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Overview

GHS is able to perform the calculations required by resolution MSC.216(82) which adopted the regulations on subdivision and damage stability as contained in SOLAS chapter II-1. These regulations are based on the probabilistic concept, using the probability of survival after collision as a measure of ships’ safety in a damaged condition.

To perform probabilistic damage calculations with GHS, the Advanced Features module is required. To determine if your license includes the use of this module, simply enter the command DIV from the GHS prompt. If you get the error message that the advance features module is required, then you need to contact Creative Systems to determine availability and costs.

Two commands in the GHS command dictionary, DAMSTAB and DIVISION, with the proper parameters, are used to perform the probabilistic damage calculations. It is recommended that the DAMSTAB2 wizard be used as it simplifies the input of parameters for probabilistic damage stability calculations. Due to some requirements that apply to passenger vessels (wind heel, passenger moments, etc.), some calculations are performed only in the wizard and are not implemented in the GHS program. This booklet will only cover performing probabilistic damage calculations using the wizard.

Excerpt from ANNEX 22 of RESOLUTION MSC.281(85) (Not a direct quote)

The harmonized SOLAS regulations on subdivision and damage stability, as contained in SOLAS chapter II-1, are based on a probabilistic concept which uses the probability of survival after collision as a measure of ships safety in a damaged condition. This probability is referred to as the “attained subdivision index A” in the regulations.

The probability that a ship will remain afloat without sinking or capsizing as a result of an arbitrary collision in a given longitudinal position can be broken down to:

- The probability that the longitudinal centre of damage occurs in just the region of the ship under consideration;
- The probability that this damage has a longitudinal extent that only includes spaces between the transverse watertight bulkheads found in this region;
- The probability that the damage has a vertical extent that will flood only the spaces below a given horizontal boundary, such as a watertight deck;
- The probability that the damage has a transverse penetration not greater than the distance to a given longitudinal boundary; and
- The probability that the watertight integrity and the stability throughout the flooding sequence is sufficient to avoid capsizing or sinking.

The first three of these factors are solely dependent on the watertight arrangement of the ship, while the last two depend on the ship's shape. The last factor also depends on the actual loading condition. By grouping these probabilities, calculations of the probability of survival, or attained index A, have been formulated to include the following probabilities:

- The probability of flooding each single compartment and each possible group of two or more adjacent compartments; and
- The probability that the stability after flooding a compartment or a group of two or more adjacent compartments will be sufficient to prevent capsizing or dangerous heeling due to loss of stability or to heeling moments in intermediate or final stages of flooding.

This concept allows a rule requirement to be applied by requiring a minimum value of *A* for a particular ship. This minimum value is referred to as the required subdivision index *R*. in the present regulations and can be made dependent on ship size, number of passengers or other factors legislators might consider important.

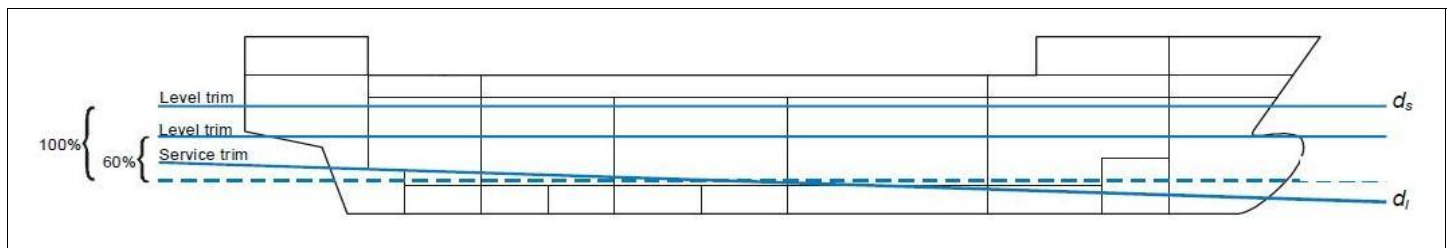
Evidence of compliance with the rules then simply becomes: $A \geq R$

It is the responsibility of the GHS user to know and understand the regulations concerning probabilistic damage stability before using the probabilistic damage ability of GHS and the DAMSTAB2 wizard.

Before using the Wizard

Before using the wizard, some consideration needs to be given to the vessel’s geometry and some information gathered. The regulations require at least three load conditions be investigated. The results of these three conditions are combined in a weighted formula based on the expected time in service at each load condition.

The 3 minimum drafts and trims to be considered are the light load, the subdivision draft and a partial load draft. The partial load draft is defined as the light load draft plus 60% of the difference between the light load and subdivision drafts.



These conditions can be handled in several ways within the wizard. A light ship weight can be defined by entering the weight and centers or the draft and trim. Then the vessel loading which achieves the required partial and subdivision drafts can be defined using either Load Editor or via a run file with the needed LOAD and ADD commands. If the vessel tank loading will not influence the results (for example a deck cargo barge with all voids empty) a single weight and centers or draft and trim can define the load condition.

The geometry of the watertight subdivision will have some influence on the Attained Index, *A* as stated above. The wizard can automatically define the divisions or groups of compartments. These divisions can also be set by the user. Doing so will change the computed Attained Index. It is up to the user to understand the regulations when specifying the divisions.

The location of longitudinal bulkheads forming wing tanks and horizontal bulkheads (decks) will also effect the computed results. When wing tanks are fitted, the probability factor for damage is reduced taking into account that inboard tanks will be flooded only a small percentage of the time. Likewise, for spaces between decks. The locations of the longitudinal and horizontal subdivisions are measured from the side shell and baseline respectively.

If progressive flooding to tanks or compartments outside the division is being considered, the affected tanks can be specified for each division.

Again, it is the responsibility of the user to understand the regulations when selecting the locations of divisions, wings and decks.

Obviously, all internal spaces within the damage zones need to be modeled as tanks or containers. A geometry file intended only for intact stability analysis may not be suitable for a damage stability analysis.

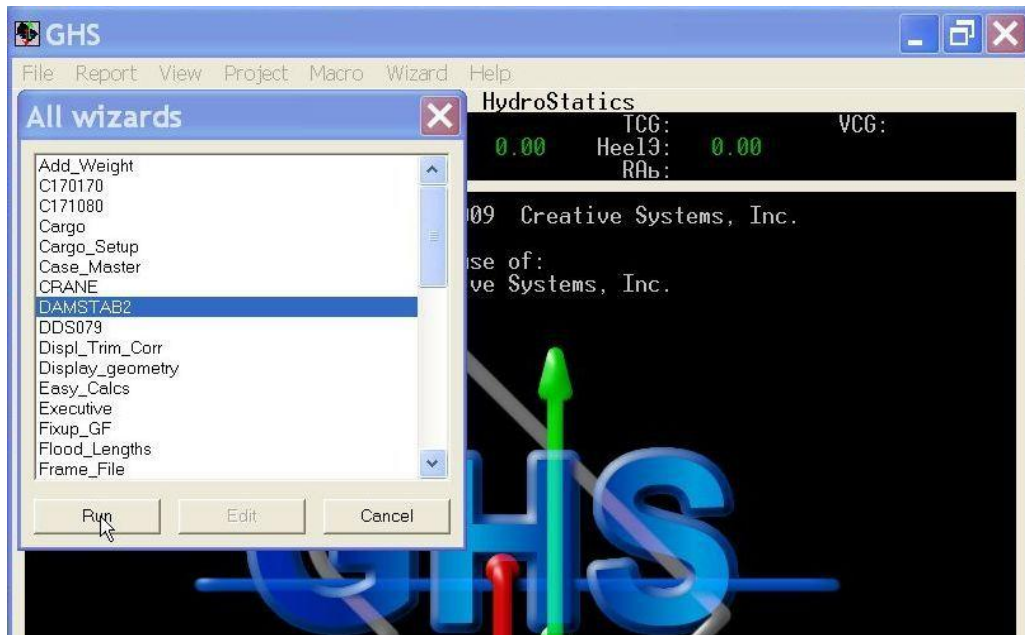
For this simple demonstration, the simple rectangular barge with tanks as shown will be used. It is in the SUBDIVY.GF geometry file.



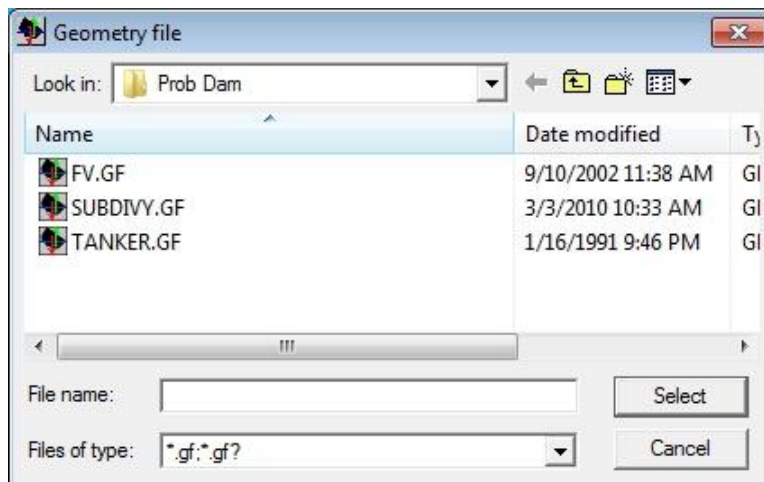
Getting started

Before starting a probabilistic damage stability run, it is strongly suggested that a new folder be created for that run. The wizard creates numerous files. These are for storing the division definitions, load conditions, parameters for the selected regulation, report files, summary files, notes and trace files. For this tutorial, create a folder in a location and with a name of your choosing. Copy the geometry file into this folder. It is helpful to have a shortcut for GHS in this folder too.

