

# SOME IMPORTANT NAVAL ARCHITECTURAL TERMS

February 2009

ITEM	EXPLANATION
A-, B- and C-class divisions	<p>SOLAS has tables for structural fire protection requirement of bulkheads and decks. The requirements depend on the spaces in question, and are different for passenger ships and cargo ships.</p> <p>A-0, A-15, A-30, A-60: Shall be constructed of steel or equivalent material, shall be constructed to prevent passage of smoke and flame for 1 h in Standard Fire Test, shall be insulated so that the average temperature of the unexposed side does not rise more than 140°C (any point no more than 180°C) above the original temperature within 0, 15, 30 or 60 minutes.</p> <p>B-0, B-15: Shall be constructed to prevent passage of flame for 0.5 h in Standard Fire Test, shall be insulated so that the average temperature of the unexposed side does not rise more than 140°C (any point no more than 225°C) above the original temperature within 0 or 15 minutes. Shall be constructed of approved non-combustible materials (However, combustible veneer may be used).</p> <p>C: Shall be constructed of approved non-combustible materials (However, combustible veneer may be used).</p>
Alternative Design, Alternative Arrangements	<p>Regulation allows for designs and arrangements which are not according to SOLAS requirements, providing an analysis is made that shows the proposed alternative design or arrangement is, with regards to safety, at the same or better level than the SOLAS requirement. Example of an alternative design are lifeboats with a higher than 150 person capacity.</p>
Attained Subdivision Index, "A"	<p>According to probabilistic damage stability rules the vessel's probability to survive a flooding damage (collision, grounding) is calculated with formula:</p> $A = \sum p_i s_i$ <p>where:</p> <ul style="list-style-type: none"> <li>i represents each compartment or group of compartments under consideration.</li> <li><math>p_i</math> is the probability that only the compartment or group of compartments under consideration may be flooded.</li> <li><math>s_i</math> is the probability of survivability after flooding of the compartment or group of compartments under consideration.</li> </ul> <p>The "A" is calculated for three different drafts and summarized with a weighted formula. If the "A" ≥ "R" (R=required subdivision index), the vessel fulfills the requirement. Typically the vessel's GM-limits for damage stability are adjusted so that "A"="R".</p>
Ballast Water Convention, Ballast Water Treatment, BWT	<p>New regulation requiring ballast water treatment systems on all ships (new and old), in order to avoid harmful organisms spreading from one location to another. Typically the treatment is by filtering and UV-light.</p>
B/5, Breadth divided by 5, B/5-line	<p>Imaginary line used in ship design and damage stability calculations: according to old rules, no damage extends inside the B/5-line (e.g. on a vessel with breadth of 32.2 m, maximum extent of any damage is 6.44 m from ship's shell). Due to this, bilge main lines, fuel tanks, etc. are normally located inside this B/5. New probabilistic rules have made this rule obsolete on new ships.</p>
Block Coefficient, $C_B$	<p>Important coefficient which describes the fullness of the hull: a lower coefficient means typically lower resistance. <math>C_B = \text{Displacement Volume} / (L \times B \times T)</math>. A typical figure for a cruise vessel is e.g. 0.65. Other often used coefficient is <math>C_M</math>, Midship Section Coefficient, which describes the fullness of Midship Section.</p>

