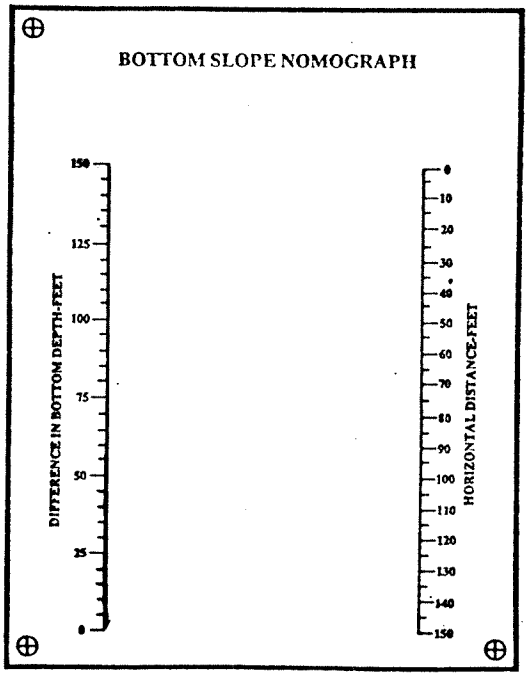


Figure 14

3. Bottom Slope Scale

To plot the Bottom Slope Scale draw a line from the 0 point on the Difference in Bottom Depth Scale to the 0 point on the Horizontal Distance Scale. Graduate the Bottom Slope Scale by drawing lines between the values of difference in bottom depth and horizontal distance on their respective scales for each calculated bottom slope value. The intersections with the Bottom Slope Scale are the values for bottom slope (see example in Figure 15).

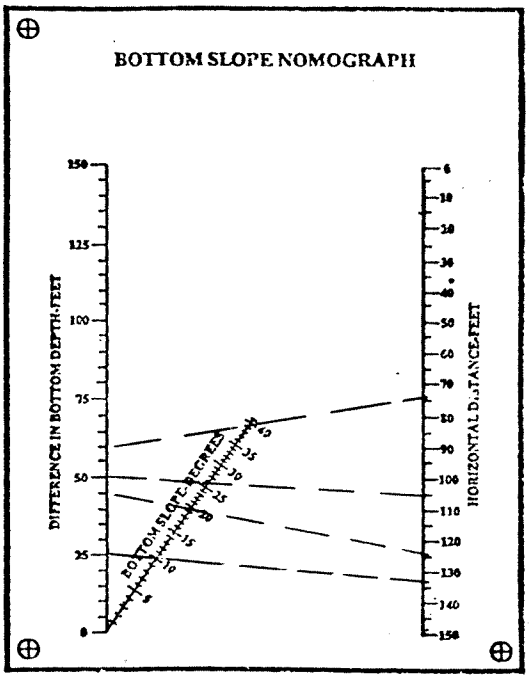


Figure 15

Note: Some construction lines are omitted for clarity.

Ship Correction Factor Curves

A family of ships resistance curves is used to determine the values for Y_2. Values for Y_2 in feet are plotted on the ordinate and values of bottom slope in degrees are plotted on the abscissas. Plot curves for the full range of R (see Figure 16 for a typical graph of some of the resistances).

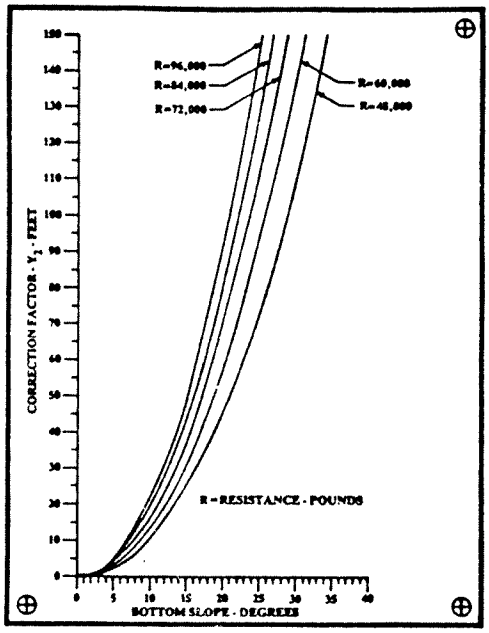

R=96,000
R=84,000
R=72,000
R=60,000
R=48,000
CORRECTION FACTOR - V_1 - FEET
R = RESISTANCE - POUNDS
BOTTOM SLOPE - DEGREES

Figure 16

APPENDIX A

ANCHOR HOLDING POWER TABLES

STANDARD NAVY STOCKLESS ANCHOR

ANCHOR WEIGHT		HOLDING POWER	
LBS	KG	LBS	KG
100	45	700	316
200	90	1,400	635
300	136	2,100	953
400	181	2,800	1,270
500	226	3,500	1,588
600	272	4,200	1,905
700	317	4,900	2,223
800	362	5,600	2,540
900	408	6,300	2,858
1,000	453	7,000	3,175
1,100	498	7,700	3,493
1,200	544	8,400	3,810
1,300	589	9,100	4,128
1,400	635	9,800	4,445
1,500	680	10,500	4,763
1,600	725	11,200	5,080
1,700	771	11,900	5,398
1,800	816	12,600	5,715
1,900	861	13,300	6,033
2,000	907	14,000	6,350
2,200	997	15,400	6,985
2,500	1,134	17,500	7,938
3,000	1,360	21,000	9,526
3,500	1,587	24,500	11,113
4,000	1,814	28,000	12,701
5,000	2,268	35,000	15,876
6,000	2,721	42,000	19,051
7,000	3,175	49,000	22,226
8,000	3,628	56,000	25,402
9,000	4,082	63,000	28,577
10,000	4,536	70,000	31,752
11,000	4,989	77,000	34,927
12,000	5,443	84,000	38,102
13,000	5,896	91,000	41,278
14,500	6,577	101,500	46,040
15,000	6,804	105,000	47,628
16,000	7,257	112,000	50,803
18,000	8,164	126,000	57,154
20,000	9,072	140,000	63,504
22,500	10,206	157,500	71,442
25,000	11,340	175,000	79,380
30,000	13,608	210,000	95,256
35,000	15,876	245,000	111,132
40,000	18,144	280,000	127,008
45,000	20,412	315,000	142,884
Based on NAVSHIPS Dwg. 803-860337			
STOCKLESS MARK 2			
60,000	27,000	554,700	247,075
Based on NAVSHIPS Dwg. 803-920808			