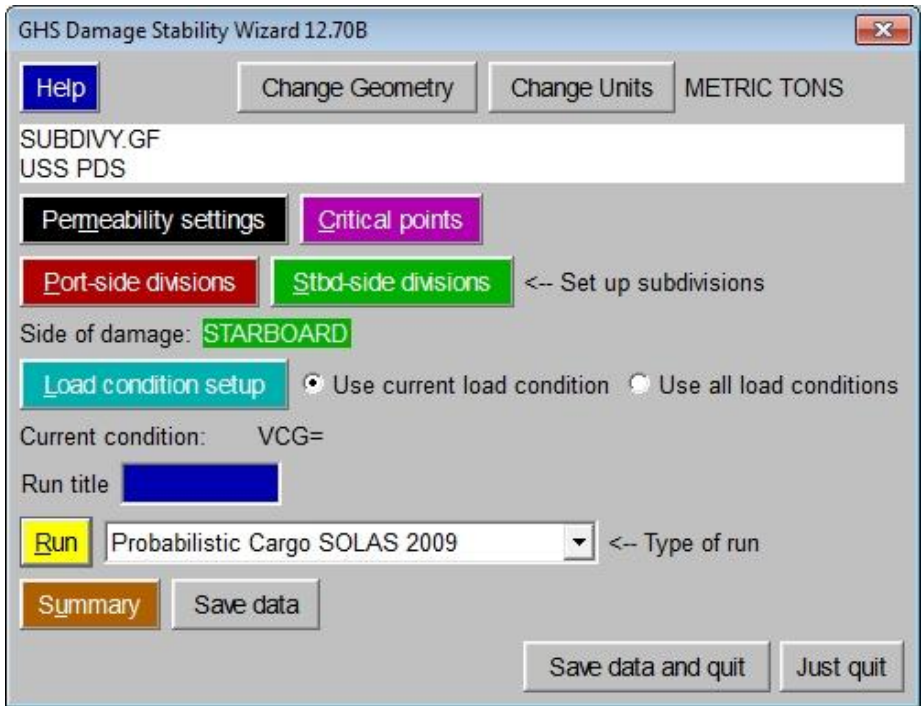
To access the wizard, use the pull down menu for Wizard, click the sub menu for All..., select DAMSTAB2 and click RUN.



If no geometry file was in memory and if file DAMSTAB2.SAV doesn't exist, the following dialog box will appear. If the file DAMSTAB2.SAV exists, the front dialog box will open with the parameters from that file already loaded. If a geometry file was already loaded, the wizard will open ready to use that geometry file. For the exercise below, select SUBDIVY.GF.

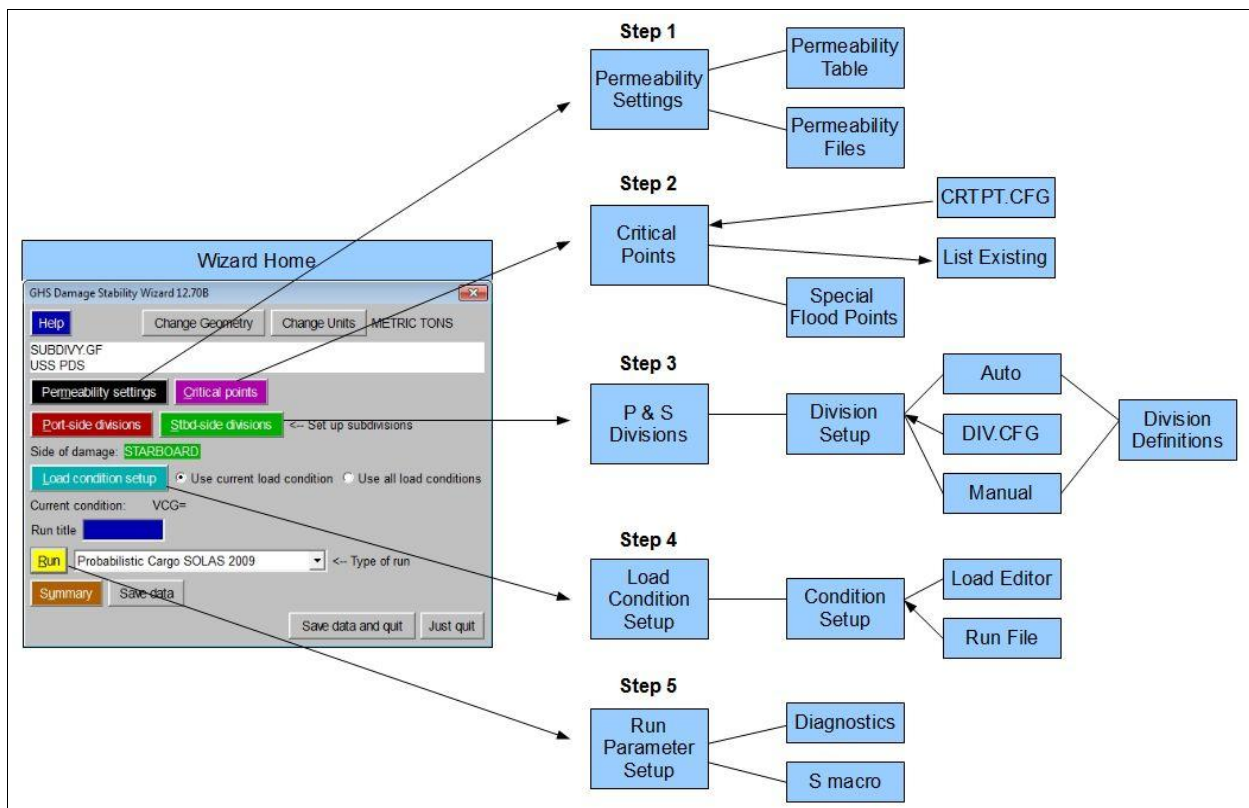


The main menu window will appear. The “Help” button will open a window with an overview of the Probabilistic Damage Stability wizard.



The geometry file and units can be changed with the corresponding buttons. The remaining buttons have hot keys indicated by the underlined letter in their labels. The “Permeability settings” and “Critical points” buttons allow you to edit the values in the wizard model. The Cargo Vessel regulations specify permeabilities when flooded that vary with different load conditions. The wizard provides a table format to set the required values without having to make changes to the geometry file or have multiple files. Special critical points can be added when said points are connected to or protected by a tank or compartment. If critical points are defined in the geometry file or a CRTPT.CFG file, these point can not be assigned to specific tanks or given special effects.

The procedure for completing a first run through the Damstab2 wizard consists of six main steps. The diagram below provides a overview of to the main options for each step.

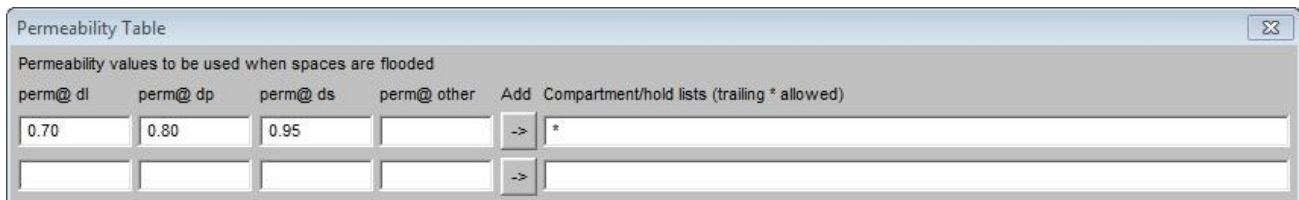


Your first Run with the Damstab2 wizard

In this exercise, we will step through the minimum inputs needed to complete a probabilistic damage stability run for the light ship load condition. In later exercises, we will learn how to set up additional load conditions and then explore the various optional parameters needed when the vessel characteristics warrant a more complete analysis.

The first run will be for the light ship condition. The vessel has the following properties: Light ship weight = 8200 tonnes at a draft of 2.0 m, LCG = 50 m, VCG = 6.0 m. The Subdivision Loadline draft is required. We will use 8.5 meters.

Click the Permeability settings button to bring up a window to select if you wish to use your own file or the table provided by the wizard. If you choose to use your file, instructions are given as to what file names to use and what parameters to include. For liquid cargo compartments, the permeabilities at the respective load conditions are 0.70 at dl, 0.80 at dp and 0.95 at ds. For this analysis, we can set them easily in the table. The table should look like this.

