VOLUME 3

HYDROSTATICS & STABILITY

Contents:

3.1 Summary

This volume contains the following programs:

- Hydrostatic tables for even keel and trim
- Intact stability including criteria evaluation for minimum required GM
- Floodable length curves
- Launching calculations
- Tonnage calculation
- Bon-Jean-data

All of these programs are based on hull geometry. The calculation of hydrostatic data for many draft-trim positions is done for such a close spacing in draft and trim that interpolation in these tables can satisfy any required accuracy either in further calculations or in printing of calculation results.
Hydrostatic data and intact stability results are stored in computer memory as basic data for calculation of loading conditions and damage stability.

General comments on all programs

The calculation method is similar to the classic methods; the number of frame sections of the ship is evaluated because it represents the basis for the longitudinal integration. The calculation of the frame sections from the hull form data is described in the program hull form. Note that frame sections can be calculated from BL up to any of the described decks on any longitudinal position.

Waterline description is used in different ways:

- Waterlines in hull form description are used only to describe the hull form geometry.
- Calculation waterlines specify levels up to which the calculation of the displacement etc. is to be done (Data sheet sth, data set 17).
- Result-waterlines specify levels at which the result is desired. (For example on Data sheet hydr).
- The only relation between these three concepts of waterlines is that waterlines in item 3 have to be within the range of waterlines in item 2.

This volume consists of:

- Hydrostatic data, intact stab etc. Data sheet sth.
- Hydrostatic data for even keel and trim. Data sheet hydr.
- Intact stability including criteria evaluation. Data sheets stb1, stb2, stb3, lcond.
- Floodable length curves Data sheet floodl.
- Launching calculation. Data sheet launch.
- Tonnage calculation. Data sheet tonnl, tonn2.
- Bon-Jean data. Data sheet bonj.

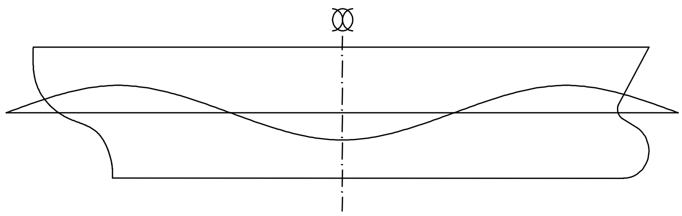
3.2 Data sheet description

Data sheet sth - calculation of basic data

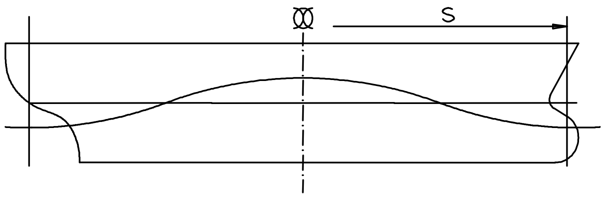
This data sheet is used to form the basic tables for hydrostatic stability data.

__16__ ***ship no*** is a number chosen by the user to identify the ship. Has to be the same as in former data sheets.
i is a trigger which determines which calculation is to be performed:
i =1 stability calculation
i =2 hydrostatic calculation - general
i =3 hydrostatic calculation for floodable length curves
i =4 hydrostatic calculation for tonnage calculation

Wave data



There is a need sometimes to perform the calculation for the ship in regular waves. These are particularly stability calculations and the longitudinal strength calculation for the ship in hogging and sagging position. All the calculations are made for the wave data specified here which means that if various conditions have to be tested for the various wave heights or position of waves, the calculations have to be done in separate runs each time starting from HULL74. Note that so called "Smith-effect" is not taken into consideration. The lifting force for buoyancy is calculated as if the pressure was static and corresponding to the WL level at each frame section.



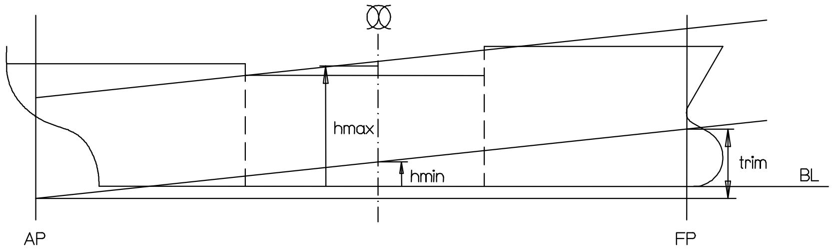
__160__ ***type*** represents wave type as follows:
type =0 no wave
type =1 sinus formed wave
type =2 trochoid formed wave

l = total wave-length (normally =Lpp)
h = total wave-height
s = x-coord for the min-point of the wave

Example:
s =0 for sagging
s =Lpp/2 for hogging
any ***s*** value can be stated

print =1 gives as intermediate result the calculated wave height for each section
hmin, hmax, nvl, tmin, tmax, ntr define all draft-trim-positions for which calc. has to be done.

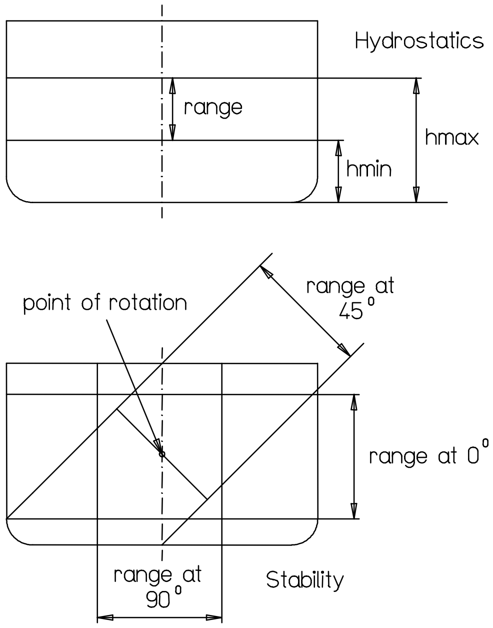
Example:
hmin =2, ***hmax*** =8, ***nvl*** =61, ***tmin***, =-2, ***tmax*** =1, ***ntr*** =11 will give a tabulation of hydrostatic or intact stability data for draft =2.0, 2.1, 2.2, ..., 8.0 and trim -2, -1.7, -1.4, ...,1 m. In total this means 61*11=671 different trimmed waterline positions.



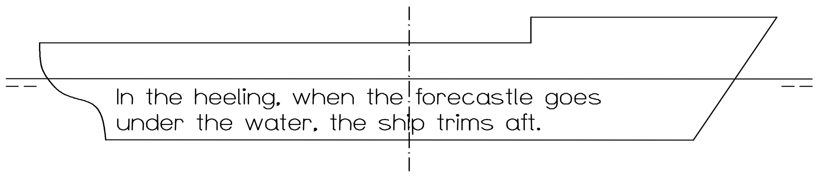
As the sketch shows, draft refers to amidships and trim is the difference in draft at FP and AP. Trim is positive if the draft forward is greater than the draft aft.

