Deterministic framework for damage stability

Mr Georgios Vavourakis
Damage stability

**DAMAGE**: Collision / Grounding / Explosion / Fire

Watertight subdivision:

Transverse / Longitudinal / Horizontal watertight bulkheads and their combinations

- Restriction of floodable areas
- Avoid sinking due to progressive flooding or capsize due to lack of stability
- Satisfaction of conventional buoyancy and stability requirements

**BUOYANCY**:

Ship's ability to compensate weight $W$ through the hydrostatic pressure acting on the hull surface (buoyancy $B$). To balance the ship, $W$ and $B$ should act in the same vertical. When this line lies in the longitudinal plane, the ship is balanced without listing.

**HYDROSTATIC STABILITY**:

Vessel’s ability to return to an equilibrium state, preferably vertical, when it’s disturbed (positive GM).
Stability standards

GM=KB+BM-KG >0.0 (in meters)

- GM: Metacentric height (m), it is also referred as initial stability
- KB : Vertical centre of Buoyancy
- BM: Metacentre Radius

\[ BM = \frac{I}{V} \]
Damage consequences

- Draft increase (reduction of freeboard)
- Change of trim
- Vessel is listing:
  - unbalanced damage condition
  - Symmetrical damage condition with negative GM0.
- Stability Variation: Reduce GM = KM - KG
  - KM: Decrease
  - KB: Small increase
  - BM: Significant decrease due to Inertia reduction, loss of waterline plane.

Small GM & small freeboard (intact condition) => extensively flooded compartments => high probability of sinking or capsizing after damage.
✓ The question to survivability standards of a ship following damage was considered towards the end of the 19\textsuperscript{th} century by several Select committees of the House of Commons. In 1890, the first Committee on watertight subdivision recommended that passenger vessels over 425ft (129.5 m) in length should be capable of floating with any two adjacent compartments open to the sea.

✓ 1890 Committee also recommended one compartment standard for cargo ships but this was not implemented due to lack of support.
No damage stability requirements – only demands for floodable length curves. The basis of the principles of subdivision standard (floodable length curves, permeabilities, criterion numeral, 1-, 2- and 3-compartment ships etc.)

Already in SOLAS 1914: never ratified due to WWI

- The degree of subdivision (permissible compartment length and number of compartments for survival) shall depend on the length of the ship and the number of passengers – a principle still in use.

The major thrust of the 1929 Convention was directed towards passenger ships—actually new passenger ships (date of keel being on or after 01/07/1931) or a ship which has converted to passenger ship date on or after that date. All other passenger ships were classed as existing and were generally exempt from the effect of the regulations.

This was the first application of the so-called “grandfather clause” meaning that the applicable regulations according to which a ship was built were maintained to the day the ship was scrapped without significant modifications.
✓ Damage length was defined as 3% of the ship’s length plus 3.05 m (10 feet). The damage should have an unlimited vertical extent from the tank top and a positive GM value should be obtained for symmetrical damage cases. A negative GM could be permitted if the heeling angle would not be greater than 7 degrees.

✓ For unsymmetrical cases the heeling angle should also be less than 7 degrees – exceptionally 15 degrees could be permitted by the Administration after careful consideration.

✓ The margin line (76 mm below the upper side of the bulkhead deck) concept was introduced so that the margin line should not be immersed in final damaged condition. Should the margin line be immersed during intermediate stages of flooding the Administration could ask for further special investigations. Cross-flooding arrangements should be separately approved by the Administration.
27 May 1965

Identical in many aspects to SOLAS 48 Convention

Minor changes were introduced:

• Vertical extent was unlimited vertically form the baseline of the ship (i.e. from the keel plate)

• GM value of at least 0.05 m for symmetrical damage cases should be obtained. (quantitatively specific standards of residual stability after damage have been introduced for the first time)

• The time for equalisation through cross-flooding arrangements should not exceed 15 minutes
25 May 1980

IMO Resolution A265 (the probabilistic subdivision standard) was introduced as an equivalent subdivision standard to the deterministic probability standard.
After a series of accidents, current regulations shown deficiencies in:

1. Due to shipbuilding development since 1913, when introduced to calculate the coefficient subdivision (reduction of old large spaces engine and boiler rooms, about 1/3), the value of F (and hence the distance between transverse bulkheads) showed greater than that should apply.