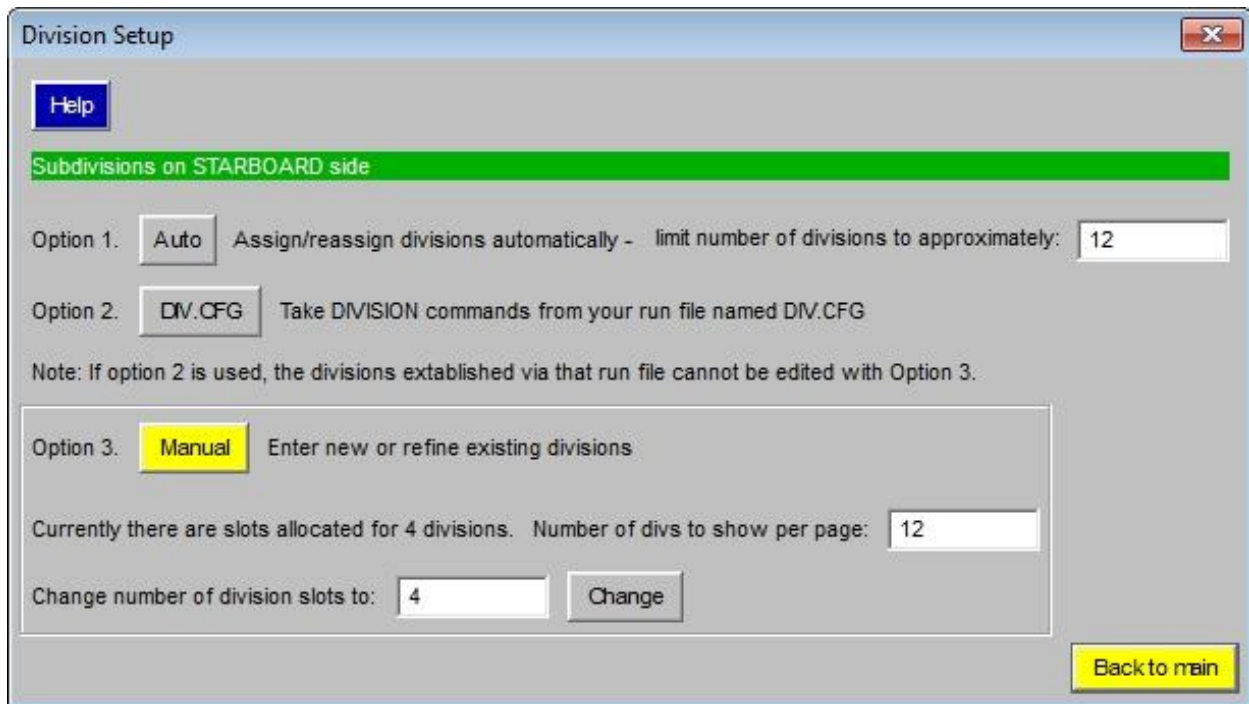


The asterisk is used as all the tanks in this model are for liquid cargo. Be sure the Use table button is selected when you are finished entering the permeabilities.

#	Description	Location			Status		Protect Layer		Inside Tank	Flood to Tank	Effect		
		L	T	V	Symm	Flood	Tight	Inactive			Long	Trans	None
89	1in_bot	24.000	8.000	11.000	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		1IN_BOT.S	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
88	1out_bot	24.000	12.000	11.000	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		1IN_BOT.S	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
87	1in_top	24.000	9.000	11.000	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		1IN_BOT.S	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
86	1out_top	24.000	11.000	11.000	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		1IN_BOT.S	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
85	2in_bot	26.000	13.000	11.000	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		2IN_BOT.S	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
84	2out_bot	26.000	17.000	11.000	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		2IN_BOT.S	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
83	2in_top	26.000	14.000	11.000	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		2IN_BOT.S	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
82	2out_top	26.000	16.000	11.000	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		2IN_BOT.S	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
81	3in_bot	74.000	13.000	11.000	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		3IN_BOT.S	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
80	3out_bot	74.000	17.000	11.000	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		3IN_BOT.S	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
79	3in_top	74.000	14.000	11.000	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		3IN_BOT.S	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
78	3out_top	74.000	16.000	11.000	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		3IN_BOT.S	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
77	4in_bot	76.000	8.000	11.000	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		4IN_BOT.S	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
76	4out_bot	76.000	12.000	11.000	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		4IN_BOT.S	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
75	4in_top	76.000	9.000	11.000	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		4IN_BOT.S	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
74	4out_top	76.000	11.000	11.000	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		4IN_BOT.S	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
73					<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>			<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
72					<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>			<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
71					<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>			<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Critical points can be assign in the geometry file, in a CRTPT.CFG file or by using the Special Flood Points table. If the critical points are defined within the geometry file or in the CRTPT.CFG file, they may have any or all of the attributes available in GHS. By using the Special Flood Points table above, additional properties are available. Note the critical point numbers in the table start at 89 and decrease. This is so any existing critical points will not be overwritten. If there is no description given, any data on that line is ignored. The columns for Symm, Flood, Tight and Inactive (Noflood) set the parameters recognized by GHS. The Flood to Tank column sets the /TANK:*tankname* parameter. The remaining columns, Protect Layer, Inside Tank, and Effect are for defining critical points that are considered protected due to its location. These properties will be discussed later for the passenger vessel run.

The next step is to set up the divisions. Click the “Stbd-side divisions” button.



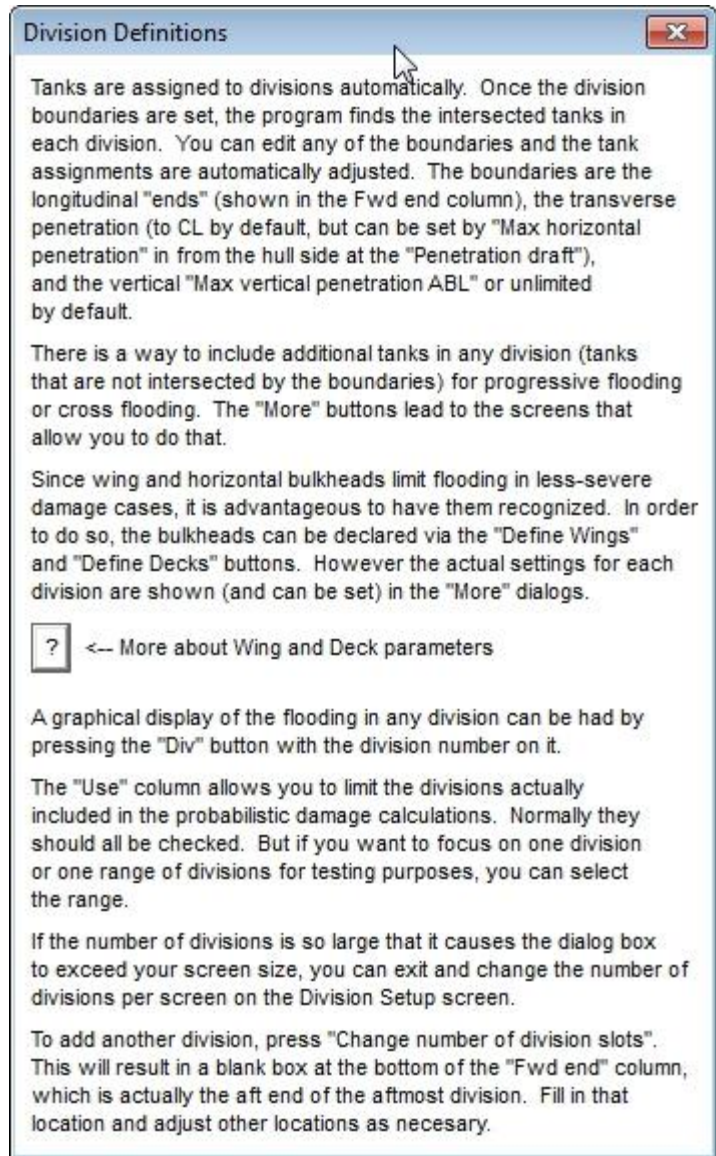
Then open the help window. If a message appears stating that the number of division slots can't be zero, enter 1 and click “Help” again. Time should be taken to read this information.

The wizard will locate the divisions based on the ends of the larger tanks. These locations can be edited.

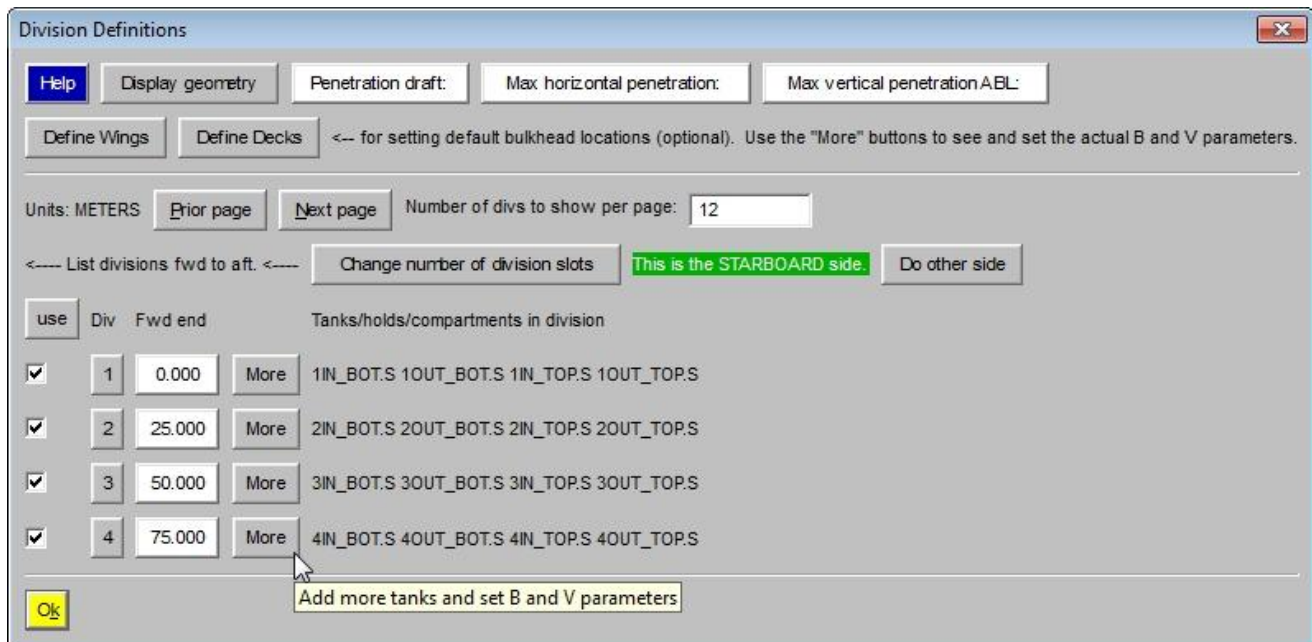
Vertical and horizontal penetration distances can be assigned.