Relevant choice of draft-trim ranges

Data ***hmin***, ***hmax***, ***tmin*** and ***tmax*** have to be defined in such a way that all ship conditions which have to be analyzed or only printed are inside that range. Special care has to be taken for the stability data. The required range of calculated drafts for various angles of heel is demonstrated in the sketches. The easiest way to check that defined range is sufficient for all angles of heel is to draw the waterlines ˝hmin˝, and ˝hmax˝, on transparent paper, lay it down on the body plan and rotate it about the point which is half distance between hmin and hmax on CL. Ships with big B/D ratio need quite bigger hmin - hmax range that the draft range for an unheeled position only. Also, the trim range may raise certain difficulties.



When the ship heels, normally it also trims, to keep the longitudinal position of LCB constant. Where such a ship has a large superstructure forward or aft (see the sketch) this trim effect can be substantial. This means that even for the zero trim stability cases, trim range has to be big enough to include those trims that will certainly appear during the heeling of the ship. If the real draft – trim position is outside the range for any calculated condition, the program fails to work for that particular case. If, for example, the ship in damaged condition is outside the range for two angles of heel, these two calculations are omitted. On the other hand, choosing the range that is too large results in a lower accuracy due to the larger spacing between the WLS and the trims respectively. For obtaining the best possible accuracy it is recommended to choose the max allowed values for ***nvl*ntr***. The balancing between ***nvl*** and ***ntr*** depends on how large the draft range is compared to the trim range and how important the trim value is in relation to draft. Normally ***nvl > ntr*** (say ***nvl*** =1.5*ntr → 3*ntr)

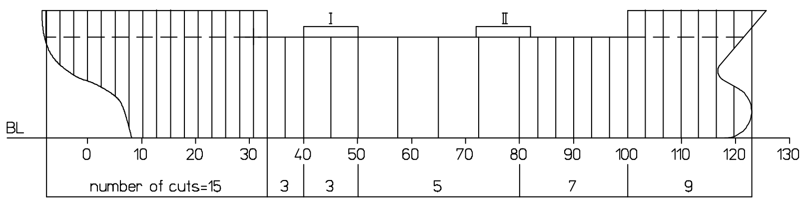


N.B. Always choose ***ntr*** ≥10

(***hmin*** + ***hmax***)/2 has to be inside proper hull form area.

Data sets **<u>18</u>** - **<u>21</u>** define how many sections have to be used in the calculation. These sections are interpolated from given hull form data. Consequently the number of calculation sections doesn't have to be limited to the number of input data sections defining the hull form.

To demonstrate this, in the following example hatch I is described as a step in the camber and hatch II as an appendage. This means that the hull form which has to be integrated has steps in area of hatch I, but not of hatch II because appendages are calculated separately. The sections to be calculated are marked on the sketch.

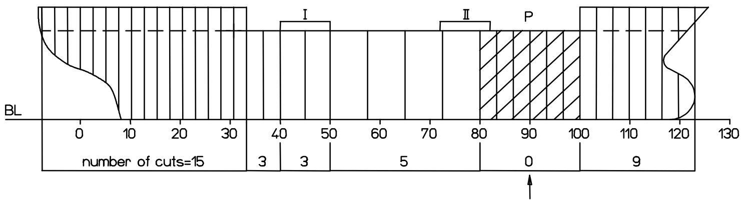


Input for the sketch

Fr	-8	33	40	50	80	100	123
dx	0	0	0	0	0	0	0

B	15	3	3	5	7	9
C	1	2	2	2	2	3

Simpson’s first rule is used in the calculation. In order to do the longitudinal integration by Simpson’s rule correctly each continuous part must be calculated separately. For each part the number of sections to be calculated is specified as well as the number of the deck up to which the calculation has to be done. It is possible to calculate only a part of the ship. For example, assume that hull form for the complete ship is defined. Stability calculation can be done for the whole ship and for the aft and fore-body separately by repeated running three times. In the same way, it is possible to calculate up to different decks without re-defining the hull form.
If number of calculation sections is equal to 0, for part (P) of the ship, hydrostatic and stability data respectively are calculated with this part excluded. (damage stability with lost-buoyancy-method).



Input for the sketch

fr	-8	33	40	50	80	100	123
dx	0	0	0	0	0	0	0
B	15	3	3	5	0	9	
C	1	2	2	2	2	3	

If //// are punched in data sets **18** - **21**, calculation will be performed only for appendages.

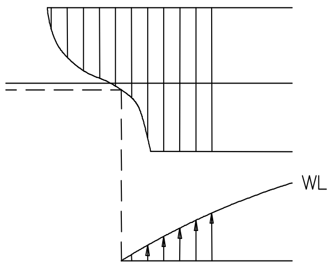
Relevant choice of number of calculation-sections

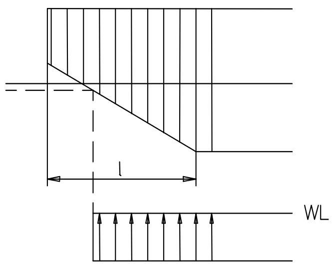
Stability

Experience shows that GZ-curves are very accurately calculated even if using a fairly small number of sections. However, as the calculation is very quick, it is still recommended that not less than 30-35 calculation sections should be used. For the parallel part of the ship one section would be enough if no trim occurs but with trim and angle of heel there is a need for more sections in the parallel part to give accurate integration longitudinally.

Hydrostatic data

If displacement and other items need to be calculated very accurately, which normally is the calculation-sections, the calculation should use more sections than are needed for the stability calculation. The computer time is very short so calculation for about 50-100 sections may be reasonable.
It is to be noted that at calc. of floating area LCF, etc, Simpson’s rule is used without special end correction. For normal ship forms (fig. a) the accuracy is enough. For ship forms as fig. b the error will be fairly big if not very many sections are used. If l is 10% of the total ship length, it is recommended to choose 51 sections for this length, which will give a spacing of (0.1L /50=0.002L) (L = ship length) between calculation frames.





General comments to choice of data

In case of uncertainty about accuracy, repeat the calculation, for different numbers of sections, waterlines and trims and then compare the results.

Angles of heel for stability data

Although the classic calculation was usually made for the angle range from 0 to 90^0, the GZ-curve for the angles above the 60^0 is of very small practical value. This can be seen in the IMO regulations that stipulate requirements for limited angles of heel. The choice of angles of heel influences the following:

- GZ curves are printed for the stated angles.
- GZ curve is fitted with spline function for the stated angles. Since the criteria evaluation is based on this fitted curve it's important that it represents an accurate approximation of the real GZ curve.