MARK II LIGHT-WEIGHT TYPE (LWT) ANCHOR

WEIGHT OF ANCHOR		HOLDING POWER	
LBS	KG	LBS	KG
8	4	375	170
16	8	728	330
30	15	1,300	590
50	25	1,970	890
75	37	2,690	1,220
100	50	3,420	1,550
150	75	4,600	2,085
200	100	5,940	2,695
300	150	8,180	3,710
500	250	12,500	5,670
750	370	18,180	8,245
1,000	500	21,500	9,750
1,500	750	32,700	14,830
2,000	1,000	40,000	18,145
2,500	1,250	50,050	22,700
3,000	1,500	60,000	27,215
4,000	2,000	75,070	34,050
5,000	2,500	91,000	41,280
6,000	3,000	106,746	48,420
10,000	5,000	163,500	74,160
13,000	6,500	204,000	92,530

Based on NAVSHIPS Dwg. 803-632566

LIGHT-WEIGHT TYPE (LWT) ANCHOR

WITH WEDGE BLOCK ADAPTERS

WEIGHT OF ANCHOR	HOLDING POWER
LBS	LBS
6,000	106,747
10,000	163,500
14,000	204,000
16,000	233,000
20,000	290,000
25,000	364,282
30,000	434,000
Based on NAVSHIPS Dwg. 805-2482962	

BALANCED FLUKE ANCHOR WEIGHT

WEIGHT OF ANCHOR ASSEMBLY		HOLDING POWER	
LBS	KG	LBS	KG
660	300	5,950	2,700
925	420	8,325	3,780
1,985	900	17,860	8,100
2,800	1,270	25,130	11,400
4,600	2,090	41,450	18,800
6,000	2,720	54,010	24,500
8,000	3,630	72,090	32,700
8,930	4,050	80,470	36,500
10,000	4,535	90,000	40,800
11,600	5,250	104,500	47,400
13,200	6,000	119,050	54,000
15,200	6,900	136,900	62,100
17,200	7,800	154,800	70,200
19,200	8,700	172,600	78,300
21,800	9,900	196,400	89,100
24,500	11,100	220,250	99,900
27,550	12,500	248,000	112,500
30,400	13,800	273,800	124,200

Based on NAVSEA Std. Dwg. 803-5000920

APPENDIX B

ANCHORING NOMOGRAPH

CALCULATION FORMS

ANCHORING NOMOGRAPH

CALCULATION FORMS

DESIGN _____

PREPARED BY: _____

CHECKED BY: _____

P R O C E D U R E

1. Wind Force (F_w)

   $F_w = 0.004A(V)^2$

   Projected frontal area (A) _____ ft^2

$F_w = 0.004A(V)$				
	0.004	$A(ft^2)$	$V^2(kt)^2$	F_w(lbs)
$F_w(10)$	0.004		100	
$F_w(20)$	0.004		400	
$F_w(30)$	0.004		900	
$F_w(40)$	0.004		1600	
$F_w(50)$	0.004		2500	
$F_w(60)$	0.004		3600	
$F_w(70)$	0.004		4900	

2. Current Force (F_c)

   $F_c = F_s + F_p$

   $F_s = f\ s\ (V^{1.825})$

   $s = 15.5\ (\Delta L)^{1/2}$

   Design Displacement (Δ) _____ tons

   Length Between Perpendiculars _____ ft

   $s = 15.5$ (_____ X _____)$^{1/2}$ = _____ ft^2

$F_s = f\ s\ (V^{1.825})$				
	0.009	$s(ft^2)$	$V^{1.825}$(kts)	F_s(lbs)
$F_s(0.5)$	0.009		0.3	
$F_s(1.0)$	0.009		1.0	
$F_s(1.5)$	0.009		2.1	
$F_s(2.0)$	0.009		3.5	
$F_s(2.5)$	0.009		5.3	
$F_s(3.0)$	0.009		7.4	
$F_s(3.5)$	0.009		9.8	
$F_s(4.0)$	0.009		12.6	

$F_p = 3.17\ N\ c(V^2)(Ap)$

Number of propellers (N) _____

$c = \frac{\text{(projected area of propeller) - (hub area)}}{\text{(disc area)}} =$ _____

Disc area of the propeller (Ap) _____ ft^2

$F_p = 3.17\ N\ c(V^2)(Ap)$						
	3.17	N	c	$V^2(kt^2)$	$Ap(ft^2)$	F_p(lbs)
$F_p(0.5)$	3.17			0.25		
$F_p(1.0)$	3.17			1.0		
$F_p(1.5)$	3.17			2.25		
$F_p(2.0)$	3.17			4.0		
$F_p(2.5)$	3.17			6.25		
$F_p(3.0)$	3.17			9.0		
$F_p(3.5)$	3.17			12.25		
$F_p(4.0)$	3.17			16.0		

$F_c = F_s + F_p$			
	F_s(lbs)	F_p(lbs)	F_c(lbs)
$F_c(0.5)$			
$F_c(1.0)$			
$F_c(1.5)$			
$F_c(2.0)$			
$F_c(2.5)$			
$F_c(3.0)$			
$F_c(3.5)$			
$F_c(4.0)$			

3. Ships Resistance

$R\ (max) = F_w(70) + F_c(4.0)$

R max = _____ + _____ = _____ lbs

Type of anchor _____

Holding power _____ lbs

4. Required Length of Anchor Chain (S_c)

$$S_c = \frac{R}{W_s} \left(\sinh \frac{W_s}{R} x\right)$$

Weight per foot of chain (W_s) _____ lbs/ft

5. Depth of Water

$$y = \frac{R}{W_s} \left[\cosh \frac{(W_s x)}{R} - 1\right]$$

This equation can be rewritten as:

$$X = \frac{R}{W_s} \cosh^{-1} \left(\frac{W_s\, y}{R} + 1 \right)$$

For R = _____ lbs

Pick values of Y and calculate the following:

Y	$\frac{R}{W_s} \cosh^{-1} \left(\frac{W_s\, y}{R} + 1 \right) = X$	$\frac{R}{W_s} \left(\sinh \frac{W_s\, x}{R} \right) = S_c$	$\arctan \left(\frac{W_s\, S_c}{R} \right) =$

Repeat above calculations for varying values of R up to the maximum holding power of the anchor.