Tanks can be added for progressive or cross flooding.

Wing and horizontal bulkheads can be set. We will ignore them for now.



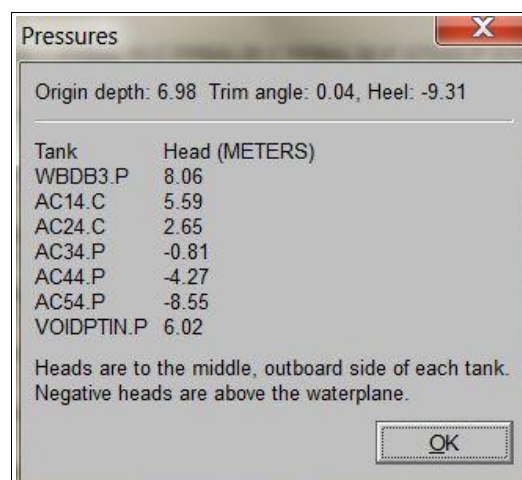
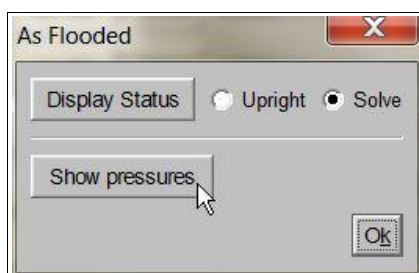
We will use the Auto option here. The Penetration draft window will appear. It will be discussed later when we investigate the passenger vessel. Clicking Continue starts a new instance of GHS, which will calculate divisions based on the geometry. That session will close, the Division Definition box will then appear, and the generated divisions will be shown.



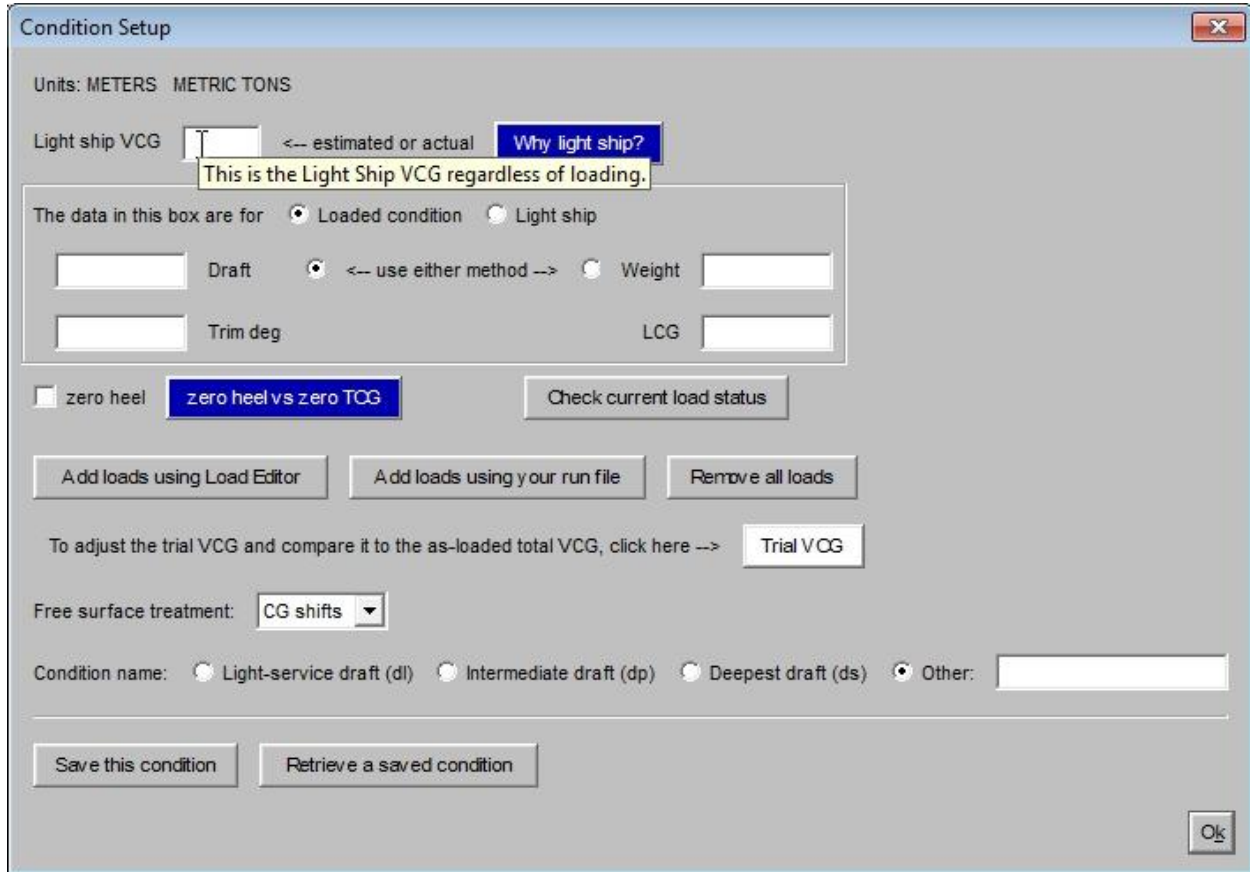
The divisions are at the obvious locations for this vessel. Since there are only 4 divisions, the “Prior page” and “Next page” button have no effect as does the “Change number of division slots” for the same reason. “Do other side” is used when the divisions or compartment arrangements are asymmetrical or port heel is expected. It has the same effect as pressing the “Port-side divisions” button in the previous window. The “use” button will ask for a single division to consider or to reset all. The check boxes can be used for the same purpose. Some additional information is included in this window describing its purpose. The tanks in each division is listed to the right. The “More” button will be discussed later.

Note that in many cases, hovering the mouse cursor over a button or field will produce a pop up tip similar to the one shown for the bottom “More” button above.

Clicking any of the numbered buttons for the first time will bring up the Load Condition menu to be discussed next. Once a loading is defined, clicking any of these button will display the dialog box shown below on the left. To open a Condition Graphic window illustrating the compartments within the division, click the “Display Status” button. Also in this dialog box is a button called “Show pressures”. Clicking this button will show the amount head for each tank in the division. These figures are used in the calculations required to evaluate crossflooding arrangements.



Clicking the yellow “OK” button at the bottom left of the “Division Definitions” window returns to the main menu. From the main menu, click “Load condition setup” to enter the data for one of the load conditions. If one of the “Div” buttons was clicked in the previous window, this window will appear directly.

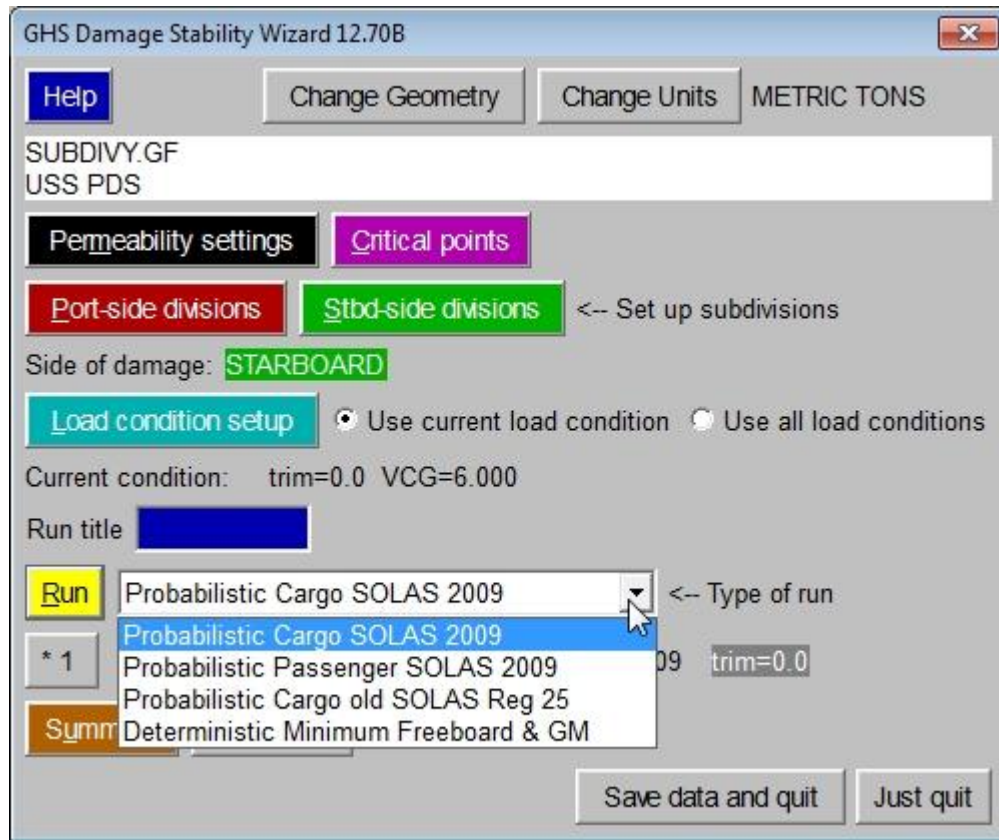


The light ship VCG is required. In fact, none of the other buttons work until a value is entered. Enter 6.0 as a VCG. The information in the box is to establish the water plane. When the draft and trim is known, enter those values in the boxes on the left. If the weight and LCG is known, enter that in the boxes on the right and select the radio button on the right also. Since this is the empty load of a barge, we will consider this condition the Light ship condition. Click the radio button for Light ship and enter 2.0 for the draft and 0 degrees for the trim.