Center of Gravity, Vertical Center of Gravity (VCG), Longitudinal Center of Gravity (LCG), KG	<p>Center of Gravity is used especially in connection with lightweight, deadweight and displacement. VCG is the vertical distance between center of gravity and keel, LCG is the longitudinal distance between center of gravity and frame #0. Lower VCG means more stability and LCG affects vessel's trim. Typical VCG figures for a Panamax cruise ship are, for example:</p> <table border="1" data-bbox="687 409 1102 517"> <thead> <tr> <th>Item</th> <th>Weight</th> <th>VCG</th> </tr> </thead> <tbody> <tr> <td>Lightweight</td> <td>39,000t</td> <td>17.8m</td> </tr> <tr> <td>Deadweight</td> <td>8,000t</td> <td>6.8m</td> </tr> <tr> <td>Displacement</td> <td>47,000t</td> <td>15.9m</td> </tr> </tbody> </table> <p>As this example shows, deadweight has a lower VCG than lightweight and thus reduces the VCG of displacement (and improves stability). The situation is kept like this by replacing used fuel with ballast water. KG is the same than VCG. See also GM.</p>	Item	Weight	VCG	Lightweight	39,000t	17.8m	Deadweight	8,000t	6.8m	Displacement	47,000t	15.9m
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CFD, Computation Fluid Dynamics	Calculation method or software which enables hydrodynamic optimization of hull form. Has lately enabled fast development of efficient hull forms. RANSE in connection with CFD denotes "Reynolds Averaged Navier Stokes Equation", and means simulation of the viscous flow. In future CFD calculations can likely replace model tests.												
COP, Coefficient of Performance	Describes the efficiency of AC-cooling compressors (chillers). For example, COP of 4.0 indicates that for a 4,000 kW cooling power, the chiller requires 1,000 kW of electric power.												
Damage Length	The length of damage used in damage stability calculations. For passenger ship the old (pre 2009) rules defined this length to be "3m + 3% of Lpp or 11 m, whichever is less". In new probabilistic rules the calculated damage lengths are based on probabilistic distribution, and the calculation can include much longer damages than was required in old rules.												
Damage Stability	The vessel's stability characteristics in damaged condition. Big cruise ships can float with several flooded watertight compartments. Old (pre 2009) rules required the ships to withstand a damage of any two adjacent watertight compartments, but in new regulations the calculation method and requirement is much more complex.												
Deadweight, DWT	Weight (and center of gravity) of vessel's cargo, stores, fuel, fresh water, passengers, crew, liquids in tanks, etc. Deadweight of a Panamax cruise vessel is typically around 8,000 t. See also lightweight and displacement.												
Design Draught, T <sub>DESIGN</sub>	The draft the vessel (and her deadweight, stability, performance, etc.) is designed for. On a Panamax cruise ship design draft is typically ca. 8.0 m. Generally more draft means better seakeeping capabilities, but less draft often means more stability. See also Scantling Draft.												
Displacement, Displacement weight	The weight (and center of gravity) of the vessel herself and vessel's cargo, stores, passengers, crew, etc. Displacement = Lightweight + Deadweight. Displacement of a Panamax (approximately 90,000 GT) cruise vessel is e.g. ca. 47,000 t. Displacement Force (symbol Δ) is Displacement Weight x g (g=9.81 m/s <sup>2</sup> ), and is the same as buoyancy.												
Displacement volume (∇)	The volume the vessel's hull displaces in water. In seawater with specific gravity of 1.025 kg/m <sup>3</sup> , the Displacement Volume for a vessel Displacement of 47,000t is 45,854 m <sup>3</sup> . Thus the vessel needs more Displacement Volume (and draft) in fresh water than in sea water for the same Displacement Weight.												
Ducktail	An extension to ship's stern. On older ships the diminished stability can be regained by adding a ducktail. Ducktail is also used on newbuildings; there the primary purpose is often to reduce the power consumption for propulsion.												
Froude Number, F <sub>n</sub>	Froude number describes the vessel's relative speed, which depends on vessel length: $F_n = \frac{v \left[ \frac{m}{s} \right]}{\sqrt{g \left[ \frac{m}{s^2} \right] \times L [m]}}$ where: v is vessel speed in [m/s] (1 knot ≈ 0.5 m/s) g is 9.81 m/s <sup>2</sup> L is vessel's waterline length												

