such hatches to be flooded full or flood-
ed to the level having the most detri-
mental effect on stability when free
surface effects are considered.

(c) In lieu of meeting the require-
ments of paragraph (a) of this section,
a vessel may comply with the provi-
sions of § 170.173(c) of this chapter,
provided that righting arms are positive
to an angle of heel of not less than 50°
(0.87 radians).

(d) For the purpose of paragraphs (a)
and (c) of this section, at each angle of
heel a vessel’s righting arm must be
calculated assuming the vessel is per-
mitted to trim free until the trimming
moment is zero.

§ 28.575 Severe wind and roll.

(a) Each vessel must meet paragraphs
(f) and (g) of this section when sub-
jected to the gust wind heeling arm
and the angle of roll to windward as
specified in this section.

(b) The gust wind heeling arm, \( L_{gw} \)
in figure 28.575 of this chapter, must be
calculated by the following formula:

\[
KE_n \left( \sum V_n^2 A_n Z_n^2 \right)/W
\]

where:

\( K=0.00216 \) when consistent English units are
used or 1.113 when consistent metric
units are used.

\( E_n \)=series summation notation where \( n \) var-
ies from 1 to the number of elements in
the series;

\( V_n^2=0.124 \ln(0.3048 h_n)+0.772 \), in feet per sec-
don (0.127 \ln(h_n)+0.772 \), in meters per
second and is the wind speed for profile
element \( n \) on a vessel;

\( S=64 \) (19.5, if metric units are used) for a
vessel that operates on protected waters;

\( 85.3 \) (26, if metric units are used) for a
vessel that operates on waters other than
protected waters;

\( \ln=\)natural logarithm;

\( h_n=\)the vertical distance from the centroid of
area \( A_n \) to the waterline for profile ele-
ment \( n \), in feet (square meters);

\( A_n=\)projected lateral area for profile element
\( n \), in square feet (square meters);

\( Z_n=\)the vertical distance between the cen-
troid of \( A_n \) and a point at the center of
the underwater lateral area or a point at
approximately one-half of the draft, for
profile element \( n \), in feet; and

\( W=\)displacement of the loaded vessel, in
pounds (Newtons).

(c) The angle of roll to windward, \( A_1 \),
is measured from the equilibrium
angle, \( A_{el} \), and is calculated by the fol-
lowing formula:

\[
A_1=109kXY\sqrt{rs}, \text{ in degrees,}
\]

where:

\( s,X,Y=\)factors from table 28.575;

\( r=0.73+0.6 Z_g/d; \)

\( Z_g=\)distance between the center of gravity
and the waterline (+ above, − below), in
feet (meters);

\( k=1.0 \) for round bilged vessels with no bilge
keels or bar keels; 0.7 for vessels with
sharp bilges, or the value from table
28.575 for vessels with a bar keel, bilge
keels, or both;

\( B=\)molded breadth of the vessel, in feet (me-
ters);

\( d=\)mean molded draft of the vessel, in feet
(meters);

\( C_b=\)block coefficient;

\( A_k=\)aggregate area of bilge keels, the area of
the lateral projection of a bar keel, or
the sum of these areas, in square feet
(square meters);

\( L=\)length, in feet (meters);

\( T=1.108 BC/square root of GM, in seconds; 2.0
BC/square root of GM, if metric units are
used;

\( GM=\)metacentric height corrected for free
surface effects, as explained in § 28.540, in
feet (meters);

\( C=0.373+0.023(B/d)+0.000131L \) or

\( 0.373+0.023(B/D)+0.00043L, \) if metric units are used.

(d) The angle of equilibrium, \( A_{el} \), in
figure 28.575, is calculated by deter-
mining the lowest angle at which the
gust wind heeling arm, \( L_{gw} \), is equal to
the righting arm.

(e) The area “b” in figure 28.575 must
be measured to the least of the fol-
lowing:

(1) The angle of downflooding, \( A_{af} \);

(2) The angle of the second intercept,
\( A_{e2} \), in figure 28.575, of the wind heeling
arm curve, \( L_{gw} \), in figure 28.575, and the
righting arm curve;

(3) \( 50° \) (0.87 radians).

(f) The angle of equilibrium, \( A_{el} \), in
figure 28.575, must not exceed \( 14° \) (0.24
radians).

(g) Area “b” in figure 28.575 must not be
less than area “a” in figure 28.575.

| Table 28.575—Roll Factors |
|---|---|
| B/d | X |
| 2.4 | 1.0 |
| 2.5 | 0.98 |
| 2.6 | 0.96 |
| 2.7 | 0.95 |
| 2.8 | 0.93 |
| 2.9 | 0.91 |
| 3.0 | 0.90 |
| 3.1 | 0.88 |
| 3.2 | 0.86 |
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TABLES 28.575—ROLL FACTORS—Continued

<table>
<thead>
<tr>
<th>B/d</th>
<th>X</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.3</td>
<td>0.84</td>
</tr>
<tr>
<td>3.4</td>
<td>0.82</td>
</tr>
<tr>
<td>3.5</td>
<td>0.80</td>
</tr>
</tbody>
</table>

Note. Intermediate values must be obtained by interpolation.

<table>
<thead>
<tr>
<th>C,</th>
<th>Y</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.45</td>
<td>0.75</td>
</tr>
<tr>
<td>0.50</td>
<td>0.82</td>
</tr>
<tr>
<td>0.55</td>
<td>0.89</td>
</tr>
<tr>
<td>0.93</td>
<td>0.97</td>
</tr>
<tr>
<td>0.70</td>
<td>1.0</td>
</tr>
</tbody>
</table>

Note. Intermediate values must be obtained by interpolation.

<table>
<thead>
<tr>
<th>100A_0/(LB)</th>
<th>k</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1.0</td>
</tr>
</tbody>
</table>

Note. Intermediate values must be obtained by interpolation.

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<table>
<thead>
<tr>
<th>100A_i/(LB)</th>
<th>k</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0</td>
<td>0.98</td>
</tr>
<tr>
<td>1.5</td>
<td>0.95</td>
</tr>
<tr>
<td>2.0</td>
<td>0.88</td>
</tr>
<tr>
<td>2.5</td>
<td>0.79</td>
</tr>
<tr>
<td>3.0</td>
<td>0.74</td>
</tr>
<tr>
<td>3.5</td>
<td>0.72</td>
</tr>
<tr>
<td>4.0</td>
<td>0.70</td>
</tr>
</tbody>
</table>

Note. Intermediate values must be obtained by interpolation.

<table>
<thead>
<tr>
<th>T</th>
<th>S</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>0.100</td>
</tr>
<tr>
<td>7</td>
<td>0.098</td>
</tr>
<tr>
<td>8</td>
<td>0.093</td>
</tr>
<tr>
<td>12</td>
<td>0.065</td>
</tr>
<tr>
<td>14</td>
<td>0.053</td>
</tr>
<tr>
<td>16</td>
<td>0.044</td>
</tr>
<tr>
<td>18</td>
<td>0.038</td>
</tr>
<tr>
<td>20</td>
<td>0.035</td>
</tr>
</tbody>
</table>

Note. Intermediate values must be obtained by interpolation.


§ 28.580 Unintentional flooding.

(a) Applicability. Except for an open boat that operates on protected waters and as provided by paragraph (i) of this section, each vessel built on or after September 15, 1991 must comply with the requirements of this section.