If in subsequent runs the loading produces a non-zero total TCG, the intact heel will not be zero. If zero heel is desired, check the zero heel box to adjust the TCG. The “Check current load status” button displays a summary of weight, centers, trim and heel. We will discuss the next three buttons in the next run when we start adding loads.

The Trial VCG is for setting an assumed VCG higher than the entered VCG. This allows the user to find a maximum VCG that still satisfies the regulations. Note that the Trial VCG should be equal to or higher than the Light ship VCG. For this exercise, use the same VCG of 6 m as there are no loads in this condition. We will see how to adjust the Trial VCG in the next run.

Be sure to set the condition name to Light-service draft (dl). Use the “Save this condition” button before continuing. Clicking OK will return to the main menu.



Select the option to Use the current condition. The trim and VCG of the current condition is shown. Enter a Run title if desired, this is optional. This will appear in the report. For this exercise select the Type of run for cargo vessel regulations. Clicking Run brings up the corresponding box to enter the necessary parameters to execute the calculations depending on which regulation was selected.

The Subdivision length is indicated on the top line by showing the locations of the ends of the divisions in geometry file coordinates. If Ls does not equal the length indicated, change the values as needed. In this case, the ends of the barge defines Ls as 100 m. The Subdivision Breadth is taken as the overall breadth of the model as a default. A different value can be entered if the Subdivision Breadth of the vessel is different.

The Subdivision Loadline Draft is required. The pop up tip suggests the GHS manual for more information. We will use the summer load line draft of 8.5 m. A maximum vertical extend of damage can be specified, if omitted, Hmax will be computed according to the regulations. This is only applicable when using the earlier Regulation 25 rules.

A Special Purpose Ship is one that carries people that are part of the ship's crew or passengers. Research ships, cable laying ships and training vessels are examples. Such ships are considered passenger ships and the special personnel are treated as passengers.

Bottom damage probability of survival, required by Regulation 9, is available as an option during the initial runs for side damage and when testing certain cases. The probability of survival must not be less than 1.0 for bottom damage. The location and extents of damage are based on vessel dimensions and are the

defaults. The run will terminate if the probability of survival falls below the minimum unless the user selects the option to find a lower VCG so the requirement is satisfied.

A message can be entered to be included on the title page in addition to the Run title entered in the main menu. The option to include division graphics will include a Condition Graphic plot of the flooded condition in addition to the default intact condition. The remaining inputs will be discussed later.

The remaining inputs will be discussed later. Click "Launch run" to start the calculations.

Discussion of Output

The wizard produces a report that is automatically displayed in the GHS preview window. This report is named DS2-*n*.pf where *n* is the number of the run. The title page includes the usual GHS header, what version of the wizard was used, a description of the regulation used, the load condition and a Condition Graphic image of the vessel. The divisions and the tanks in them in on the following page(s). The flood point information is next followed by a description of the loading, then the permeability settings used for the run. The results of the analysis should look like this.

```
Executing DAMSTAB /sdi216C /side:STARBOARD /L:0,100 /B:40 /DLL:8.5 /N1:500 /macro:PROBSURV
```

PROBABILISTIC DAMAGE STABILITY MSC.216(82)									
Cargo Vessel Version									
Subdivision length: 100.000					Terminals: 0.000 , 100.000a				
Breadth: 40.000					Draft: 2.000				
Subdivision load line draft: 8.500									
Divisions	P	Smin	P*S*V	A	Depth	Trim	Heel	Range	MaxRA
None	0.00000	1.000	0.000	0.000	2.000	0.00	0.00	50.21	10.625
1	0.21642	1.000*	0.216	0.216	2.834	0.67f	1.20s	28.46	9.527
2	0.18284	1.000*	0.183	0.399	2.374	0.19f	1.01s	37.79	9.975
3	0.18284	1.000*	0.183	0.582	2.050	0.19a	1.01s	37.79	9.975
4	0.21642	1.000*	0.216	0.799	1.673	0.67a	1.20s	28.46	9.527
1-division damage:				0.799	Probability of damage: 0.799				
1+2	0.06707	1.000*	0.067	0.866	3.676	1.18f	3.15s	18.92	7.789
2+3	0.06698	1.000*	0.067	0.933	2.515	0.00	2.51s	51.81	9.140
3+4	0.06707	1.000*	0.067	1.000	1.615	1.18a	3.15s	18.92	7.788
2-division damage:				0.201	Probability of damage: 0.201				
1+2+3	0.00018	1.000*	0.000	1.000	4.173	1.18f	5.72s	19.59	6.446
2+3+4	0.00018	1.000*	0.000	1.000	2.115	1.18a	5.72s	19.58	6.445
3-division damage:				0.000	Probability of damage: 0.000				
Attained index in this condition:				1.000	Total probability of damage: 1.000				
Required index:				0.492					
Values marked with * computed by macro.									
Distances in METERS.								Angles in deg.	

Under the header, the parameters used in the DAMSTAB command is given. The number of divisions damaged are shown in groups in the table. The first column "P", is the probability of being damaged. The second column is labeled "Smin" indicating the probability of survival when damaged. The label "Smin" indicates that the search for the minimum S has been performed, otherwise the column would be labeled simply "S". The "P*S*V" column is the product of P, S, and V. V is the factor for any horizontal bulkhead or deck? which may be present. The "A" column is the attained so far which is a running summation of the P*S*V values with subtotals for each grouping.

On the right hand side are five columns showing the most important characteristics if each damage case. "Depth, Trim and Heel" (the latter two in degrees) represent the waterplane in the damaged equilibrium condition. "Range" is the range of stability beyond equilibrium. "MaxRA" is the greatest righting arm in this range.

The next page is the Summary Data page. Pertinent information is repeated from the title page. At the bottom is the attained index for this load condition and the minimum index needed for this condition. For cargo ships, the required index can be reduce by 50% for the individual load conditions.

```

===== Summay Data =====

Calculation method: SDI216C
Condition name: Light-service draft (dl) (code 0)
Damage side: Starboard

Displacement: 8200.0 METRIC TONS
Trim: 0.00 degrees
VCG: 6.000 METERS
Free surface moment: 0.0 METRIC TONS-METERS

Attained index: 1.000
Minimum index needed for this draft: 0.246
Overall Required index: 0.492
    
```

The report ends with pages of notes.

```

===== Notes =====

Final flooding is with damaged compartments freely open to the sea
(lost buoyancy).

Max RA taken within limited Range.
Rl is the non-dimensional range. Ml is the non-dimensional maximum RA.
TRACE OFF

Div 1
LIN BOT.S IOUT BOT.S LIN TOP.S IOUT TOP.S
Damaged between 0.00 and 25.00a
Final equilibrium heel: 1.20 K: 1.000
Min downflooding height is 8.108, point 80
STBD range: 28.46 Rl: 1.000 max RA: 9.527 Ml: 1.000
heel at downflood: 29.67 critical pt 80
S Final = 1.0000

Div 1
LIN TOP.S IOUT TOP.S
Damaged between 0.00 and 25.00a
Final equilibrium heel: 0.00 K: 1.000
Min downflooding height is 9.000, point 74
STBD range: 43.34 Rl: 1.000 max RA: 10.488 Ml: 1.000
heel at downflood: 43.34 critical pt 80
S Final = 1.0000
    
```

The first section provides comments and information pertaining to the run. After that, grouped by the tanks assumed damaged, are intermediate results. The tanks assumed flooded are listed. Note that in the two cases for one division damaged, the first group includes all the tanks and the second only includes two tanks. The wizard checks for all possible combinations of damage in the division. Since damage to the upper tanks may be more critical due to the higher VCG, this case is included. Only the case giving the lowest attained index is included in the table about. This feature can be turned off by checking the box for the Quick mode in the "parameters" window. The final equilibrium angle is used to determine K, the coefficient use to determine S final. The lowest flood point is given. This point is the one that determines the range of stability. This range and the maximum RA is used to find the respective non-dimensional values also used to find S final.

Second Run – partial load condition

Next we will add some loads to the partial load draft. That is defined as 60% of the difference between the light-service draft and subdivision draft more than light-service draft. For the light-service draft of 2.0 m and the subdivision draft of 8.5 m, the partial draft is 5.9 m.

After exiting the preview window, you should be back at the main wizard window. This would be a good time to click the “Save data” button if you haven’t already. To start another load case, click the “Load condition setup” button to get to the Condition Setup window. Save the light load condition using the “Save this condition button. This is not the same as the Save data we just did. Now you are ready to start the next load case.

Enter the Load Editor and load the inboard tanks, tops and bottoms, in divisions 1 and 4 to 95%. Then add a deck load of 6400 mt at 50 m aft, on CL and at 12 m high. Press “Solve” and the header information should look like this.



Notice the VCG as loaded is 7.141 m. Click “Exit” (not the red X) to return to the Condition Setup window. Enter this value for the Trial VCG. The loaded tanks now will produce free surface effects. There is the option of having this treated as a Moment of Transference, or CG shift, or as a free surface correction. The equilibrium waterplane will not be effected, but the range of stability and maximum righting arms will differ slightly. Which one you use is up to you or the classification society. The results below are from a run using the FSM option. Select the Intermediate draft button, save this condition and click “Ok”.

Click “Run”, check the values in the Cargo Parameters box and launch the run. The report preview will open with the changes for the new load condition. In the Status report, page 4, the light ship VCG is 5.999. This is simply a numerical difference, but it demonstrates that the Trial VCG was used as the total VCG and since the VCG of the loads are fixed, GHS adjusted the LIGHT SHIP VCG accordingly. If a higher Trial VCG was entered, then the LIGHT SHIP VCG would have been higher.