	Generally a lower $F_n$ means lower resistance (for fast, small vessels the situation can be opposite). Typical figure for a Panamax cruise ship is $F_n=0.25$ .
Fuel Consumption	Using a typical engine specific fuel oil consumption of 200 g/kWh (when tolerances, heat value corrections, etc. are taken into account, the real heavy fuel oil consumption is seldom below this, and often even above this), this corresponds to a fuel consumption of 0.2 t/h per 1 MW. Thus, a ship using 30 MW for propulsion and hotel load, consumes 6t heavy fuel oil (HFO) per hour.
Free surface correction	The GM is corrected with "free surface correction": i.e. tanks with free surface reduce the stability of the vessel; this correction is e.g. -0.1 m. The more "free surfaces" (slack tanks, pools, splash areas) there is, the bigger the correction is, and thus more the GM reduces.
GM, (transverse) Metacentric Height	Describes the righting moment of the vessel: higher GM means better stability (condition for positive stability is that $GM>0$ ). Typical value for GM on a Panamax cruise vessel is ca. 2.0 m. $GM = KM - KG$ , where KG is the VCG of the ship (lightweight + deadweight) and KM is the distance from keel to the metacenter (see figure below). KM has to be higher than KG for a ship stay upright (and GM to stay positive). GM can also used for the longitudinal stability of the vessel: then symbol $GM_L$ is used.
Growth Margin	An additional margin added into vessel weight calculation to cover for later weight increases. Practically all ships get heavier when they age; this is due to conversions, modifications, painting, etc. and without preparing for this, the ship can later end up with stability problems, requiring a ducktail or a sponson.
GT (Gross Tonnage), (formerly GRT)	Gross Tonnage describes the volume and size of the vessel. GT includes all the enclosed spaces (not balconies, sun decks or similar areas). GT is calculated with a formula:  $GT = (0.2 + 0.02 \times \log_{10} V)V$ where V = vessel's calculated volume in $m^3$ .  Notes: <ul style="list-style-type: none"> <li>• Earlier 1 GRT was 100 <math>ft^3</math>, or 2.83 <math>m^3</math>; thus figures for e.g. "Titanic" cannot be directly compared with GT figures of today's vessels.</li> <li>• For example, if vessel's enclosed volume is 294 000 <math>m^3</math>, the GT is ca. 91,000.</li> <li>• GT is often the base for different port and other fees.</li> <li>• As GT is logarithmic, it cannot be used for accurate comparison between vessels of different size: for example, on a 10,000 GT ship one GT is 3.44 <math>m^3</math>, but on a 150,000 GT vessel one GT corresponds to 3.19 <math>m^3</math>.</li> </ul>
Heeling, Heeling angle	The angle vessel is leaning away from upright position.
Hotel Load	The electric power needed for other ship functions than propulsion, i.e. for AC, lighting, galleys, etc. For a Panamax vessel a typical hotel load is close to 10 MW.
Intact Stability	The vessel stability in intact (normal, non-damaged) condition. In intact conditions the vessel has to withstand heeling, wind, etc. to fulfill the criteria stated in rules.
KM, (transverse) Metacentric Height	KM is the distance from Keel to Metacenter, which depends on the vessel draft, displacement and hull form. Typical KM for a Panamax cruise vessel is 18 m. High KM means more stability, but often at the expense of speed and sea keeping capabilities. See figure below.
Lightweight, LWT	Vessel's "empty" weight (and center of gravity), i.e. weight of the vessel without fuel, stores, water, cargo, passengers, crew, etc. Needed liquid in ship system piping and system tanks is included, but not liquids in e.g. storage tanks.  Typical lightweight for a Panamax cruise ship is ca. 39,000 t. See also displacement and deadweight.
Longitudinal Center of Buoyancy (LCB)	Longitudinal Center is the longitudinal center of water the vessel's hull displaces. When the vessel floats, LCB and LCG are in same position. Position of LCB is very important for the hull resistance. Typically LCB is located slightly aft of midship (Lpp/2).
Main Dimensions	The vessel main dimension area:

	<p>L<sub>OA</sub>, Length overall: the vessel's absolute maximum length.</p> <p>L<sub>PP</sub>, Length between perpendiculars: the distance between rudder shaft (typical) and the point where bow stem enters water at design draft (typical). Basis for many calculations and coefficients.</p> <p>B, Breadth (moulded): The vessel breadth without the shell plating, i.e. the actual breadth of the vessel is slightly more.</p> <p>T, Draft (design): The planned design draft for the vessel.</p> <p>Other typically used dimensions include waterline length, air draft and scantling draft.</p>
Main Fire Zones (MFZ), Main Vertical Zones (MVZ), Main Fire Zone Bulkheads (MFZB)	<p>The vessel has to be divided into vertical fire zones: the basic rule is that maximum length of a fire zone is 40m, which can be in certain situations extended to 48m. Today's practice is to use 48m fire zones where ever possible. The maximum permissible area of one main fire zone on one deck is 1,600 m<sup>2</sup>. On some of today's newbuildings these areas are extended beyond the SOLAS maximums, often based on special cases, or on so called "Alternative Design Principles".</p> <p>Additional requirement is that the bulkheads between main fire zones should not have steps.</p>
Margin Line	<p>Imaginary line that is defined to be 3 inches (76mm) below bulkhead deck: in pre 2009 rules, in damaged condition the Margin Line may not submerge. With new probabilistic stability rules margin line has become obsolete.</p>
MCR, maximum continuous rating	<p>The rated or maximum continuous power of a diesel engine. In real life this power is never used: on diesel-electric ships 90% of MCR is a typical maximum and on a diesel mechanical ship the typical figure is 85% MCR.</p>
Net Tonnage (NT, formerly NRT)	<p>Describes vessel's "net" volume, i.e. is lower than GT. It is calculated with a more complicated formula than for GT: the formula takes into account the volume of cargo spaces, vessel draught and number of passengers. On a ca. 90,000 GT ship NT is typically ca. 54,000, i.e. ca. 60% of GT. Often basis for different port, passage etc. fees.</p>
Permeability	<p>Permeability is the ratio of maximum flooded water (in damaged condition) volume to the space volume. It is used in damage stability calculations. For example, the permeability of stores is 0.6, i.e. when a 100 m<sup>3</sup> store is flooded, 60 m<sup>3</sup> of water is assumed in damage stability calculations. For engine rooms the permeability is 0.85 and for tanks, voids and cofferdams 0.95.</p>
Probabilistic Damage Stability Rules	<p>New rules in force since 1.1.2009. In these the damage stability requirements are no longer based on simple rules, but on calculation methods where vessel's theoretical and simplified survival probability is calculated. See Attained and Required Subdivision Index.</p>
Propeller Pressure Pulses, Propeller Excitation Frequency	<p>Pressure pulses propeller generates in ship's hull (mainly due to the propeller blade passing near the vessel hull). The higher the pressure pulses are, the higher the probability for vibration problems. A good level for highest pressure pulses is lower than 1.5 kPa. More propeller blades (e.g. 5 instead of 4 - or use of pod propulsion - can reduce the pressure pulses).</p> <p>Still, even if the propeller pressure pulses are low, the natural frequency of vessel's structures needs to be designed to be above the propeller blade frequency. Typical blade frequency is, for example, 11 Hz (132 rpm x 5 blades).</p>
Pump power demand	<p>Electric power demand for a seawater pump can be roughly estimated with a formula:</p> $P_{el}[kW] = \frac{h[m] \times flow[\frac{m^3}{h}]}{228}$ <p>where: h is pump pressure head flow is pump capacity</p> <p>As an example, a seawater pump with 2.5 bar pressure head (25 m) and capacity of 100 m<sup>3</sup>/h, takes ca. 11 kW of electric power.</p>