Here are some advices based on this:

- Limit the calculation range to really needed. Normally, max. 50^0-60^0 for intact stability and max 20^0-45^0 for the damage stability.
- Choose closer angles in most important range, but, to ensure good curve fitting, the spacing must not change rapidly.
- Total number of angles is normally between 6 and 12.

Example for the choice of angles
Intact stability 0 5 10 15 20 25 30 35 40 45 50^0 or 7 15 22 30 40 50 60^0.
Damage stability 0 2 4 6 9 12 15 20 25^0

The angles for damage stability are selected under the assumption that the requirements apply for small angles (example angle of heel max 15^0 etc.). For the special type of the ships, e.g. gas carrier, the above angles are not applicable.

Some special options in the program not mentioned in the Data sheet

There is a possibility to add two print codes, ***prin1*** and ***prin2*** after ***ship no*** and ***i*** in the first line of the data sheet. These codes, which enable printing of the intermediate result; are used only in special cases to check the program that the final result is correct. Some of the print codes give very extensive printout and should therefore be used very carefully. (it's convenient to reduce the number of sections, WLS, trims, etc. in order to limit the printout.).

Print codes give the following printing:

<u>For stability calculation:</u>

<u>16</u> ***prin1*** =1 prints the y-z coordinates for all calculated frame sections (requested in data set **<u>18</u>** - **<u>21</u>**)
prin1 =2 as for ***prin1*** =1 but frame areas and frame area moment for all calc. WLS (specif. in data set **<u>17</u>**) are also printed; printing is made only for the first angle of heel
prin1 =3 as for prin1=2 but areas and moments are printed for all angles of heel
prin2 =1 displacement and displacement moments are printed for all calculated draft-trim values specified in data set **<u>17</u>**; printing is made only for the first angle oh heel
prin2 =2 as above but printing is made for all angles of heel

<u>For hydrostatic calculation:</u>

prin1 =1 the y-z coord. for all calculated frame sections (requested in data set **<u>18</u>** - **<u>21</u>**) are printed
prin1 =2 as for ***prin1*** =1 but the frame areas and moments are included
prin2 =1 hydrostatic data for calculated WLS and trims are printed

<u>160</u> after ***l***, ***h***, ***s*** in the second data line a ***print code*** =1 can be added giving the calculated wave height for each section an intermediate result

<u>17</u> after ***ntr*** in the data set **<u>17</u>** the following two figures can be added
ipnt max number of points to be generated for the frame polygon representing a frame-section; the default value is 100 and it is advised not change this
print code =1 intermediate result is printed at calculation of a frame-section (very extensive printout)
print code =-2 omit all printed warnings occurring at interpolation of frame-sections (give ***ipnt*** =0 when this print code is stated)
<u>Note</u>: ***ipnt*** =0 if print code is given

<u>21</u> there are two extra options for ***deck number***, data set **<u>21</u>**, which can be applied:
deckno =-1 calculation is made to the highest deck described for the section in question
deckno =-2 calculation is made to the lowest deck described for the section in question

Hydrostatic calculation for a specific trim

It is possible to calculate all hydrostatic data for one specific trim by stating tmin = tmax and ntr =1. The result from hydr will contain all normal hydrostatic data but only for the particular trim stated above. Any print codes stated for printing of displacement, LCB, KMT etc. for a range of trims, are neglected.

Hydrostatic calculation for one waterline

There is a special option built in the program hydb (hydrostatic calculation) for calculating and printing intermediate results for one WL only. Give as input
hmin = hmax WL level
tmin = tmax trim
nvl =1; ***ntr*** =1
Execute STHYD and HYDB
Program output prints out Simpson's coefficient, section area, halfbeam etc. for each calculated section and finally the ship data for stated WL and trim.
This option is very useful for quick check of a printed result in hydrostatic data.

3.3 Hydrostatic data for even keel and trim

Data sheet hydr

This sheet defines which hydrostatic information has to be printed and how it has to be arranged.
In the example, hydrostatic data are requested for drafts between 2 and 6 m for 2 cm intervals.
The density of SW is 1.025 t/m³ and calculation is requested for 10 trims.

Printing code data set 45

The result is printed in the sequence indicated with the printing codes. This means that the user can easily form his standard but still has enough flexibility when special cases occur. A list of hydrostatic items that can be printed appears overleaf of data sheet hydr.
The "Basic Items" represents the data calculated in the calculation part. In printing of these data only linear interpolation is used.
Items on the following page are calculated from the basic data. The formulae used for these calculations are also given. There are alternatives in the matter of coefficients. They may refer either to perpendicular length and moulded breadth (codes 25 - 28) or length and breadth below the waterline in question (codes 35 - 37).
The last three items at the bottom of the page (code numbers 41, 42, 43) are the only ones used for printing of trimmed conditions. The trim values are entered in the third line of sheet hydr.
(Therefore, data has to be entered both in form of printing code and the values of the trim).
N.B. If not otherwise specified, coefficients refer to the moulded ship and other data to the ship with shell plating included.

Returning to data set **44**.

44 ***nset*** the number of tables to be printed on one page. Normally only one table set is printed on each page but when printing only a few data, it's convenient to print more sets of tables below each other on the same page.

ipage in all SEAKING program outputs, program version, data and page number are printed on the top of each page. This parameter enables the user to omit this line.

itext enables adding the text to the print codes in data set **46** that will be printed in the corresponding line. If such text is omitted, the program prints out the standard text. However, if any text has to be omitted, entering ***itext*** =1 suppresses printing of any (standard) text.

Calculation of basic tables for hydrostatics and stability

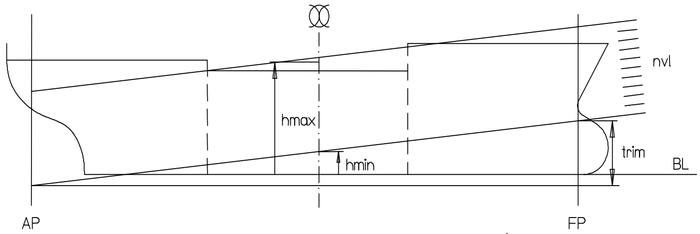
	ship no	i	0	prin1	prin2
16					

i =1 stability
i =2 hydrostatics generally
i =3 hydrostatics for floodable length
i =4 hydrostatics for tonnage

	type	l	h	s
160				

wave data or a blank card

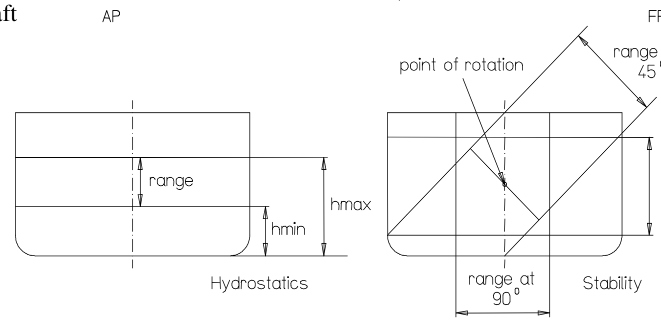
	hmin	hmax	nvl	tmin	tmax	ntr
17						



hmin lowest calculated waterline from BL at midship
hmax highest calculated waterline from BL at midship
nvl total number of waterlines in hmin - hmax range
tmin lowest trim (max trim aft, with minus sign; trim aft negative, trim fore positive)
tmax greatest trim (max trim forward)
ntr total number of trim in tmin - tmax range