2. The longitudinal damage extent is a random variable for a given compartmentation, the damage area may be completely different.

3. Size effect, permeability and different operating draughts were not taken properly into account.

**Equivalent regulations:** probability calculus method for quantitative ship survivability assessment after damage. Calculation of the probability of ship survival after damage (Achieved subdivision index A), which must be greater than a certain value (required subdivision index R).
SOLAS 80

• Different countries introduced enhanced stability criteria for passenger ships in damaged condition, for which reason these criteria were unofficially called SOLAS 80 or STAB 80.

• The first set of damage criteria where demands for residual stability are introduced.
<table>
<thead>
<tr>
<th>Supplement No 2 to 1928 Instructions and 1949 Instructions (Para 69(8) (c))</th>
<th>SYMMETRICAL FLOODING</th>
<th>ASYMMETRICAL FLOODING</th>
<th>The stability calculation to be “considered on its merits”</th>
</tr>
</thead>
<tbody>
<tr>
<td>1948 Convention Reg 7(e) &amp; (f)</td>
<td>If angle of heel &gt; 7° arrangements required to expeditiously reduce to less than 7°</td>
<td>If angle after arrangements does not submerge margin line - acceptable - otherwise further mods required</td>
<td></td>
</tr>
<tr>
<td>1952 (Construction) Rules Rule 8 and Sch 3</td>
<td>Final stage - residual GM +ve; may be -ve if heel less than 7°</td>
<td>Margin line not to be submerged in final stage</td>
<td></td>
</tr>
<tr>
<td>1960 Convention Reg 7(b) (iii), (e) and (f)</td>
<td>Positive residual GM of at least 50mm at final stage</td>
<td>Do - and ensure that maximum angle of heel during flooding will not endanger safety of ship</td>
<td>No</td>
</tr>
<tr>
<td>1965 (PSC) Rules 1965 Rule 9 and Sch 3</td>
<td>Do</td>
<td>Do</td>
<td>Do - Plus range of stability in damage condition if doubtful may be investigated to satisfaction of administration</td>
</tr>
<tr>
<td>1974 Convention</td>
<td>Do</td>
<td>Do</td>
<td>As 1952 Rules</td>
</tr>
<tr>
<td>1980 (PSC) Regs</td>
<td>Do</td>
<td>Do</td>
<td>As 1960 Convention</td>
</tr>
<tr>
<td>1984 (PSC &amp; S) Regs</td>
<td>Do</td>
<td>As 1980 Regs</td>
<td>As 1980 Regs</td>
</tr>
</tbody>
</table>
### Rule Development of Damage Stability

<table>
<thead>
<tr>
<th>Year</th>
<th>Convention</th>
<th>Longitudinal</th>
<th>Transverse</th>
<th>Vertical</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>1914</td>
<td>Art IX (6)</td>
<td>Spacing of BHD recesses 3.05m + 0.02L</td>
<td>BHD Recess - sufficient distance from ship's side</td>
<td>No mention</td>
<td>NIL</td>
</tr>
<tr>
<td>1928</td>
<td>Instructions paras' 78 and 79</td>
<td>3.05m + 0.02L</td>
<td>B/5 measured inboard from ship's side at deepest sub-division loadline</td>
<td>No mention</td>
<td>NIL</td>
</tr>
<tr>
<td>1929</td>
<td>Convention Reg's V(3) &amp; V(7)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1942</td>
<td>Instructions Paras 69(3) &amp; 69(7)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1948</td>
<td>Convention Regn 7(d), 1952 MS (Construction) Sch 3 para 1(c), 1956 Instructions</td>
<td>3.05m + 0.03L or 10.67m whichever is less</td>
<td>Do</td>
<td>From top of double bottom up to margin line</td>
<td>Any lesser extent which would result in a more severe condition</td>
</tr>
<tr>
<td>1960</td>
<td>Convention Regn 7(d)</td>
<td>Do</td>
<td>Do</td>
<td>From base line upwards without limit</td>
<td>Do</td>
</tr>
<tr>
<td>1960</td>
<td>Convention 1965 MS (Passenger Ship Construction) Rules</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1974</td>
<td>Convention</td>
<td>Do</td>
<td>Do</td>
<td>Do</td>
<td>Do</td>
</tr>
</tbody>
</table>