Note the permeability of 0.80 should be displayed for all tanks.

Executing DAMSTAB /sdi216C /side:STARBOARD /L:0,100 /B:40 /DLL:8.5 /N1:500 /macro:PROBSURV

PROBABILISTIC DAMAGE STABILITY MSC.216(82)									
Cargo Vessel Version									
Subdivision length: 100.000		Terminals: 0.000 , 100.000a							
Breadth: 40.000		Draft: 5.900							
Subdivision load line draft: 8.500									
Divisions	P	Smin	P*S*V	A	Depth	Trim	Heel	Range	MaxRA
None	0.00000	1.000	0.000	0.000	5.899	0.00	0.00	16.23	4.826
1	0.21642	0.933 *	0.202	0.202	6.078	0.15f	1.92s	12.13	3.470
2	0.18284	0.894 *	0.164	0.365	7.233	0.69f	4.14s	10.23	2.318
3	0.18284	0.894 *	0.164	0.529	6.037	0.69a	4.14s	10.23	2.318
4	0.21642	0.933 *	0.202	0.731	5.823	0.15a	1.92s	12.13	3.470
1-division damage:				0.731	Probability of damage: 0.799				
1+2	0.06707	0.743 *	0.050	0.781	9.031	2.09f	9.31s	4.89	0.712
2+3	0.06698	0.000 *	0.000	0.781	8.741	0.00	18.82s	0.00	
3+4	0.06707	0.743 *	0.050	0.831	5.389	2.09a	9.31s	4.89	0.712
2-division damage:				0.100	Probability of damage: 0.201				
1+2+3	0.00018	0.000 *	0.000	0.831	3.011	2.24f	156.46s	0.00	
2+3+4	0.00018	0.000 *	0.000	0.831	-0.903	2.24a	156.46s	0.00	
3-division damage:				0.000	Probability of damage: 0.000				
Attained index in this condition:				0.831	Total probability of damage: 1.000				
Required index:				0.492					
Values marked with * computed by macro.									
Distances in METERS.								Angles in deg.	

The probability of damage is the same since the divisions are the same. The probability of survival has decreased. For the case with divisions 2 and 3 flooded, there is no range of stability due to the flood points, therefore the chance of survival is zero. When 3 divisions are flooded, the vessel capsizes.

===== Summay Data =====
Calculation method: SDI216C
Condition name: Intermediate draft (dp) (code 1)
Damage side: Starboard
Displacement: 24191.4 METRIC TONS
Trim: 0.00 degrees
VCG: 7.141 METERS
Free surface moment: 16827.1 METRIC TONS-METERS
Attained index: 0.831
Minimum index needed for this draft: 0.246
Overall Required index: 0.492

The Summary Data above is similar to the first run. The free surface moment shown is the intact free surface moment with the normal permeabilities. When the flooded cases were analyzed, there is no free surface effect from any loaded tank that was flooded.

```

Div 1
1IN_BOT.S 1OUT_BOT.S 1IN_TOP.S 1OUT_TOP.S
Damaged between 0.00 and 25.00a
Final equilibrium heel: 1.92 K: 1.000
Min downflooding height is 4.415, point 84
STBD range: 12.13 R1: 0.758 max RA: 3.470 M1: 1.000
heel at downflood: 14.03 critical pt 84
S Final = 0.9331
    
```

Looking at the results from the flooded first division, we can verify results using GHS without the wizard. Be sure to save the condition and the data and exit the wizard. In GHS, change the permeability of the tanks in that division to 0.80. Then change their type to flooded using the Load Editor or at the command prompt. Once done, solve and view the status and righting arm using free surface moments. The results should look like this:

Baseline draft: 6.082 @ Origin, Trim: Fwd 0.15 deg., Heel: Stbd 1.92 deg.		Weight(MT)	LCG	TCG	UCG	
Part						
LIGHT SHIP		8.200.00	50.000a	0.000	6.000	
DECK LOAD 1		6.400.00	50.000a	0.000	12.000	
Total Fixed		14.600.00	50.000a	0.000	8.630	
	Load SpGr	Weight(MT)	LCG	TCG	UCG	FSM
1IN_BOT.P	0.950 1.025	1.198.93	12.472a	4.941p	2.376	2106.93
1IN_TOP.P	0.950 1.025	1.198.93	12.472a	4.941p	7.376	2106.93
4IN_BOT.S	0.950 1.025	1.198.93	87.472a	5.059s	2.376	2106.93
4IN_TOP.S	0.950 1.025	1.198.93	87.472a	5.059s	7.376	2106.93
4IN_BOT.P	0.950 1.025	1.198.93	87.472a	4.941p	2.376	2106.93
4IN_TOP.P	0.950 1.025	1.198.93	87.472a	4.941p	7.376	2106.93
Total Tanks		7.193.58	62.472a	1.600p	4.876	12641.56
Total Weight		21.793.58	54.117a	0.531p	7.391	
		Displ(MT)	LCB	TCB	UCB	RefHt
HULL		24.411.21	49.643a	0.749s	2.990	-6.078
1IN_BOT.S	Flooded 1.025	-1.025.00	12.500a	5.000s	2.500	-6.078
1OUT_BOT.S	Flooded 1.025	-1.025.00	12.500a	15.000s	2.500	-6.078
1IN_TOP.S	Flooded 1.025	-249.51	12.391a	5.229s	5.612	-6.078
1OUT_TOP.S	Flooded 1.025	-318.12	12.414a	15.180s	5.779	-6.078
Total Displacement	1.025	21.793.58	54.106a	0.383p	2.965	
Righting Arms:			0.001	0.000s		
RIGHTING ARMS vs HEEL						
Depth	Trim°	Heel°	Total CG: Displ(MT)	LCG = 54.118a	TCG = 0.550p	UCG = 7.971
6.079	0.15f	1.92s	21,793.58	0.000	0.000	4.413<84>
6.440	0.47f	6.92s	21,793.62	0.000	1.488	2.645<84>
6.781	0.81f	11.92s	21,793.71	0.000	2.986	0.837<84>
6.991	0.98f	14.04s	21,793.76	0.000	3.468	0.001<84>
7.318	1.19f	16.92s	21,796.04	0.000	3.910	-1.200<84>
7.989	1.62f	21.92s	21,793.57	0.000	4.217	-3.394<84>
8.147	1.73f	23.07s	21,793.58	0.000	4.224	-3.904<84>
8.641	2.08f	26.92s	21,789.75	0.000	4.139	-5.587<84>
9.193	2.49f	31.92s	21,793.58	0.000	3.854	-7.714<84>
9.665	2.88f	36.92s	21,793.77	0.000	3.446	-9.772<84>
10.075	3.27f	41.92s	21,793.76	0.000	2.956	-11.759<84>
10.417	3.64f	46.92s	21,793.76	0.000	2.410	-13.660<84>
10.684	3.99f	51.92s	21,793.74	0.000	1.826	-15.457<84>
10.873	4.31f	56.92s	21,793.72	0.000	1.214	-17.137<84>
10.976	4.59f	61.92s	21,793.70	0.000	0.585	-18.684<84>

The equilibrium heel angles are the same. Only the free surface effects from the loaded tanks are present. The free surface effects of the flooded tanks are not included. The lowest flood point is point #84 at 4.415 from the wizard, 4.413 from GHS. The range is from equilibrium to the point of down flooding, 12.13 from the wizard, 12.12 from GHS. The maximum righting arm is 3.470 from the wizard, 3.468 from GHS. Your values may vary slightly due to differences in initial values, processors or time zones.

Third run – Subdivision draft condition

Repeat the steps above to add a fix weight of 10660 mt at 50 m aft, on CL, and 14 m high. be sure to reset the Trial VCG. After reviewing the report file, return to the main wizard program and click the “Summary” button. This produces a summary of all three runs.

Summary for SDI216C - Probabilistic Cargo SOLAS 2009 trim:0.00							
Run 1-1 Light-service draft (dl)	Starboard	trim:	0.00	att index:	1.000		
Run 2-1 Intermediate draft (dp)	Starboard	trim:	0.00	att index:	0.831		
Run 3-1 Deepest draft (ds)	Starboard	trim:	0.00	att index:	0.000		
Warning: This attained index is less than the minimum $0.5 \times 0.492 = 0.246$							
Draft	@LCF	Attained	Factor	Weighted	VCG	FSM	VCG+
dl	2.00	1.000	0.2	0.200	6.000	0	6.000
dp	5.90	0.831	0.4	0.332	7.141	16827	7.837
ds	8.50	0.000	0.4	0.000	9.239	16827	9.722
Attained index:				0.5324			
Required index:				0.4920			

The individual attained indexes are present. Since the third one did not meet the requirement that it must be at least 50% of the required, a warning is given. The three attained indexes are then combined in a weighted summation to find the overall attained index. Since it is greater than the required index, no warning is given.

To see if the wing and horizontal bulkheads offer any benefit, the location and distances must be entered. Return to the Division Definition Window. Opening the help button and clicking on the “?” will display some helpful information.

The regulations need to be consulted for sloping and stepped bulkheads.

WING and Deck (HBHD) Parameters

The Wing parameter is the horizontal distance from the side shell to a wing bulkhead in a particular division. In other words, it is the damage penetration distance that would reach the bulkhead.

This serves two purposes: 1) The probability of damage outboard of the bulkhead is based on this distance; 2) The program uses this distance to determine whether to flood tanks.

In practice you will want to make the WING parameter slightly less than the distance from shell to the bulkhead to make sure that it doesn't breach the bulkhead. If there is curvature of the side shell and/or sloping or stepped bulkheads, consult the regulations for the proper way to measure this distance. The program will, in most cases, make the correct decision about which tanks to flood. However if you find a case where it is flooding an inboard space when it should not be doing so, you can manually assign that space to a particular wing layer in the More/Division Details dialog.