Restrictions in number of WLS and trims:

- for stability: nvl*ntr ≤ 1200 (recommended nvl =40, ntr =30)
- for hydrostatics: nvl*ntr ≤ 3200 ; nvl < 140 (recommended nvl =60, ntr =30)



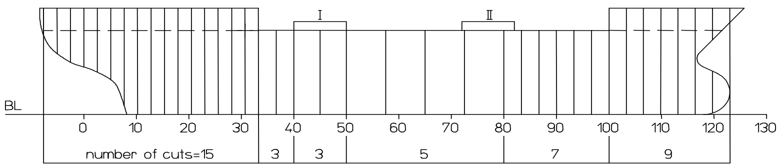
max 50 frame numbers can be stated

18	fr											
19	dx											
20	B											
21	C											

fr, dx x coordinates which divide ship into calculation parts
(If hydrostatic data have to be calculated for aft and fore body, fr.dx has also to be given for midship section.)
(This is done by stating fr =0 and dx = entered value for "distance from frame 0 to Lpp/2" in Data sheet 1.
B number of sections for the part above; must be odd and less than 200
C number of the highest deck included in the calculation for the part above

Input for the sketch:

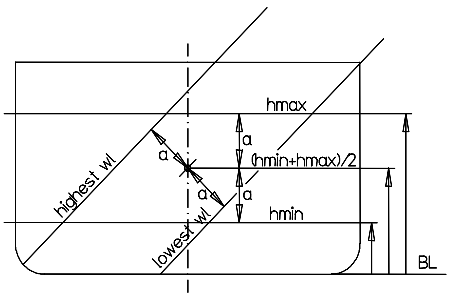
fr	-8	33	40	50	80	100	123
dx	0	0	0	0	0	0	0
B	15	3	3	5	7	9	
C	1	2	2	2	2	3	



22	one blank line

angles of heel only for stability calculation (maximum 14 angles)

23	0.1													



Note

The choice of hmin and hmax, which refer to midship section, is very important. For stated angles of heel the calculated WLS are defined in accordance with the sketch. Calculation cannot be made for any condition is outside the range (for all angles of heel). Apart from this, the tmin - tmax range has to include all trims for all conditions and angles.

Example of data sheet sthyd – data for hydrostatics:

```
402 2

-9.6 25.4 36 -15 15 30
0 0
-4.2 171.2
101
1
```

Hydrostatic data result part

	ship no	
43		If user creates his own print table using codes **46**

	ship no		iprint	
43		0	1	If user wants to use standard vertical printout with fixed values

req. drafts for hydrostatics | ←normally blank→ |

	hminr	hmaxr	dhr	ρ sw	ktrim		nset	ipage	itext
44					1	0			

nset = number of tables/page
ipage =1 data and page no not printed
itext =1 'standard' text is not printed

trims for which hydrostatic data are required (max 20) (the values are multiplied by ktrim)

45														

	code	no. of dec	mult.	salt water	text (max. 40 char.)
46					
	1000. (in the last line of the print codes)				

Print codes for control of the layout:

code — refers to the list

no of dec. — req number of decimals. Only 8 characters can be fitted. If no of dec =-1, the program automatically assigns number of decimals.
Advice:
Put number of decimals for draft and other linear data (LCB, LCF etc.) and put -1 for displacement etc. Such a print code is usable both for large and small ships.

mult. — factor by which the values are multiplied before printing. This enables results to be in other units than those of input data

Example: hull form in m

code	mult	
2	1	displ in m^3
2	35.315	displ in ft^3

salt water — blank (no action)
1 value is multiplied by ρsw before printing

Example: hull form in m; ρsw =1.009 t/ m^3

code	mult	salt water	
2	1	-	displ in m^3
2	1	1	displ in ton

Example: hull form in m; ρsw =1/35

code	mult	salt water	
2	1	-	displ in m^3
2	1	1	displ in ton

List of codes for basic items

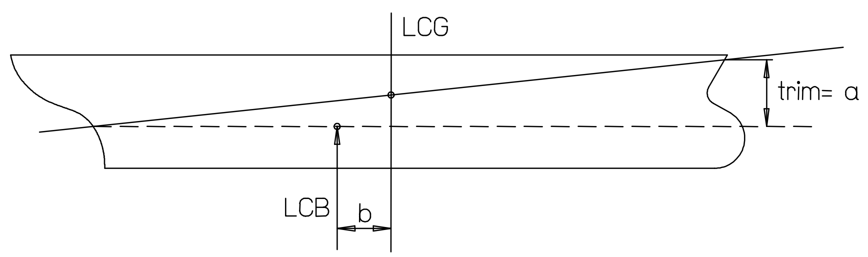
Code	Item
	Basic items
-1	New page (used only if the result is to be divided between several pages)
0	New line with text if stated
1	Moulded draught
1.1	B.O.K. (bottom of keel) draught
1.2	B.O.K. draught (m $\rightarrow$ ft)
	Displacement
2	Displ. moulded
3	Displ. total
4	Displ. after body
5	Displ fore body
6	Displ. - moment after body
7	Displ. – moment fore body
8	Displ. – moment about BL
	Waterplane
9	Area moulded
10	Area total
11	Area moment about midship
12	I longitudinal
13	I transverse
	Other items
14	Wetted surface
15	Greatest transverse area (moulded; not necessary the midship area)
16	Greatest transverse area (total)
17	Max breadth of the actual waterplane
18	Actual length on waterplane
19	Maximum breadth up to waterplane
20	Maximum length up to waterplane