6. Vertical distance from waterline to the hawsepipe _____ ft

APPENDIX C

EXAMPLE NOMOGRAPH

SHIPS INFORMATION BOOK
VOLUME I
SECTION 9260-1

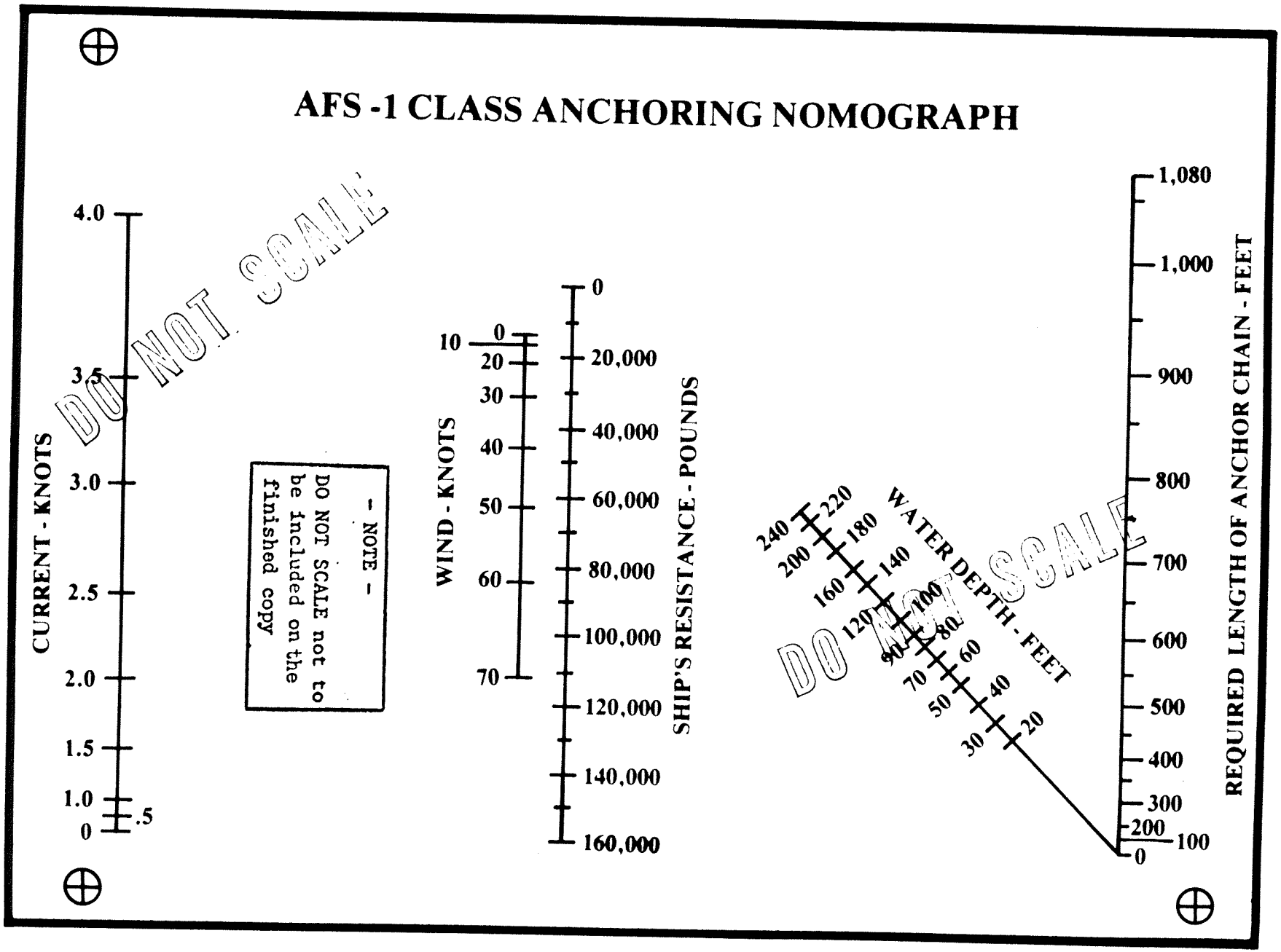
ANCHORING

THE NOMOGRAPHS AND GRAPHS IN THIS SECTION PROVIDE THE USER WITH THE MINIMUM LENGTH OF CHAIN REQUIRED TO ANCHOR IN A FIRM SAND BOTTOM, AND THE HORIZONTAL DISTANCE FROM THE SHIPS' BOLSTER TO THE ANCHOR. ANCHOR CHAIN CORRECTION FACTORS ARE DEVELOPED FOR ANCHORING ON A SLOPING BOTTOM. NO FACTORS ARE INDICATED TO MODIFY THE RESULTS FOR OTHER BOTTOMS. IN MUD BOTTOMS OR BOTTOMS WITH A COMBINATION OF MUD AND SAND, THE HOLDING POWER OF THE ANCHOR IS IN GENERAL LESS THAN IN SAND.

CAUTION: THE NOMOGRAPHS AND GRAPHS ARE APPLICABLE TO THIS CLASS ONLY.

CAUTION: USE ONLY THE ORIGINAL OR EXACT COPIES OF THESE NOMOGRAPHS AND GRAPHS. OUT OF SCALE COPIES GIVE ERRONEOUS ANSWERS. TO DETERMINE IF THE NOMOGRAPHS AND GRAPHS ARE ACCURATE MEASURE THE DISTANCE BETWEEN THE TARGET POINTS ⊕. THESE DISTANCE MUST BE 6, 8, AND 10 INCHES TO WITHIN 1/16 OF AN INCH.