1. **Longitudinal extent of damage is assumed:**
   1. Clear of main WT bulkheads if FOS>0.5
   2. To include one WT BHD if FOS between 0.33 and 0.5
   3. To include two main WT BHDS if FOS<0.33

2. **1914 Convention not implemented**

3. **1929 Convention** - extent of damage assumed was based on minimum spacing of bulkheads and recesses.

4. **1948 Convention** increased longitudinal extent of damage and introduced vertical extent.

5. **1960 Convention** increased vertical extent of damage and acknowledged other lesser damages which could result in worse damage conditions.

6. **1960 Convention** although accepting that side damage on small ships would be more severe than on big ships, and that a higher transverse requirement would lead to congestion of fittings and to larger angles of heel under some conditions - decided on reflection to make no change in the B/5 extent of damage.
## Assumptions on the extent of damage (UK criteria)

<table>
<thead>
<tr>
<th>Reference</th>
<th>Longitudinal</th>
<th>Transverse</th>
<th>Vertical</th>
<th>Other</th>
<th>Comments</th>
</tr>
</thead>
</table>
| 1914 Convention Art IX (6) | Spacing of BHD recesses 3.05m + 0.02L | BHD Recess - sufficient distance from ship's side | No mention | NIL | 1. Longitudinal extent of damage is assumed:  
.1 clear of main WT bulkheads if FOS > 0.5  
.2 to include one WT BHD if FOS between 0.33 and 0.5  
.3 to include two main WT BHDs if FOS < 0.33 |
| 1929 Convention Regulations V(3) & V(7) 1942 Instructions Paragraphs 69(3) & 69(9) | 3.05m + 0.02L | B/5-measured inboard from ship's side at deepest subdivision load line | No mention | NIL | 2. 1914 Convention not implemented |
| 1948 Convention Régulation 7(d), 1952 MS Construction Schedule 3 paragraph 1(c), 1956 Instructions | 3.05m + 0.03L or 10.87m whichever is less | Ditto | From top of double bottom up to margin line | Any lesser extent, which would result in a more severe condition | 3. 1929 Convention - extent of damage assumed was based on minimum spacing of bulkheads and recesses. |
| 1960 Convention Regulation 7(d) 1965 MS, PSC | Ditto | Ditto | From base line upwards without limit | Ditto | 4. 1948 Convention increased longitudinal extent of damage and introduced vertical extent. |
| 1974 Convention 1980 MS, PSC Rules 1984 MS, PSC Rules | Ditto | Ditto | Ditto | Ditto | 5. 1960 Convention increased vertical extent of damage and acknowledged other lesser damages, which could result in worse damage conditions. |
|                     |              |            |          |       | 6. 1960 Convention: although accepting that side damage on small ships would be more severe than on big ships and that a higher transverse requirement would lead to congestion of fittings and to larger angles of heel under some conditions, decided on reflection to make no change in the B/5 extent. |
SOLAS 90

✓ Herald of free Enterprise (7 March 1987)
✓ Resulted in different new safety measures for passenger ships
✓ Amendments to Chapter II-1 of the SOLAS Convention
First amendments of 21 April 1988 came into force in 22 October 1988:

• Requirement of installation of indicators for all vehicle loading doors to prevent water ingress through the doors

Other amendments of 28 October 1988 came into force in 29 April 1990:

• Demands for enhanced residual stability criteria in damaged condition. These criteria apply to passenger ships built after 29 April 1990. An allowance for factors such as passenger crowding to one side, wind pressure and launching of survival craft was also included in these criteria in the determination of minimum allowable GZ in damaged condition.