List of codes for items that are calculated from the basic items

Code	Items	Formula
21	Sum of fore and aft displ. moments about midship	(**7**-**6**)
22	M.C.T. 0.01m or 0.01ft	(**12/**Lpp)*0.01
23	Transverse metacentre KM_T	(**13**+**8**)/**3**
24	Longitudinal metacentre KM_L	(**12**+**8**)/**3**
25	CB on basis of Lpp, Bm	**2**/(Lpp*Bm***1**)
26	Prismatic coefficient Lpp, Bm	**2**/(Lpp***15**)
27	Coefficient of waterplane area Lpp, Bm	**9**/(Lpp*Bm)
28	Midship section area coefficient	**15**/(Bm***1**)
29	L.C.B. from midship (Lpp/2)	(**6**+**7**)/**3**
30	L.C.F. from midship	**11/10**
31	x coordinate which divides Δ in two equal parts	(**5**-**4**)/**16**
32	factor trim/trim lever a/b see sketch	**3***Lpp/**12**
33	V.C.B.	**8/3**
34	Δ moment about midship (compare to **21**)	**6**+**7**
35	Block coefficient (special coefficient)	**2**/(**20*19*1**)
36	Prismatic coefficient (special coefficient)	**2**/(**20*15**)
37	Waterplane coefficient (special coefficient)	**9**/(**18*17**)
38	L.C.B. aft-body	**6/4**
39	L.C.B. fore-body	**7/5**
40	“Midship section area coefficient”	**15**/(**19*1**)
41	Δ calculated for trimmed conditions	
42	L.C.B. calculated for trimmed conditions	
43	KM_T calculated for trimmed conditions	
44	The name of the ship	
45		
46	V.C.B. calculated for trimmed conditions	
47	Transverse centre of buoyancy	
48	Transverse centre of waterplane area	
49		
50	Tonnes per 1cm of immersion (tonnes/0.01m)	

Note: If not otherwise specified, coefficients refer to moulded ship while other data include shellplate.

Input data	ρsw	Displacement in
m	1.025	metric tonnes sw
m	1.009	British tonnes sw
ft	0.028567	British tonnes sw
ft	0.029025	metric tonnes sw



Example of Data sheet hydr:

```
402
2 18 0.1 1.025 1. 0
0
1 3 1
1.1 3 1
0
2 -1 1
2 -1 1 1
3 -1 1
3 -1 1 1
9 -1 1
10 -1 1
11 -1 1
12 -1 1
13 -1 1
14 -1 1
22 -1 1
23 -1 1
24 -1 1
25 4 1
26 4 1
27 4 1
28 4 1
29 3 1
30 3 1
33 3 1
50 -1 1
1000.
```

3.4 Intact stability including criteria evaluation

Data sheet stb1 - intact stability results

<u>47</u> ***ship no*** is the same number as stated for hull form data.

meth The heel of the ship normally causes a change of trim (the equilibrium trim position requires LCB and LCG to coincide). If the ship has a large forward or aft superstructure that is submerged in the heeled position, this change of trim can be substantial. From the stability point, it's important to realize that this trim effect almost always results with a reduction of the righting lever for the ship. Hand calculation, however, is mostly made for fixed trim to limit the amount of work and also there are some computer programs that do not cater for the trim effect. For these reasons, to enable results comparison, the option to do the calculation for fixed trim is given.
omitp omits the printout of input
Printing of the following intermediate results:
prin1 =1 Cross-curves interpolated from data calculated by the program stabb.
prin2 =1 MS-curves interpolated for small angle-intervals.
prin3 =1 GZ-curves fulfilling each of the limiting criteria asked for.

<u>48</u> ***point no*** represents the following type of points:
point no =1 indicates openings (these points are used for calculating the flooding angle (vf), necessary for the criteria evaluation). On the result page, the angle of heel at which certain point is immersed is printed for all stated points.
point no =2 indicates deck edge

Example of printout for stated points:

```
402

ANGLE OF HEEL AT WHICH STIPULATED POINTS BECOME IMMERSED
========================================================

THE TABLE APPLIES FOR TRIM=  0.000  IN UPRIGHT CONDITION


COORDINATES FOR SPECIAL POINTS ON THE SHIP
POINT   FRAME       Y       Z    TYPE
    1  25.000  11.620  21.970   1.000
    2  -7.000   8.134  17.741   2.000
    3  -3.500   9.346  17.704   2.000
    4   0.000  10.509  17.686   2.000
    5   3.500  11.576  17.637   2.000
    6  11.000  13.446  17.580   2.000
    7  21.600  15.448  17.520   2.000
    8  41.000  16.100  17.500   2.000
    9 150.875  16.100  17.500   2.000
   10 204.000  10.727  17.663   2.000
   11 204.000  12.438  20.532   2.000
   12 208.770  10.118  20.585   2.000
   13 213.541   7.149  20.652   2.000
```

*** INDICATES THAT THE POINT IS NOT FLOODED FOR CALC.RANGE OF ANGLES

POINT NUMBER AS DEFINED IN ABOVE TABLE

DISPL	1	2	3	4	5	6	7	8	9	10	11	12	13
10500	****	****	****	****	****	****	69.3	64.3	58.8	****	****	****	****
15500	****	****	****	****	****	****	58.8	54.7	50.2	****	69.2	****	****
20500	****	****	****	****	****	61.1	50.6	47.4	43.9	62.5	61.7	****	****
25500	****	****	****	69.6	62.7	52.7	44.4	41.7	38.7	54.4	55.5	63.4	****
30500	63.8	****	67.1	59.8	54.3	46.2	39.3	37.1	34.6	47.6	50.0	57.1	67.9
35500	58.1	65.3	58.1	52.2	47.5	40.7	34.9	33.0	30.9	42.0	45.4	51.6	61.4
40500	53.0	56.5	50.3	45.4	41.4	35.8	30.9	29.4	27.8	37.4	41.5	46.9	55.5
45500	48.3	48.6	43.5	39.4	36.1	31.4	27.3	26.0	24.8	33.5	38.0	42.8	50.5
50500	43.8	41.5	37.3	34.1	31.3	27.3	23.7	22.6	21.8	30.0	34.9	39.3	46.1
55500	39.6	35.2	31.8	29.0	26.6	23.2	20.1	19.2	18.7	26.2	32.0	36.0	42.3

This example shows that, for instance, at displacement of 35500 tons, point number 1, which represents opening, is immersed at the angle of 58.1.

Stability criteria

During the last years an intensive effort has been made and still is at IMO in order to stipulate relevant stability requirements for various types of ships. Instead of building in these regulations directly to the program, the user has to state his individual requirements in the input data. Such approach is more flexible since it doesn't require modification with every change of IMO rules and can also be used to evaluate the effect of various new proposals for stability criteria.

Each line indicates one requirement and there can be up to 15 requirements. The program finds minimum GM necessary to meet certain requirement. The max-value of these GM-values is then the overall GM-REQUIREMENT. This evaluation is performed for each draft (and trim if requested) and gives then limiting GM-curve.