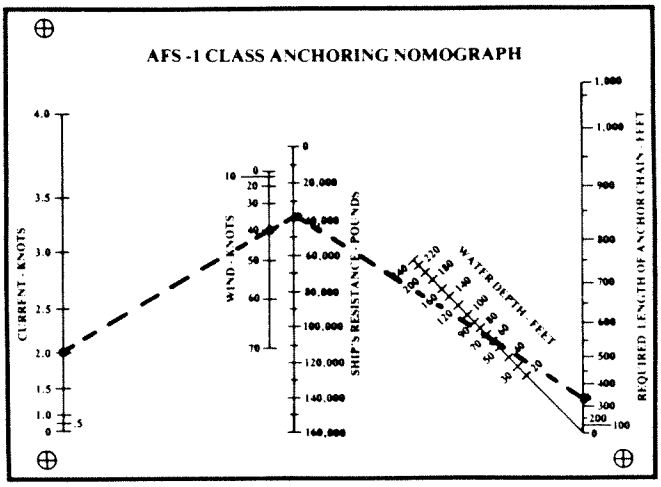
APPLICABLE TO AFS-1 CLASS


AFS -1 CLASS ANCHORING NOMOGRAPH
CURRENT - KNOTS
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0
.5
DO NOT SCALE
- NOTE -
DO NOT SCALE not to be included on the finished copy
WIND - KNOTS
10
0
20
30
40
50
60
70
SHIP'S RESISTANCE - POUNDS
0
20,000
40,000
60,000
80,000
100,000
120,000
140,000
160,000
WATER DEPTH - FEET
240
220
200
180
160
140
120
100
90
80
70
60
50
40
30
20
DO NOT SCALE
REQUIRED LENGTH OF ANCHOR CHAIN - FEET
1,080
1,000
900
800
700
600
500
400
300
200
100
0

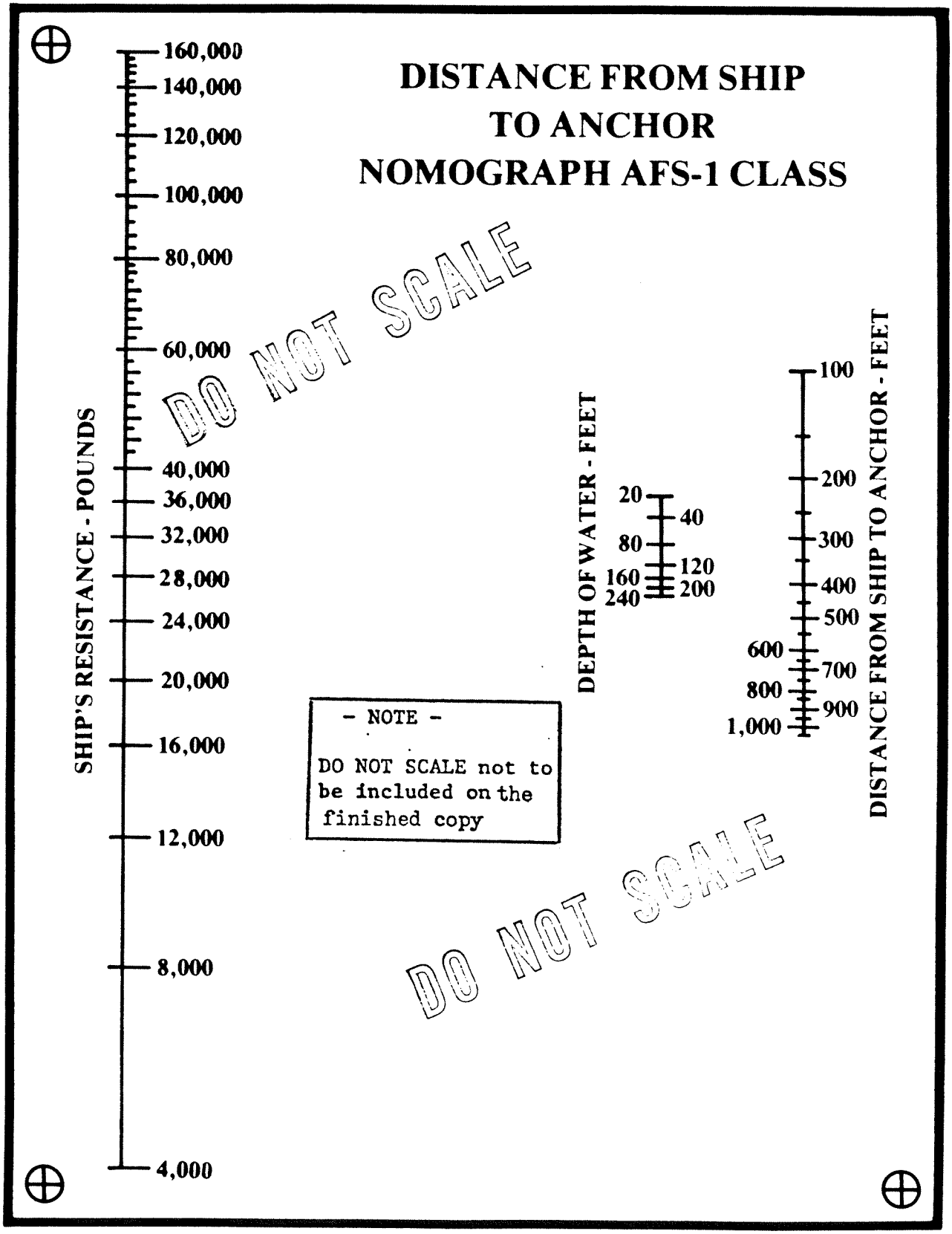
PROCEDURE:

1. THROUGH THE ANTICIPATED MAXIMUM VALUES OF CURRENT AND WIND DURING THE STAY AT THE INTENDED ANCHORAGE, DRAW A STRAIGHT LINE THROUGH THE RESPECTIVE SCALES TO INTERSECT THE "SHIP'S RESISTANCE" SCALE.