Amendments of 11 April 1989 came into force in 1 February 1992:

• Requirement for fast-closing sliding doors in all the watertight bulkheads on passenger ships. These doors must be controlled from the bridge and must be kept closed at sea, except in exceptional circumstances.
SOLAS 90 requires the following in the final condition after damage:

- A minimum range of 15 degrees beyond the angle of equilibrium which should not exceed 12 degrees for two-compartment flooding and 7 degrees for one compartment flooding.

- A minimum area of 0.015 m.rad under the residual GZ curve.

- A minimum residual GM of 0.05m with a maximum GZ of at least 0.10m, increased as necessary to meet certain stipulated heeling moments due to wind heeling, passenger crowding and lifeboat launching.

- Passenger ships, including Ro-Ro Passenger vessels constructed on or after 29 April 1990 should comply with SOLAS 90 standards.
SOLAS 90

Heel < 12° (2 Comp.) or 7° (1 Comp.)

Range > 15°

GM > 0.05 m

GZ > 0.10 m

Area > 0.015 rad·m

Progressive flooding

Heeling angle (degrees)
SOLAS 90

Fig 3.3 Changes in residual stability standards for damaged vessels of ships [36]
Amendments adopted on 10 April 1992

Main objective of these demands was that existing Ro-Ro passenger ships should be upgraded to the so-called SOLAS 92 standard opening on the ships survivability index, the A/Amax ratio, which should be calculated on the basis of some principles from IMO Resolution A265. The calculations should be carried out according to MSC Circular 574 (3 June 1991):

“The calculation procedure to assess the survivability characteristics of existing Ro-Ro passenger ships when using a simplified method based upon resolution A.265(VIII).”
SOLAS 92

Ships should be upgraded to the new SOLAS 92 standard, which was slightly modified version of the SOLAS 90 standard.

SOLAS 1992 Amendments also stated that Administration may allow

• Reduction of the minimum range of the residual righting lever Curve defined in Paragraph 2.3.1.

\[
\frac{15}{Range}
\]

• Range may be reduced to minimum of 10 degrees, in case where the area under the righting lever curve is increased by the ratio:

• Calculation of the residual righting lever (GZ) referred to in paragraph 2.3.3 by the following formula provided that in no case GZ will be less than 0.09 m.

\[
GZ = \frac{HeelingMoment}{Displacement}
\]
SOLAS 92

- Reduction of the range residual righting level curve

<table>
<thead>
<tr>
<th>Degree of compliance</th>
<th>Compliance</th>
</tr>
</thead>
<tbody>
<tr>
<td>$A/\text{Amax} &lt; 70%$</td>
<td>1 October 1994</td>
</tr>
<tr>
<td>$70% = &lt; A/\text{Amax} &lt; 75%$</td>
<td>1 October 1996</td>
</tr>
<tr>
<td>$75% = &lt; A/\text{Amax} &lt; 85%$</td>
<td>1 October 1998</td>
</tr>
<tr>
<td>$85% = &lt; A/\text{Amax} &lt; 90%$</td>
<td>1 October 2000</td>
</tr>
<tr>
<td>$90% = &lt; A/\text{Amax} &lt; 95%$</td>
<td>1 October 2005</td>
</tr>
</tbody>
</table>
SOLAS 95

The Tragic accident to Estonia on 28 September 1994 led to the new stability requirements. Following the accident, considering the urgency of the situation and the public outcry for an immediate solution of the problem with the existing ships, the IMO set up a panel of experts to consider the issues carefully and make suitable recommendations.

Following the work carried out by the IMO panel of experts recommended SOLAS ’90 as the new global standard for all existing ferries with dates of compliance ranging from 1 October 1998 to 1 October 2010 depending on a combination of the vessel’s A/Amax value, the number of persons carried and age. In November 1995 SOLAS 90 standards were accepted as new global standards for existing vessels.
Diplomatic Conference in London (20-29 November 1995), many amendments were decided

• A significant improvement in damage stability standards for all existing ferries. A new regulation requires all existing passenger ferries to comply fully with the SOLAS 90 standard, in accordance with a phase-in programme extending from 1 October 1998 for ships with A/Amax less than 85% to 1 October 2005 for those meeting 97.5%.