Example of data sheet sthyd – data for hydrostatics-stability:

```
402 1

-10 25 36 -15 15 30
0 0
-4.2 171.2
81
1

0.1 7 15 22 30 40 50 60 70 90
```

Example of data sheet stb1 – intact stability results:

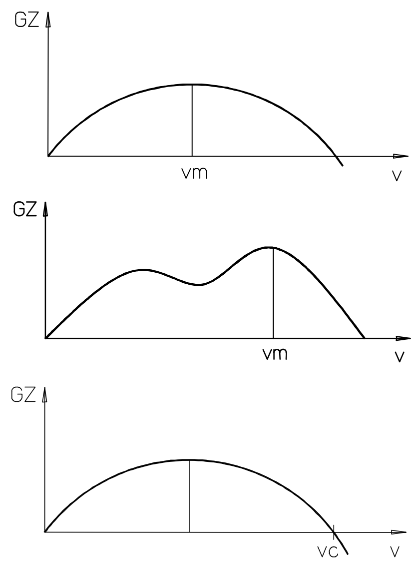
```
402

1 0 17.6 11.62 21.97 1
2 0 -4.2 8.134 17.741 2
3 0 -2.1 9.346 17.704 2
4 0 0 10.509 17.686 2
5 0 2.1 11.576 17.637 2
6 0 6.6 13.446 17.58 2
7 0 14.88 15.448 17.52 2
8 0 30.4 16.1 17.5 2
9 0 118.3 16.1 17.5 2
10 0 160.8 10.727 17.663 2
11 0 160.8 12.438 20.532 2
12 0 164.616 10.118 20.585 2
13 0 168.433 7.149 20.652 2

1 0.055 0 30
1 0.09 0 40
1 0.03 30 40
3 0.09 0
3 0.03 30
4 0.2 30 90
7 0 25
7 0.15 0



2 10500 55000 5000 1.025 10500 10.566
0
0 1 0 2 0 2 1 4 0 5 0 8 0 9 0 10 0 1 -3
```

To simplify the input, it is possible to state reference to complete sets of criteria for various regulations. Entering criteria type 101 corresponds to IMCO 167 and is equivalent to the following set of criteria:

Criteria	Parameters			Description	
type	p1	p2	p3		
1	0.055	0	30	Area =0.055	between 0° and 30°
1	0.09	0	40	Area =0.09	between 0° and 40°
3	0.09			Area =0.09	between 0° and vf
1	0.03	30	40	Area =0.03	between 30° and 40°
3	0.03	30		Area =0.03	between 30° and vf
6	0.2	30		GZ =0.2	in at least one point in the interval 0°-30°
11	0	25		GZ-max	at an angle not less than 25°
7	0.15	0		GM =0.15	

Explanation of abbreviations:

GZ righting arm in m or ft. GZ has the same unit as being used for hull data
v angle of heel
A area under GZ curve
(mrad or ftrad, see GZ above)
vm angle at which GZ has its max-value
vf angle of heel when any opening is flooded. (i.e. any of the stated points type 1)
vc capsizing angle
vr calculated range i.e. the last angle stated on data sheet sth. (In some cases the program might fail to calculate all stated angles because draft- trim range has been given too small on sheet sth. In this case vr =max. really calculated angle)

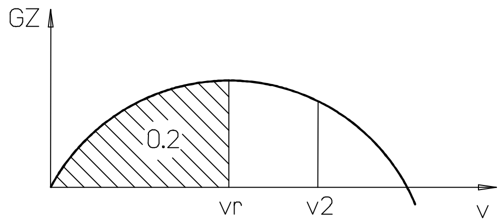


General comments to all criteria

If v1≥vr it is not possible to calculate required GM; in that case ****** is printed for GM. Sometimes, the second angle v2, vf, vm or vc is greater than vr and since the GZ-curve is know only to the point vr, the correct calculation cannot be performed. In such a case the program replaces mentioned angles with vr and performs the calculation thereafter. This might result with the calculated GM higher than what is required.

Example:

Criteria 1
v2 =50° and vr =40°
Required area: 0.2

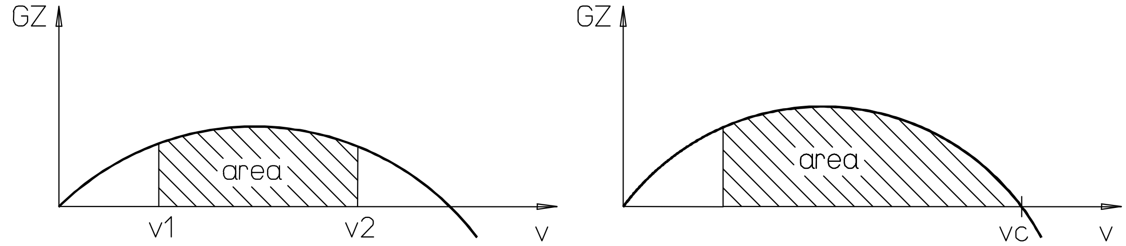


The program prints GM necessary to meet the requirement 0.2 to the angle 40°of 50°. This is indicated by the program and can be printed by stating print code =4 in data set **54** in data sheet stb3.

Description of each criteria

Criteria type 1

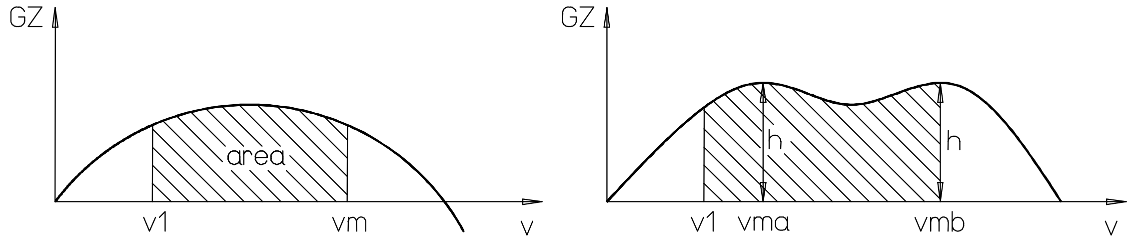
Area between the angles v1 and v2.



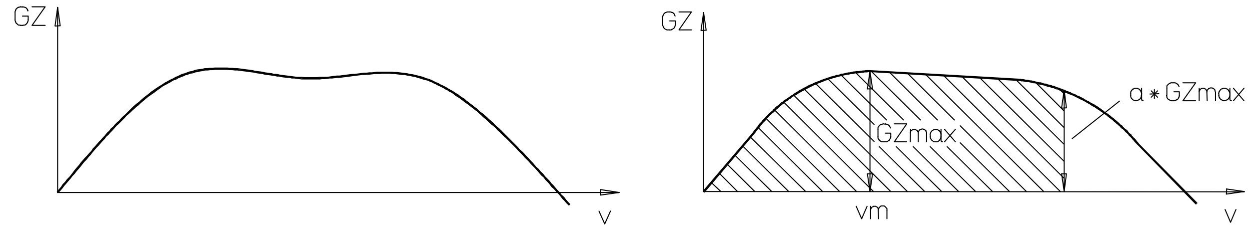
If v2 > vc area is calculated to vc
If v2 > vr area is calculated to vr
If v1 > v2 characters **** are printed for GM

Criteria type 2

Area between the angles v1 and vm.