2. FROM THIS INTERSECTION DRAW A SECOND STRAIGHT LINE THROUGH THE DESIRED DEPTH AT THE ANCHORAGE INDICATED ON THE "DEPTH OF WATER" SCALE INTERSECTING THE "REQUIRED LENGTH OF ANCHOR CHAIN" SCALE. THIS IS THE LENGTH OF ANCHOR CHAIN REQUIRED TO ANCHOR IN A NONSLOPING FIRM SAND BOTTOM AT THE SELECTED DEPTH, CURRENT AND WIND VALUES.

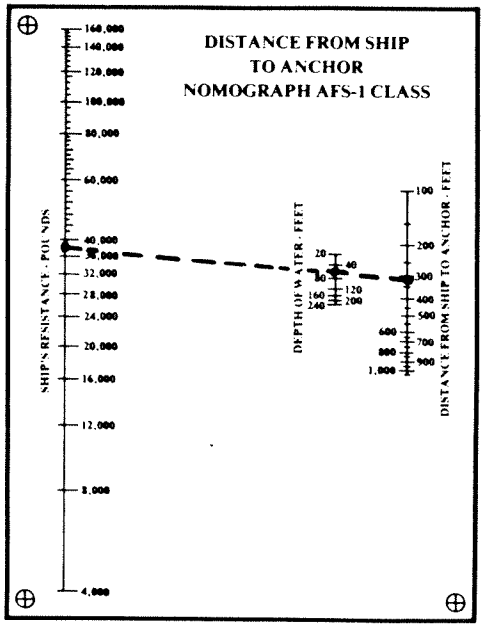


GIVEN: 2 KNOTS-CURRENT
40 KNOTS-WIND
60 FEET-DEPTH WATER
THEN: SHIP' RESISTANCE = 38,000 POUNDS
REQUIRED LENGTH OF ANCHOR CHAIN = 330 FEET


DISTANCE FROM SHIP
TO ANCHOR
NOMOGRAPH AFS-1 CLASS
SHIP'S RESISTANCE - POUNDS
160,000
140,000
120,000
100,000
80,000
60,000
40,000
36,000
32,000
28,000
24,000
20,000
16,000
12,000
8,000
4,000
DEPTH OF WATER - FEET
20
40
80
120
160
200
240
DISTANCE FROM SHIP TO ANCHOR - FEET
100
200
300
400
500
600
700
800
900
1,000
DO NOT SCALE
- NOTE -
DO NOT SCALE not to be included on the finished copy
DO NOT SCALE

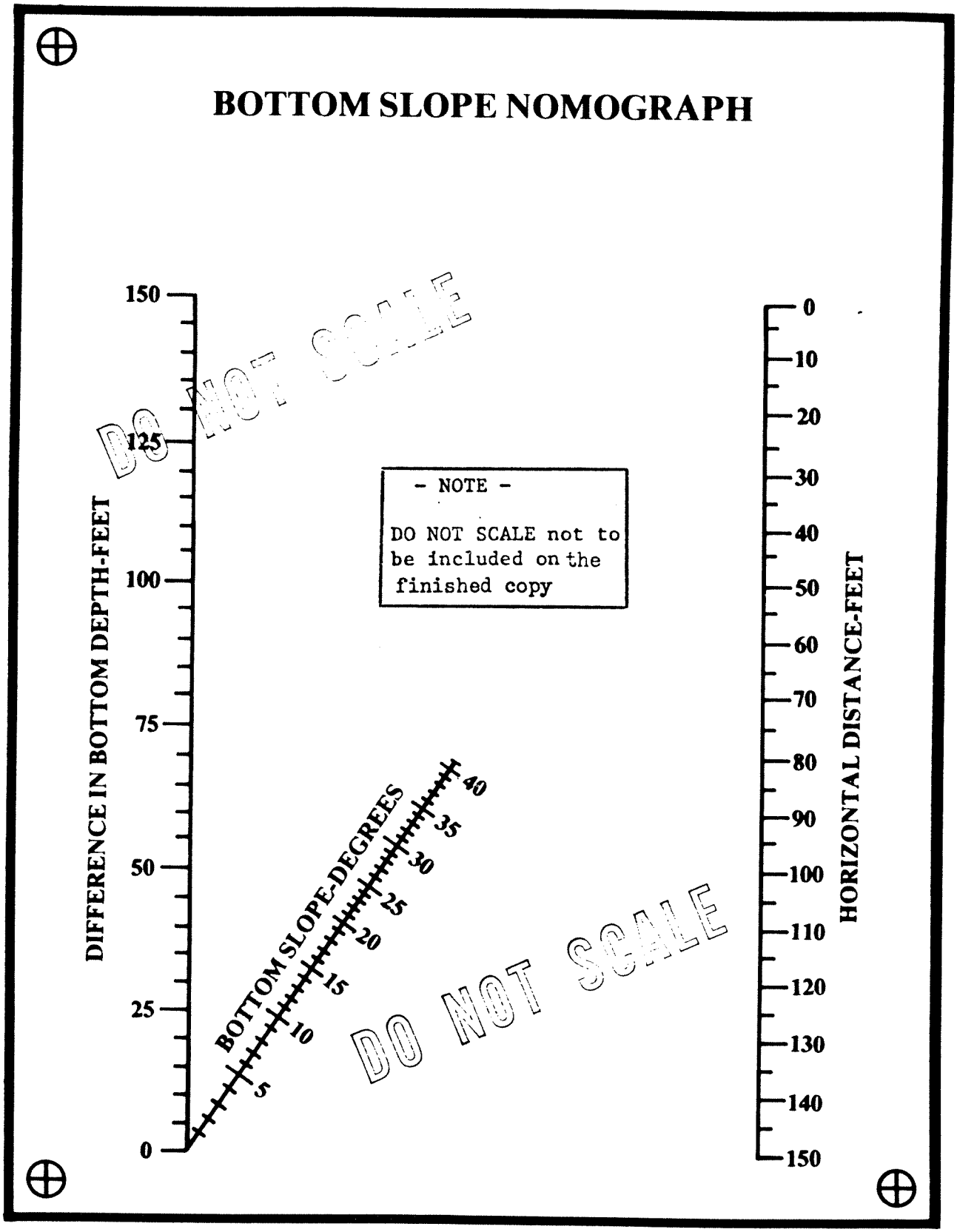
PROCEDURE:

1. USING THE PREVIOUS VALUES FOR SHIP'S RESISTANCE AND DEPTH DRAW A STRAIGHT LINE THROUGH THESE VALUES ON THEIR RESPECTIVE SCALES INTERSECTING THE "DISTANCE FROM SHIP TO THE ANCHOR" SCALE. THIS IS THE HORIZONTAL DISTANCE FROM THE SHIP'S HAWSE PIPE TO THE ANCHOR THAT THE PREVIOUSLY DETERMINED AMOUNT OF ANCHOR CHAIN GIVES AND DETERMINES THE SWING CIRCLE OF THE SHIP'S BOW AT THE SELECTED VALUES OF WIND AND CURRENT.



GIVEN: 38,000 POUNDS-SHIP'S RESISTANCE
60 FEET-DEPTH OF WATER
THEN: DISTANCE FROM SHIP TO ANCHOR = 310 FEET

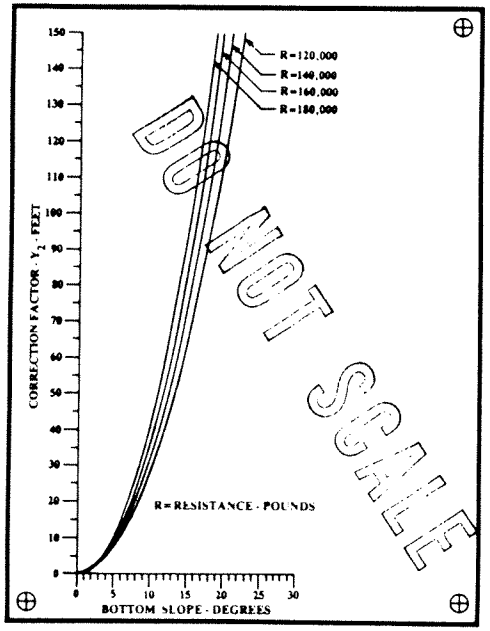
BOTTOM SLOPE NOMOGRAPH

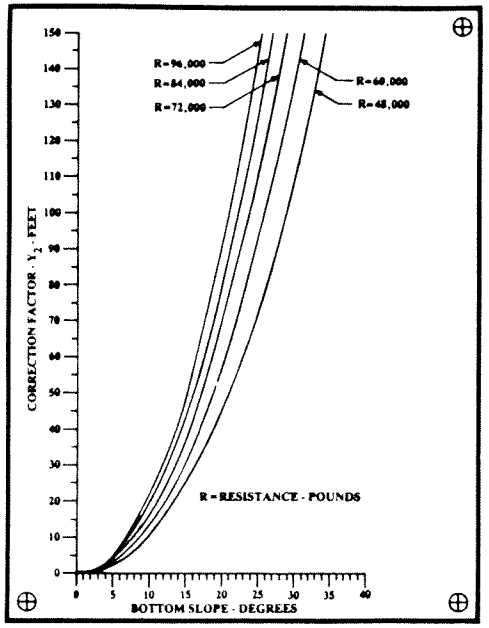


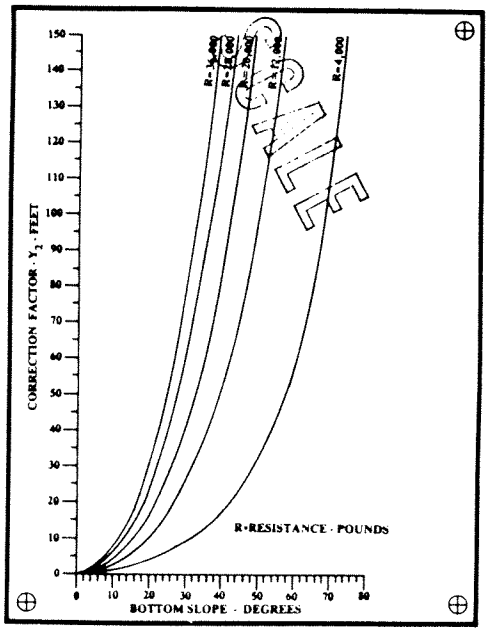
AFS-1, CLASS CORRECTION FACTOR CURVES

- NOTE -
DO NOT SCALE not to be included on the finished copy

DO NOT SCALE

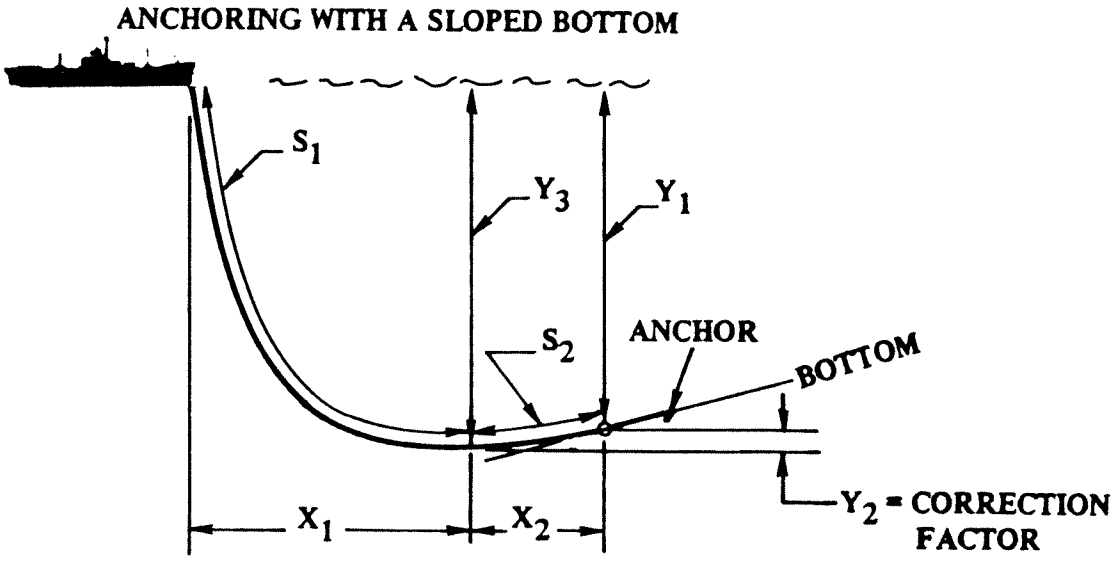




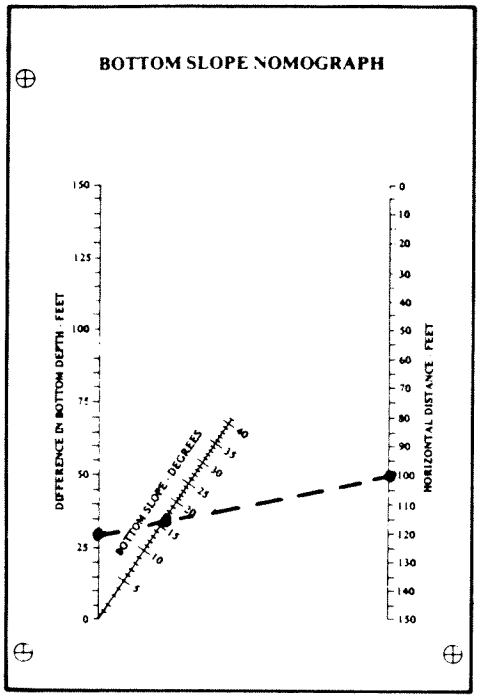


BOTTOM SLOPE CORRECTION FACTOR

1. THE ILLUSTRATION BELOW REPRESENTS THE WORST CASE WHEN ANCHORING ON A SLOPED BOTTOM AND SHOWS THAT A CORRECTION FACTOR MUST BE APPLIED TO THE PREVIOUS TWO NOMOGRAPHS TO OBTAIN THE CORRECT AMOUNT OF CHAIN AND DISTANCE FROM THE SHIP TO THE ANCHOR.