• A special phase-out schedule was introduced for ships with more than 400 passengers, so that they must comply with a 2-compartment standard according to a phase-out programme extending from 1 October 1998 (A/Amax<85%) to 1 October 2010 (A/Amax>97.5%).
### Time table for existing ferries to comply with SOLAS 90 standards as accepted at SOLAS 95

1 compartment vessels

<table>
<thead>
<tr>
<th>A/Amx</th>
<th>Date of Compliance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than 85%</td>
<td>1 October 1998</td>
</tr>
<tr>
<td>Less than 90%</td>
<td>1 October 2000</td>
</tr>
<tr>
<td>Less than 95%</td>
<td>1 October 2002</td>
</tr>
<tr>
<td>Less than 97.5%</td>
<td>1 October 2004</td>
</tr>
<tr>
<td>More than 97.5%</td>
<td>1 October 2010</td>
</tr>
</tbody>
</table>

### Time table for existing ferries to comply with SOLAS 90 standards as accepted at SOLAS 95

1 compartment vessels

<table>
<thead>
<tr>
<th>No of Persons</th>
<th>Date of Compliance</th>
</tr>
</thead>
<tbody>
<tr>
<td>1500 or more</td>
<td>2002</td>
</tr>
<tr>
<td>1000&lt;No of Pass&gt;1500</td>
<td>1 October 2006</td>
</tr>
<tr>
<td>600&lt;No of Pass&gt;1000</td>
<td>1 October 2008</td>
</tr>
<tr>
<td>400&lt;No of Pass&gt;600</td>
<td>1 October 2010</td>
</tr>
</tbody>
</table>

Age of the ship equal or greater than 20 years.
At the 1995 diplomatic conference a compromise was achieved by adopting a resolution permitting regional arrangements to be made as regards specific stability requirements, where the survivability requirement with 50 cm water on deck was the severest requirement.

Other amendments to the SOLAS Convention, which had an effect on car ferries from 1 July 1997, were as follows:

• Watertight doors acting as a vehicle loading/unloading ramp must not be subject to damage if the bow visor is damaged or detached

• Strengthening of the water-tightness requirements on the car deck (ventilation ducts, and no stairs directly form the car deck to compartments below (a vertical distance of at least 2.3 m from the car deck to the door sill leading to the spaces below the car deck)

• Regulations for escape routes for rapid and orderly movement of passengers (escape route analysis required as well as sufficient strength of hand rails)

• Requirement for fast rescue boats

• Requirements for helicopter landing area or pick-up area
The Stockholm Agreement –
The point of no return is reached when the ship has attained approximately the angle of heel $q_{\text{max}}$, at which the maximum of the GZ-curve occurs.

This angle, at a large majority of cases, is less than 10 degrees.
In the process of seeking a generalised damaged stability criterion, the following quantities describing the above scenario at the point of no return were considered:

✓ the elevation of water on deck above the sea level, \( h \), and

✓ the depth of the deck edge below sea level, \( f \), measured at the centre of damage at the inner shell of wing spaces, if any.
Exception from Stockholm Agreement:

Each flag may **exempt** from the application of the above requirements and accept proof, on the basis of this ship model tests carried out in accordance with the model test method, which demonstrates that the ship will not capsize the assumed extent of damage.
Analytical calculation of stability after damage

- Analytical calculation of all possible damage situations, taking into account the compartmentation of the ship.
- Theoretical damage extent (SOLAS):
  - Longitudinal: 3% L + 3 m
  - Transverse: B / 5
  - Vertical: From B.L. upwardly without restriction.
- Cases correspond to a lesser extent of damage are examined, when it may lead to critical damage conditions.
- Consideration of specific provisions and features that occur in each damage case (asymmetric flooding, permanent ballast, cross-connections, down-flooding etc.)
- Iterations to calculate the intermediate and final stage of flooding process
- Investigation of satisfaction of statutory buoyancy and stability criteria after damage.
- Reduction to the minimum required GM in intact condition (worst case scenario)
Deterministic analysis concept