Required Subdivision Index, "R"	<p>In probabilities damage stability rules, if the attained subdivision index "A" is greater or equal to required subdivision index "R", the vessel fulfills stability requirements. For passenger ships, the R is calculated as follows:</p> $R = 1 - \frac{5000}{L_s + 2.5 \times N + 15225}$ <p>where:</p> <ul style="list-style-type: none"> <li>L<sub>s</sub> is subdivision length in meters (simplified: the length of the watertight part of the hull).</li> <li>N=N<sub>1</sub>+2 x N<sub>2</sub></li> <li>N<sub>1</sub> = number of person who have lifeboat seats</li> <li>N<sub>2</sub> = number of persons without lifeboat seats</li> </ul> <p>The formula means, for example, the fewer passengers there are, the lower "R" is accepted. Also, increasing the lifeboat capacity from SOLAS minimum (lifeboats for 75% of total number of persons onboard on international voyages) will also reduce the "R".</p>
Resistance	Vessel's resistance against moving. This includes, e.g. friction resistance, wave making resistance and wind resistance. For estimating vessel's propulsion power demand these are measured in model tests before finalizing hull form and propulsion power.
Scantling draft (T <sub>SCANTLING</sub> )	The draft vessel structures are designed for (hull plating, tank bulkheads, etc.), i.e. the maximum structural draft for the vessel. Typically scantling draft is slightly more, or the same, than design draught. If stability requirements do not require otherwise, the scantling draft is the maximum draft to which the vessel can be loaded.
Safe Return to Port	New significant regulation (1 <sup>st</sup> July 2010). This requires (simplified) that a passenger vessel has to be able to return to nearest port, with required systems working, when: <ol style="list-style-type: none"> <li>a) any compartment is flooded; or</li> <li>b) any room is lost due to fire</li> </ol>
SECA, SO <sub>x</sub> Emission Control Area	Sea areas where there are stricter SO <sub>x</sub> limits than in other areas. Today, for example, North Sea, English Channel and Baltic Sea are SECAs and require use of low sulfur fuel (or scrubbing systems).
Service Speed	Speed the vessel is optimized for in normal operation, or capable to sustain in typical sea conditions. In connection with Service Speed a sea margin is defined, for example "service speed to be 22.5 knots with 15% sea margin". This means that the vessel has the power for 22.5 knots in trial conditions + 15% additional power for sea margin. Sea margin compensates for rough weather, hull fouling, etc.
Shaft Power, P <sub>s</sub>	The power available at vessel's propeller shaft. On a diesel-electric ship this is typically 0.92 x available diesel engine power due to losses in electric drive and shafting. On a diesel-mechanical ship there are less losses, i.e. shaft power is ca. 0.985 x available diesel engine power. See also MCR: available diesel power is less than MCR.
Sponson	An extension on ship side; this can be required if the vessel faces stability problems in her service life. See also ducktail. Sponson typically increases the resistance.
THD, total harmonic distortion	On ships this typically means the distortion in electric distribution network caused by electrical propulsion drive. For example, a specification can require THD to be below 5%.
Trial Speed	Vessel speed in trial conditions. Trial conditions are typically defined as follows: <ul style="list-style-type: none"> <li>• Vessel at design draft and even keel</li> <li>• Clean hull</li> <li>• Defined engine / propulsion motor load (e.g. 90% MCR)</li> <li>• In deep water, no current, calm weather, no waves</li> <li>• Fin stabilizers folded in.</li> </ul> <p>Thus in normal operation vessel seldom reaches the Trial Speed. Trial speed is measured during sea trial: due to weather conditions, etc. the measured speed needs often to be corrected. See service speed.</p>
Trim	When a vessel is not on even keel (i.e. the bow is higher than stern, or vice versa), the vessel is trimmed, or has trim. For example "the vessel has 0.5 m stern trim", when her draft in stern is 0.5 m more than draft in foreship.

<p>Weight Reserve</p>	<p>Weight reserve in the vessels weight calculation (both weight and center of gravity). This is e.g. 2% and 0.2 m. This is margin against calculation inaccuracies and changes during design and building stage. See also Growth Margin. Weight reserve is adjusted during the building process as the weight data gets more accurate.</p>
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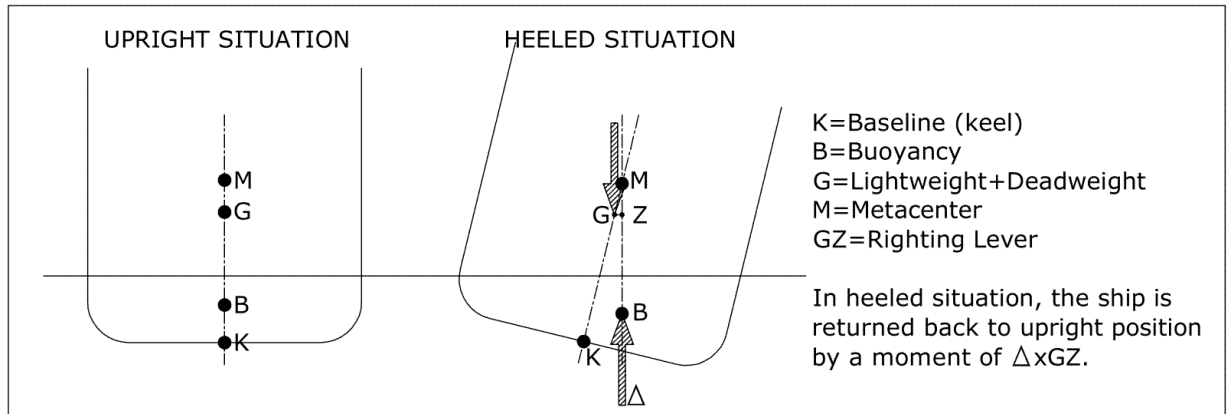


Figure: definition of GM, KG and other related terms.