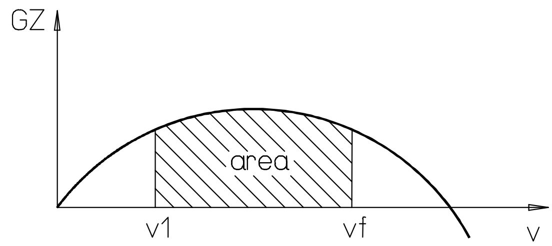
Left figure shows the case when calculated GM gives exact minimum area.
Right figure shows an example with two maxima, vma and vmb. GM is calculated in such a way that two maxima have identical values (h). Area between v1 and vma is smaller than required and area between v1 and vmb is bigger that required. Although for this case there doesn't exists GM which assures exact required area, GM value which gives two identical max-values is the real required GM value.
Sometimes it's difficult to determine the angle for maximum GZ with high accuracy if the curve is almost horizontal.



A small deviation in the GZ might give a big difference in angle vm and corresponding area. To check the influence of this flat part on the GZ-curve, the factor "a" can be used. The area is then calculated up to the angle where GZ has declined to a * GZmax. Normally "a" is omitted. If used choose 0.9 ≤ a ≤ 1.

Criteria type 3

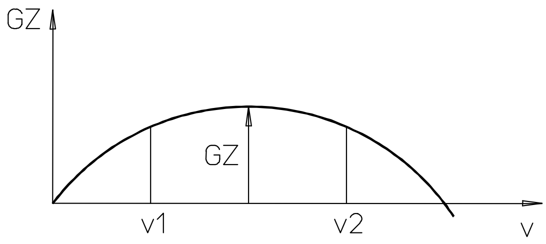
Area between angles v1 and vf.



If vf > vr, area is calculated to angle vr
If v1 > vf, **** is printed for GM

Criteria type 4

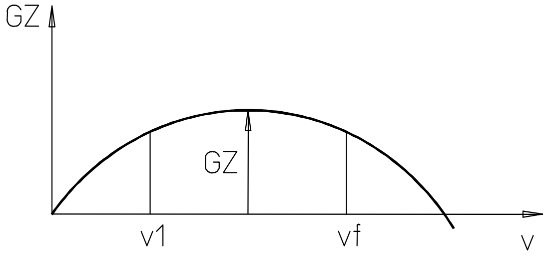
Required GZ to be obtained between angles v1 and v2.



If v2 > vr, GZ is calculated to vr (v2 is replaced by vr)

Criteria type 5

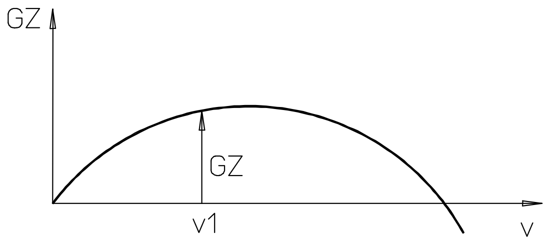
Required GZ to be obtained between v1 and vf.



If vf > vr, GZ is calculated to vr (v2 replaced by vr)
If v1 > vf, **** is printed for GM

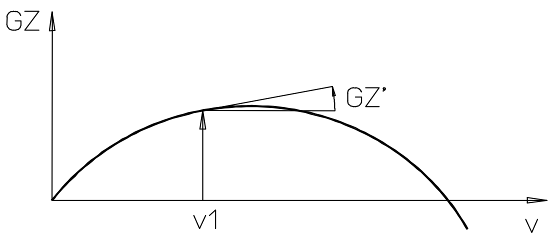
Criteria type 6

Required GZ has to be obtained exactly at v1.



Criteria type 7

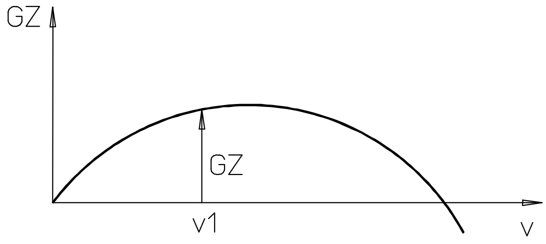
Required slope to be obtained at v1.



If v1 =0 the slope corresponds to the required GM.

Criteria type 8

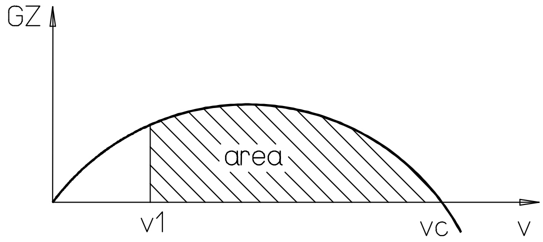
Righting moment to be obtained at v1.



Moment=displacement*GZ

Criteria type 9

Required area has to be obtained under the positive GZ-curve from v1 to vc.



If vc > vr, area is calculated to vr. (vc replaced by vr)

Criteria type 10

Allowable grain heeling moment.
If metric units are used ***p1*** =0.
If imperial units are used ***p1*** =1.
VCG1, VCG2 define the range of VCG
DVCG is the step in VCG
The result is allowable grain heeling moments for stated VCG-values in accordance with MSC 23 (59).
The following five requirements have to be met:

- Minimum GM =0.3 m
- Maximum angle of heel =12°
- Area ≥ 0.075 mrad to the angle of flooding
- Area ≥ 0.075 mrad to the max. righting arm
- Area ≥ 0.075 mrad to 40°