- The deterministic concept is based on given damage assumptions (damage length, transverse extent, vertical extent).
- Depending on the ship type, number of passengers or potential risk to the environment by the cargo carried, compliance with a required compartment status is to be proved.
- In the case of passenger ships this can easily be achieved as only small differences of loading and a small range of draughts needs to be considered.
- In the case of tankers, the large variety of substances to be carried and their distribution in the ship require performance of an extensive, systematic analysis in order to get as many allowed loading conditions as possible.
- In general only these loading conditions are permitted. For this type vessel, experience has shown that a calculation of a limited number of representative loading conditions may be inadequate.
- In case an approved computer is available on board, using a verified damage stability calculation program, deviating loading conditions from the previously allowed ones are permitted, providing satisfaction of the damage stability criteria is ensured with the aid of this computer.
The scope of subdivision and damage stability analysis is determined by the required damage stability standard and aims at providing the ship's master with clear intact-stability requirements. In general, this is achieved by determining VCG-respective GM-limit curves, containing the admissible stability values for the draught range to be covered.

Within the scope of the analysis thus defined all potential or necessary damage conditions will be determined, taking into account the damage stability criteria, in order to obtain the required damage stability standard. Depending on the type and size of ship, this may involve a considerable amount of analyses.
Documents to be submitted

- principal dimensions
- lines plan, plotted or numerically
- hydrostatic data and cross curves of stability (incl. drawing of the buoyant hull)
- definition of sub-compartments with moulded volumes, centres of gravity and permeability
- layout plan for the sub-compartments with all internal and external opening points including their connected sub-compartments, and particulars used in measuring the spaces, such as general arrangement plan and tank plan
- lightship data
- load line draught
- co-ordinates of opening points with their level of tightness (e.g. weathertight, unprotected)
- watertight doors location with pressure calculation
- co-ordinates of margin line, respective deck contour
- side contour and wind profile
- cross- and down- flooding devices and the calculations thereof according to IMO Res. A.266 with information about diameter, valves, pipes length and coordinates of inlet/outlet
- pipes in damaged area when the destruction of these pipes results in progressive flooding
- damage extensions and definition of damage cases

Source: DNV-GL
Documents to be submitted

- Additionally a Watertight Integrity Plan is to be prepared showing the subdivision of the vessel. The drawing is to include the assumption for the damage stability calculation and is to be submitted at the earliest possible date together with the damage stability calculation. The drawing should contain the main- and local internal subdivision of the hull as well as information about arrangements of watertight longitudinal and transverse bulkheads, cargo hold entrances, air ventilation ducts, down- and cross-flooding ducts etc.

Source: DNV-GL
Deterministic calculations

Limit curve calculation:

- **Initial condition with:**
  - draught, trim, GM, respective displacement with centres of gravity
  - permanent solid or liquid ballast or min./max. quantities in tanks

- **Result list with:**
  - table with permissible VCG-respective GM values for the observed range of draughts

- **Results for each damage case:**
  - draught, trim, heel, GM in damaged condition
  - righting lever curve (incl. GZmax and range)
  - critical weathertight and unprotected openings with their angle of immersion
  - dimension of the damage and details of sub compartments with amount of in flooded water/lost buoyancy and out flooded liquids with their centres of gravity
Deterministic calculations

Calculation of distinctive loading conditions

• Loading condition with:
  • draught, trim, GM
  • displacement of the ship and solid cargo plus consumables with centres of gravity
  • liquid cargo with density, filling ratio and centres of gravity,
  • filled tanks with density, filling ratio and centres of gravity

• Results for each damage case:
  • draught, trim, heel, GM in damaged condition
  • righting lever curve (incl. GZmax and range)
  • critical weathertight and unprotected openings with their angle of immersion
  • dimension of the damage and details of sub compartments with amount of in flooded water/lost buoyancy and out flooded liquids with their centres of gravity

Special documents for passenger vessels

For passenger vessels for which the deterministic concept is applicable, the calculation of the floodable length curve acc. to SOLAS II-1, Reg. 4 to 7 is to be submitted including the factor of subdivision F and criterion numeral CS including intermediate results.