2. TO DETERMINE THE BOTTOM SLOPE ON A CHART OF THE ANCHORAGE MEASURE OFF A CONVENIENT HORIZONTAL DISTANCE FROM THE DESIRED ANCHOR DROP POINT. THE HORIZONTAL DISTANCE SHOULD BE IN THE DIRECTION OF THE DOWNWARD SLOPE. CALCULATE THE DIFFERENCE IN DEPTHS OVER THIS HORIZONTAL DISTANCE. ON THE BOTTOM SLOPE NOMOGRAPH DRAW A STRAIGHT LINE BETWEEN THE VALUES FOR "HORIZONTAL DISTANCE" AND "DIFFERENCE IN BOTTOM DEPTH" ON THEIR RESPECTIVE SCALES. THE INTERSECTION OF THIS STRAIGHT LINE WITH THE "BOTTOM SLOPE" SCALE GIVES THE ANGLE OF THE BOTTOM SLOPE IN DEGREES. IF THE LINE DOES NOT INTERSECT THE "BOTTOM SLOPE" SCALE, THE BOTTOM SLOPE IS TOO SEVERE FOR SAFE ANCHORING.

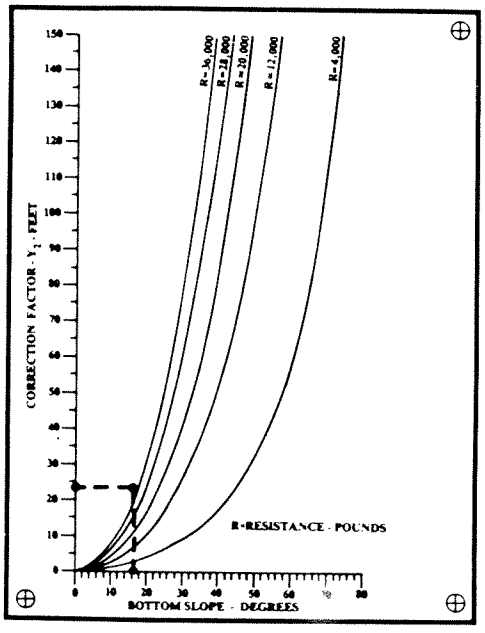


EXAMPLE:

GIVEN: 30 FEET - DIFFERENCE IN BOTTOM DEPTH
100 FEET - HORIZONTAL DISTANCE

THEN: BOTTOM SLOPE = 16.5 DEGREES

3. USING THE BOTTOM SLOPE ANGLE AND THE SHIP'S RESISTANCE VALUE FIND THE "CORRECTION FACTOR (Y_2)" ON THE CORRECTION FACTOR CURVES. IT MAY BE NECESSARY TO INTERPOLATE.

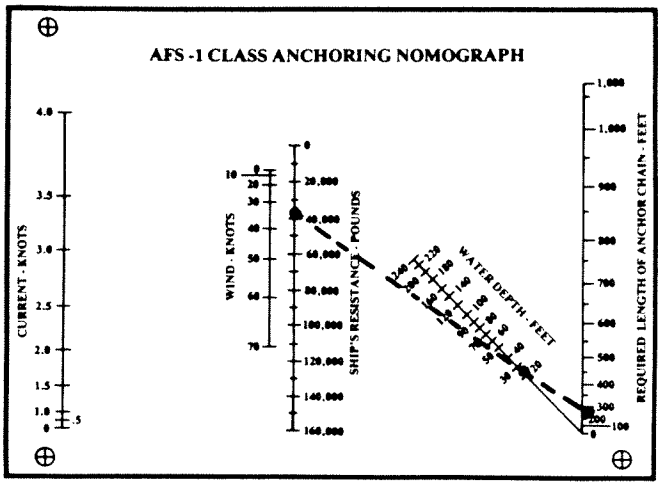


EXAMPLE:

GIVEN: 16.5 DEGREES - BOTTOM SLOPE
38,000 POUNDS - SHIP'S RESISTANCE

THEN: CORRECTION FACTOR (Y_2) = 24 FEET

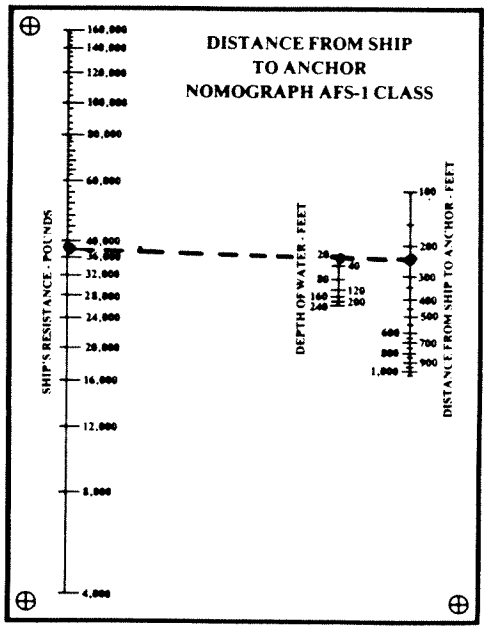
4. FIND THE VALUES FOR S_2 AND X_2 (SEE ILLUSTRATION) USING Y_2 AS THE "DEPTH OF WATER" AND THE "SHIP'S RESISTANCE" ON THE ANCHORING NOMOGRAPH AND THE DISTANCE FROM SHIP TO ANCHOR NOMOGRAPH.



EXAMPLE:

GIVEN: 38,000 POUNDS-SHIP'S RESISTANCE
24 FEET-DEPTH OF WATER

THEN: REQUIRED LENGTH OF ANCHOR CHAIN = 250 FEET



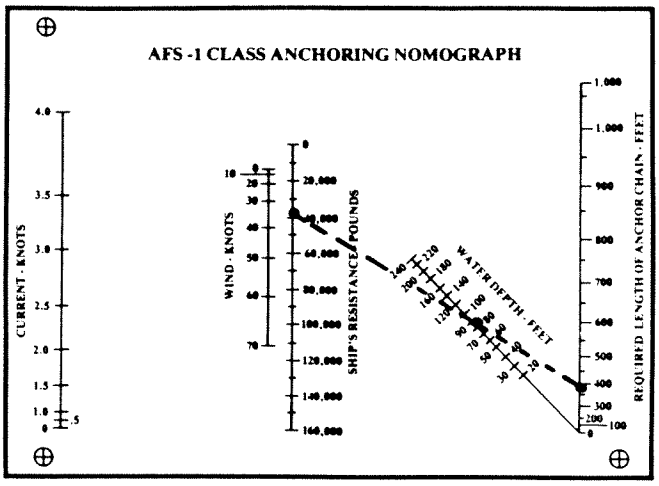
EXAMPLE:

GIVEN: 38,000 POUNDS - SHIP'S RESISTANCE
24 FEET - DEPTH OF WATER

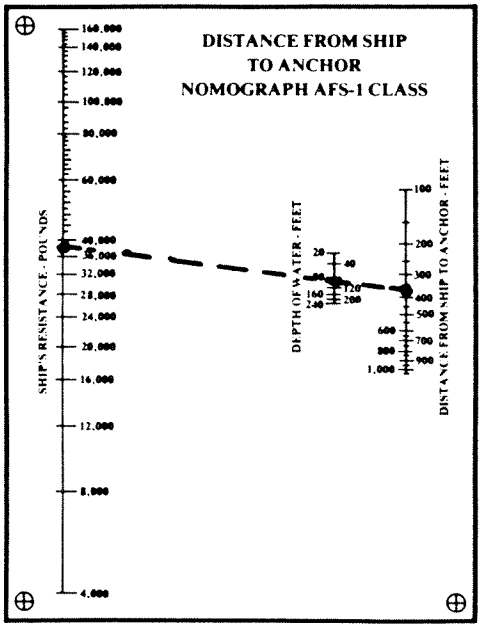
THEN: DISTANCE FROM SHIP TO ANCHOR = 240 FEET

5. ADD Y_2 TO THE DEPTH AT ANCHORAGE Y_1 TO GET Y_3 (SEE ILLUSTRATION).

6. FIND THE VALUES FOR S_1 AND X_1 USING Y_3 AS THE "DEPTH OF WATER" AND THE "SHIP'S RESISTANCE " ON THE ANCHORING NOMOGRAPH AND THE DISTANCE FROM SHIP TO ANCHOR NOMOGRAPH.



EXAMPLE:
GIVEN:
38,000 POUNDS-SHIP'S RESISTANCE
84 FEET (60 + 24)-DEPTH OF WATER
THEN:
REQUIRED LENGTH OF ANCHOR CHAIN = 380 FEET



EXAMPLE:
GIVEN: 38,000 POUNDS-SHIP'S RESISTANCE
84 FEET (60 + 24)-DEPTH OF WATER
THEN: DISTANCE FROM SHIP TO ANCHOR = 360 FEET

7. THE TOTAL LENGTH OF CHAIN REQUIRED IS S_1 PLUS S_2. THE TOTAL DISTANCE FROM SHIP TO ANCHOR IS X_1 PLUS X_2.

EXAMPLE

TOTAL REQUIRED LENGTH OF ANCHOR CHAIN = 630 FEET (380 + 250)

TOTAL DISTANCE FROM SHIP TO ANCHOR = 600 FEET (360 + 240)

8. THIS IS FOR THE WORST CASE WHEN THE SHIP WOULD SWING FULL CIRCLE. IF THE SHIP BOW DOES NOT SWING FULL CIRCLE AND THE ANCHOR SHANK POINTS UP SLOPE THEN S_2 AND X_2 ARE SUBTRACTED FROM S_1 AND X_1 FOR THEIR RESPECTIVE TOTAL VALUES.