Similarly the Deck or HBHD parameter is the distance from baseline up to a horizontal bulkhead. Again, this number is used both to calculate probability of damage and to determine which tanks to flood. The More/Division Details dialog provides the means of overriding the automatic assignments of tanks to vertical layers as well.

There are two ways to enter the locations of these bulkheads. Returning to the Port-side or Stbd-side Division windows and selecting option 3, Manual, the Define Wings and Define Decks buttons will display a table for the distances and locations. As recommended above, the distances are slightly less than the actual distances. For our vessel, the entries would be as follows.

Wing Definitions

[Help](#)

In from shell	Aft end	Fwd end
9.950	25.00	0.00
4.950	75.00	25.00
9.950	100.00	75.00

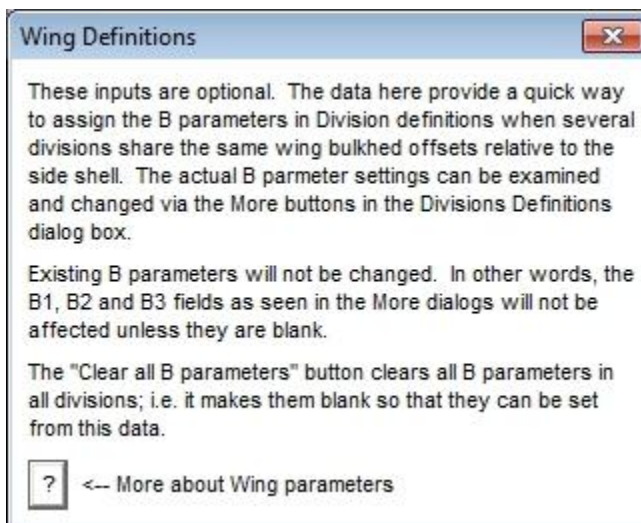
Deck Definitions

[Help](#)

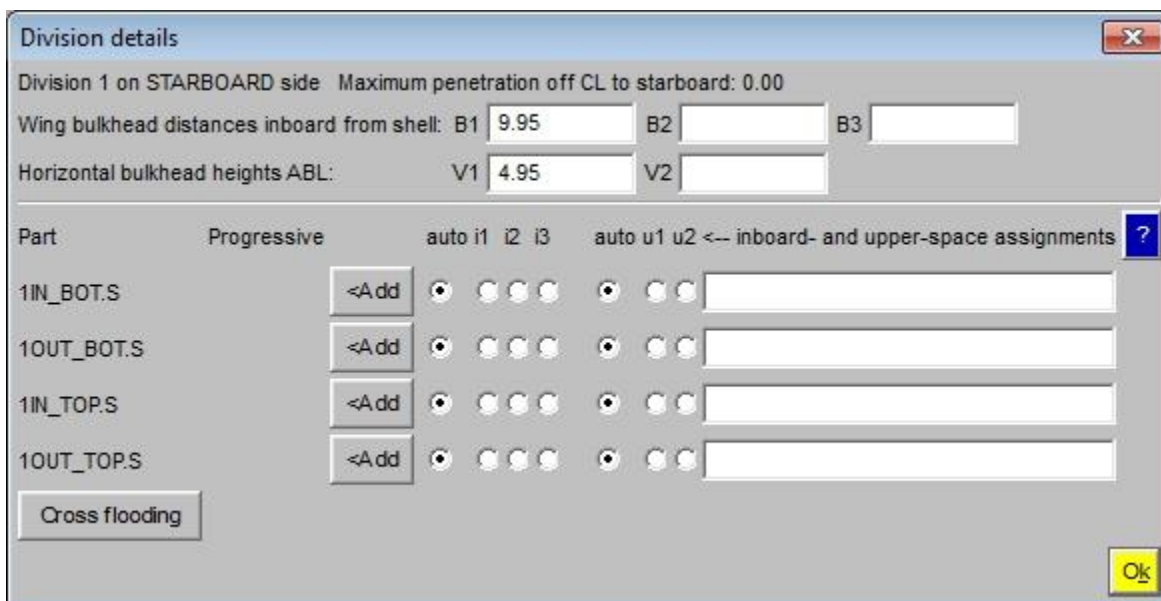
Height ABL	Aft end	Fwd end
4.95	25	0
2.45	75	25
4.95	100	75

The help window explains how to enter the data into the tables.

For this vessel, defining the wings and decks using the table above is adequate. Once set, the values entered can be checked by clicking the More button in the Division Definition window.



Using the More button for each division allows you to assign these locations on a division by division basis. This is helpful when there are canted bulkheads near the ends of a vessel.

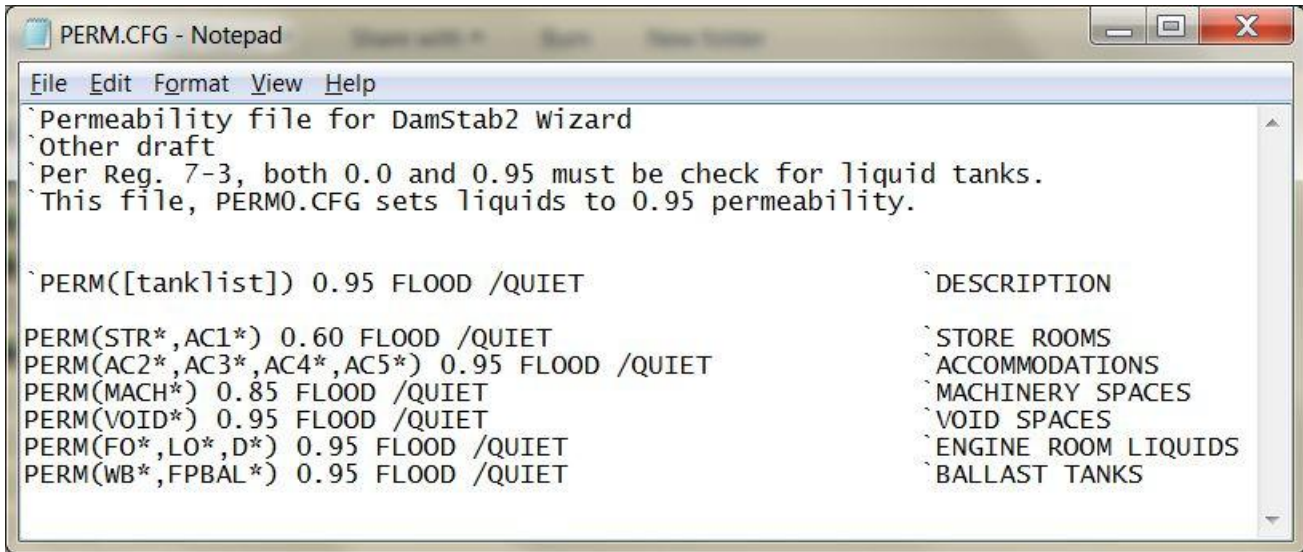


We see the bulkhead and deck location for this division is displayed in B1 and V1. The <Add button is used to specify a tank that will flood when the corresponding tank is flooded. It does not have to be in the division. No time calculation is performed. For tanks declared for progressive flooding, intermediate flooding can be selected as an option before launching the run for passenger vessels.

Tanks inboard of B1 are automatically assigned to i1, tanks inboard of B2 are assigned to i2, tanks above V1 are assigned to u1 and so on. The automatic assignments can be overridden with the radio buttons. If this is done, a comment can be made in the space provided.

Accepting the input above, click Ok to return to the Division Definition window, click Ok again to return to the main window to rerun the deepest draft case. Looking at the report shows that an attained index of 0.106 was achieved. The previous run produced an attained index of zero. Including the wing and deck locations did improve the attained index, however, the vessel still fails.