Source: DNV-GL
Regulations according to ship type:

Classification Societies Rules and Regulations: reference to subdivisions and stability after damage of special categories of ships:

- Chemical Tankers
- Liquefied Gas Carriers
- Passenger ships
- Offshore Supply Vessels

IMO CONVENTIONS, CODES AND RESOLUTIONS:

SOLAS (consolidated edition 1992) / Chapter II-1 / Part A, Reg. 1 to 3 and Part B, Reg. 4 to 25 or equivalent, IMO Res. A.265 (VIII), as amended by IMO Res. MSC.25 (60), apply to new and existing Ro/Pax ships.


MARPOL 73/78 / Annex I / Reg. 25 applies to tankers.
Regulations according to ship type:


International Code for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk (IGC Code) / Chapter II

IMO Res. A.453 (XII) / Section 3, applicable to Offshore Supply ships.

IMO Res. A.534 (13) / Chapter 2, applicable to specific types of ships.
✓ For the on-board documentation Damage Control Plans and Damage Control Booklets are to be prepared. These documents are intended to provide the ship's officer in charge with clear information on the ship's watertight compartmentation and equipment related to maintaining the boundaries and effectiveness of the compartmentation so that, in the event of damage to the ship, proper precautions can be taken to prevent progressive flooding through openings therein and effective action can be taken to quickly mitigate and, where possible, recover the ship's loss of stability.
Damage Control Plan

For passenger and dry cargo ships for which a damage stability calculation is to be performed a Damage Control Plan is to be prepared, containing the following information if applicable and partly beyond the requirements of MSC/Circ. 919:

✓ ship's name
✓ Shipyard and hull no.
✓ Class-register-no, Character of Classification and damage stability marking
✓ principal dimensions
✓ permissible number of persons to be carried
✓ subdivision index R
✓ main and local watertight subdivision
✓ numbering of compartments
✓ frame numbers and spacing
✓ penetration lines (e.g. B/5 or 760 mm-line) in each deck view
✓ simplified instructions in case of damage in order to prevent progressive flooding
✓ emergency exits
✓ watertight door location with control stations
✓ position of weathertight and unprotected opening points
✓ pipes in damaged area when the destruction of these pipes results in progressive flooding
✓ valves at bulkheads penetrations
✓ cross- and down flooding arrangement
✓ permanent solid or liquid ballast or min./max. quantities in tanks

For the sake of clarity, unnecessary details, such as accommodation details or decks not considered in the damage stability calculation, are to be deleted from the Damage Control Plan.
Damage Control Booklet

In addition to the aforementioned, booklets shall be made available according to MSC/Circ. 434 and MSC/Circ. 919 containing the following information:

✓ introduction and description of this manual
✓ principal dimensions and main data
✓ stability limiting values (VCG/GM limit curve)
✓ ship's watertight arrangement
✓ position of watertight doors and hatches with
✓ information about operational instructions
✓ position of all weathertight and unprotected openings
✓ piping arrangement incl. available pumps and
✓ valve arrangement
✓ cross- and downflooding arrangement
✓ summary of the damage stability calculation with description of the analysis concept and damage stability criteria
✓ information of the damage control locations
✓ position of sounding devices

For the sake of clarity, unnecessary details, such as accommodation details or decks not considered in the damage stability calculation, are to be deleted from the Damage Control Plan.
The main purpose of such a document is to stipulate appropriate action in case of damage. The chapter for damage control should include information such as:

- workflow of damage scenario
- closing of watertight and weathertight openings
- check of the extent of damage and sounding of compartments
- use of pumps
- use of loading computer
- liquid transfer operations
- information to external authorities and emergency response group

The booklet should be supplemented with copies of the general arrangement plan, tank capacity plan and piping diagram as well as information about used abbreviations and the definition of the co-ordinate system.
Thank You