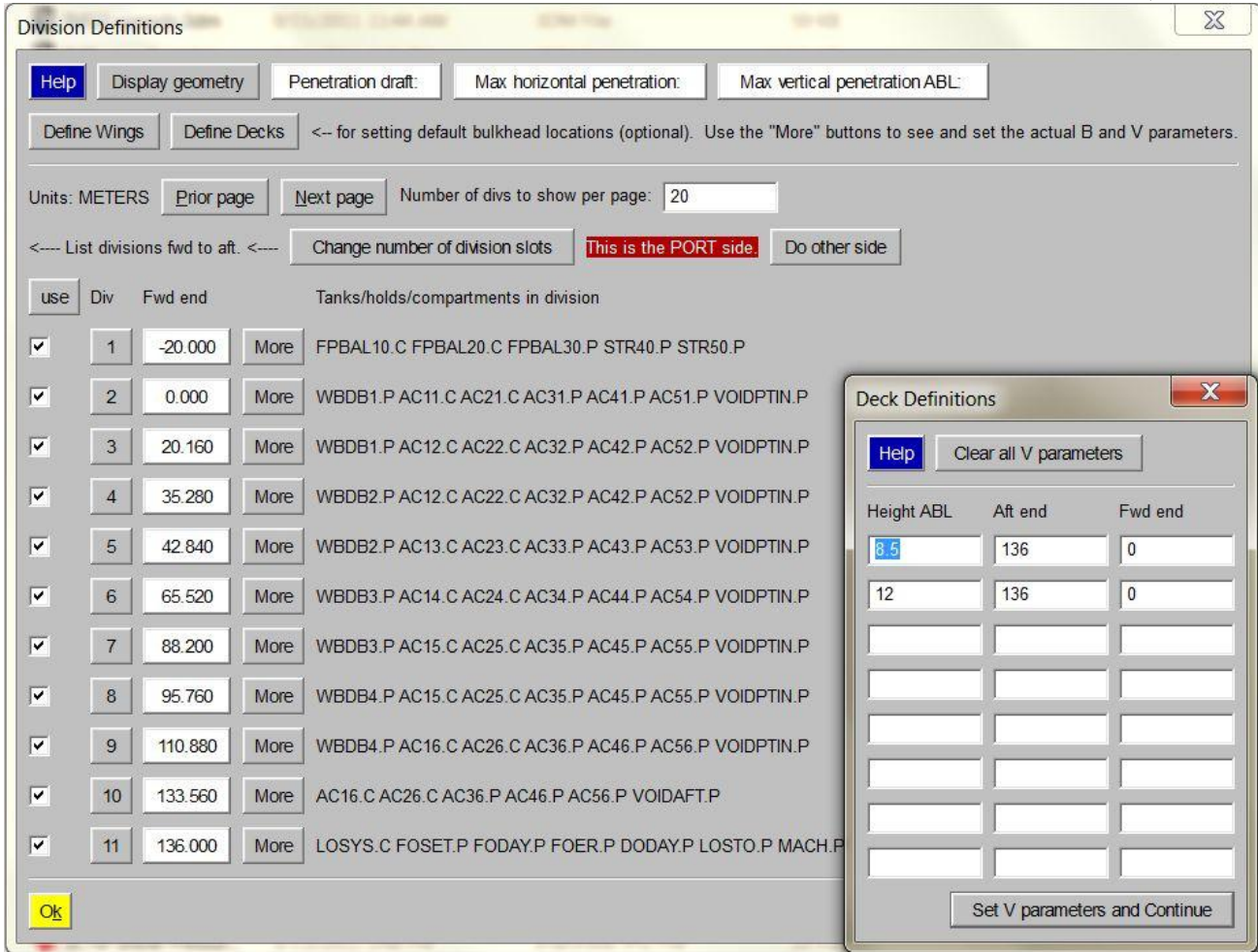
An example of a permeability file is shown in the image below:



Critical points – Since the downflooding points are already set up in the geometry file they do not need to be entered into the Wizard again. The existing points in the GF file can be verified by clicking on “List Existing Critical Points”. Additional critical points and special critical points can be added within the Wizard and both sets of points will be analyzed.

Port divisions – Use the Auto division maker with 11 divisions. Next we need to set the deck definitions for the two decks above the subdivision waterline, which is 6.0 m. The first two decks above the waterline are located at 8.5 and 12.0 m above the baseline. Enter these values into the “Define Decks” window along with the longitudinal extent of the decks which is 0 to 136a.

Starboard divisions – select “Do other side” → Stbd → then click “Auto” and “Continue” to generate the division definitions on the Starboard side. Again set the deck definitions.

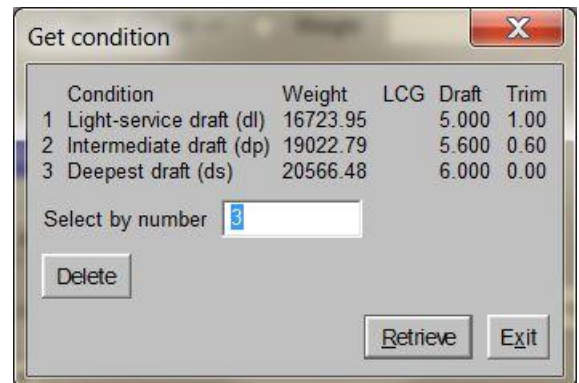


We are almost ready for our first run, the next step is to set up and save the following three load conditions and save all our files thus far.

The draft and trim values for the Light-service (dl), Intermediate draft (dp), and Deepest draft (ds) follow:

1. Light-service (dl) 5.0 m 1.0 degrees aft trim
2. Intermediate draft (dp) 5.6 m 0.6 degrees aft trim
3. Deepest draft (ds) 6.0 m 0.0 degrees aft trim

Both the Lightship VCG and the Trial VCG should be set to 9.0 meters.



Set up the “SDI216 Passenger parameters” window with the values as shown. For a vessel this size, 1000 passengers is a good estimate. Be sure to click, “Includes notes in report”. This prints the Survival Probabilities for each set of damages tanks for each division.

SDI216 Passenger parameters

Units: METERS

Subdivision Length Terminals Aft: 156.240 Fwd: -20.000

Subdivision Breadth 28.307

Subdivision Loadline Draft 8.000

Maximum possible vertical extent of damage above BL (Hmax) (optional).

Maximum number of passengers 1000 Maximum beam: 28.307

Special Purpose Ship

Survival Craft heeling moment 0 METRIC TONS-METERS

Number of passengers for whom lifeboats are provided 1000

Number of persons in excess of lifeboat capacity 0

Include intermediate stages of flooding Do stages only in progressive flooding

Passenger crowding moment <-- Leave blank for automatic calculation based on Max number of passengers.

Wind heeling moment <-- Leave blank for automatic calculation of wind heeling moment.

Include side damage probability of survival report Setup

Include bottom damage probability of survival report Setup

Message to add to title page: Starboard All Divisions

Include division graphics in report

Stop after 2 simultaneous divisions flooded.

Quick mode All penetration mode

Check stability in both directions Disable user-assigned flooding

Respect division ends for flooding of inboard spaces

Take maximum RA within limited range

Include notes in report

Diagnostics S macro

Launch run Back to main

The information needed and options available for a cargo vessel run are the same for a passenger vessel. There are additional parameters needed for a passenger vessel run. The prompts for, “Maximum number of passengers”, “Survival Craft heeling moment”, the “Number of passengers for whom lifeboats are provided” for and the “Number of persons in excess of lifeboat capacity” are self explanatory.

The options to include intermediate stages of flooding or intermediate stages of flooding for progressive flooding only are present.

Passenger crowding moment can be given to override the moment computed from the number of passengers and maximum beam. Wind heeling moment can be specified if the superstructure is not included in the model or determined by other means.

Like the bottom damage probability of survival for cargo vessels, passenger vessel are also subject to side damage probability of survival. The side and bottom damage calculations for passenger vessels are required per Regulations 8 and 9. The probability of survival must not be less than 0.9 or 1.0 for side or bottom damage respectively. The location and extents of damage are based on vessel dimensions and are the defaults. The run will terminate if the probability of survival falls below the minimum unless the user selects the option to find a lower VCG so the requirement is satisfied.

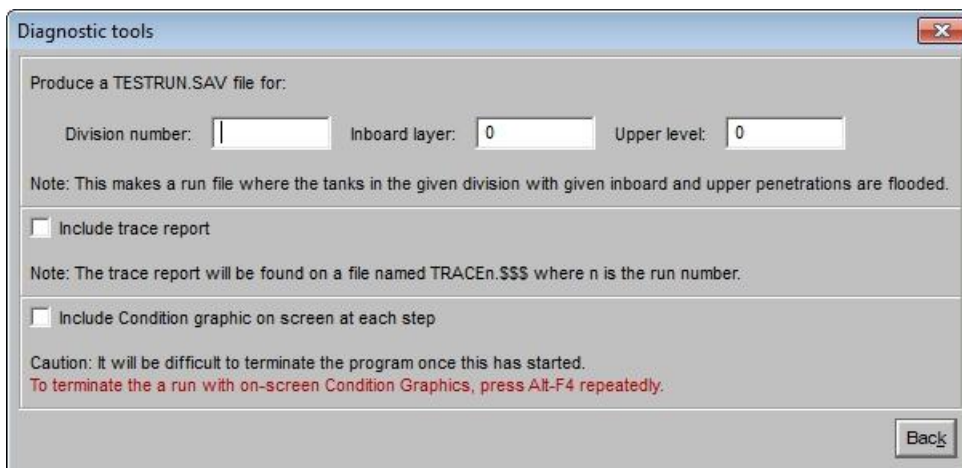
Run Options

The bottom area of the window covers the following options. They are the same for both cargo vessels and passenger vessels.

- Stop after *n* simultaneous divisions flooded
Forces the run to end after the specified number of adjacent divisions are flooded. Also, the run will end when there is no contribution to the attained index for a given set of divisions.
- Quick mode
Turns off checking for worst case combinations of flooding to shorten the time of runs. For example, in the case of horizontal bulkheads, the wizard will check the case with only the upper compartments flooded as the higher VCG may be more critical.
- All penetration mode
Considers all penetration combinations under multi-division damage.
- Check stability in both directions, for asymmetrical vessels or loadings
- Disable user-assigned flooding
Overrides the layer assignments in the Division Details window.
- Respect division ends for flooding of inboard spaces
Uses the division ends when accounting for the tanks most outboard extent.
- Take the maximum RA within the limited range
If unchecked, the maximum RA within the entire range of stability will be used to determine the s factor instead of the maximum RA within the limited range specified in the regulations.
- Include notes in the report
To eliminate pages in reports during initial runs.

Diagnostic & S macro

The Diagnostic button provides several ways to obtain or view intermediate results for checking and troubleshooting.



Specifying a division and the desired layer and level, a run file is produced and executed at the end of the Probabilistic Damage run. The results show the equilibrium condition and the tanks that are flooded. A

righting arm calculation and graph is included. Of particular usefulness, a trace file provides output which shows intermediate values calculated during the run with additional explanatory notes. The last option will enable the display, on the screen only, of a Condition Graphics window for all cases with a non zero Smin.

Terminating the run by pressing the Alt-F4 key is not recommended as it may cause the program to behave erratically. It may be better practice to select the division or divisions of concern and select only those in the Division Definition window for a shorter run and page through the displays.

The “S macro” button displays information if a user wants to use their own macro to calculate the S factor. The contents of such a macro will not be discussed here as it is beyond the scope of this manual.