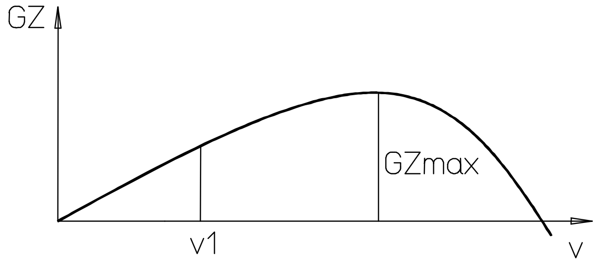
There is an option to print a table indicating which of the above requirements is the most onerous for each case. See the following example.

```
ALLOWABLE GRAIN HEELING MOMENTS IN ACCORDANCE WITH MSC.23(59)
============================================================
COLUMN 2 STATES THE MAXIMUM VCG TO MEET THE STATED CRITERIA EXCLUDING GRAIN
THE TABLE APPLIES FOR TRIM=  0.000  IN UPRIGHT CONDITION

          MAX   MAXIMUM ALLOWABLE HEELING MOMENTS AT FOLLOWING VCG
   DISPL    VCG     6.60   6.70   6.80   6.90   7.00   7.10   7.20
    5000  9.051     3466   3356   3245   3134   3024   2913   2803
    6000  8.637     3071   2938   2806   2673   2540   2408   2275
    7000  8.127     2780   2625   2470   2315   2160   2006   1851
    8000  7.821     2616   2439   2262   2085   1908   1731   1554
    9000  7.655     2586   2387   2188   1989   1790   1590   1391
   10000  7.582     2698   2476   2255   2034   1813   1592   1370
   11000  7.527     2930   2686   2443   2200   1956   1713   1470

ANALYSES OF LIMITING REQUIREMENTS

THE CODES BELOW INDICATE THE MOST LIMITING REQUIREMENT
1  MINIMUM GM= 0.3M
2  MAXIMUM ANGLE OF HEEL 12 DEGREES
3  AREA= 0.075 MRAD TO ANGLE OF FLOODING
4  AREA= 0.075 MRAD TO MAX RIGHTING ARM
5  AREA= 0.075 MRAD TO 40 DEGREES
```

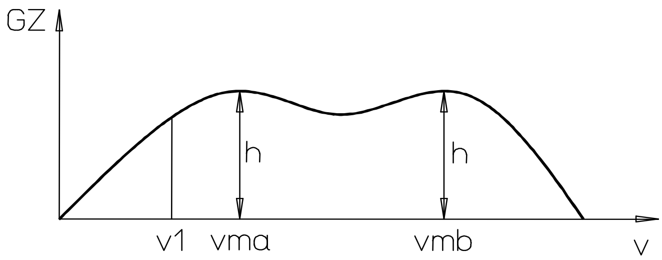
```
       ANALYSIS FOR FOLLOWING VCG VALUES
DISPL    6.60   6.70   6.80   6.90   7.00   7.10   7.20
 5000       2      2      2      2      2      2      2
 6000       2      2      2      2      2      2      2
 7000       2      2      2      2      2      2      2
 8000       2      2      2      2      2      2      2
 9000       2      2      2      2      2      2      2
10000       2      2      2      2      2      2      2
11000       2      2      2      2      2      2      2
```

Criteria type 11

The maximum righting lever (GZmax.) should occur at an angle of heel not less than v1.



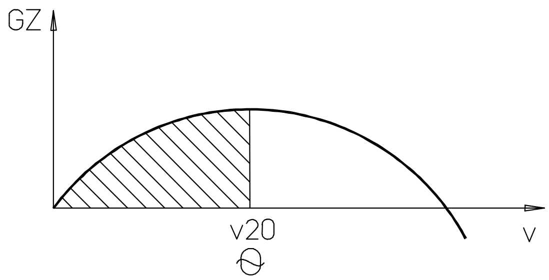
As already discussed in criteria type 2, it might be difficult to find the angle for GZmax if the GZ-curve has a flat part. Factor "a" can be used to calculate GM fulfilling the requirement that GZ at v1 should be at least a*GZmax (however, "a " is normally omitted).
The case of two maxima is also explained in Criteria 2. (Two equal maximum values at va and vb).



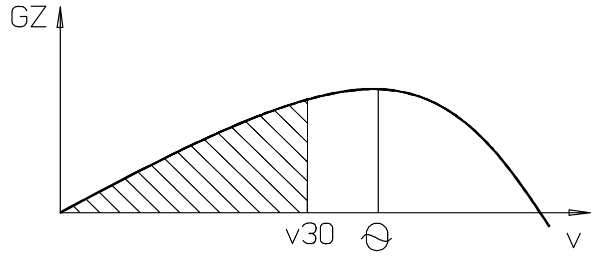
The corresponding GM is printed.

Criteria type 12

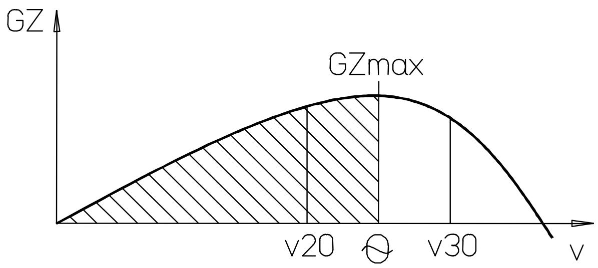
The area to be contained depends on the angle Θ where max GZ occurs.
a) Θ = v20. Area up to v20 must be ≥ A20.



b) Θ ≥ v30. Area up to v30 must be ≥ A30.



c) v20 < Θ < v30



The area up to the angle Θ must be greater than the area determined by linear interpolation:
area ≥ A20+(A30–A20)*(Θ-v20) / (v30-v20)
If v20 > vr, area is calculated to vr (v20 is replaced with vr)
If v30 > vr, area is calculated to vr and A30 = A20+(A30-A20)*(vr-v20) / (v30-v20)

Criteria type 13

IMO Resolution A562(14), weather criterion
Parameters
p1 =0
p2 =Ak Total overall area of bilge keels or area of the lateral projection of the bar keel, or sum of these areas.
p3 =0
p4 =0

Criteria type 14

Maximum angle of heel 15° or half angle of deck immersion.
Parameters
p1 =7
p2 =0
p3 =0
p4 =0

Data sheet wind data 82 (stb2) - calculating wind heeling moment

Data are used to print wind heeling moments. If there is no need for these data leave two blank lines. User can enter his own wind pressure or use the default pressure. The calculation of wind moment is done in the upright position. It is assumed that wind moment varies with the cosine of the heeling angle.
The program can also treat horizontal areas such as helicopter decks. For those areas, it is supposed that wind moment varies with the sinus of the heeling angle.

500 ***type =2*** user defined pressures on corresponding levels above waterline in dataset **50**

type =2 default pressures according to IMO MODU CODE (with the following values) if not defined by the user

Level above waterline	Wind pressure	Level above waterline	Wind pressure
0.000	0.165	91.500	0.236
15.300	0.165	91.500	0.245
15.300	0.182	106.500	0.245
30.500	0.182	106.500	0.251
30.500	0.198	122.000	0.251
46.000	0.198	122.000	0.258
46.000	0.215	137.000	0.258
61.000	0.215	137.000	0.264
61.000	0.226	152.500	0.264
76.000	0.226		
76.000	0.236		

type =3 pressure according to 'criteria for the US naval ships', with the following values:
The reference wind speed for those wind pressures is 51.5 m/s (100 knots).

Height above WL		Lever		Pressure	Pressure
ft	m	ft		tons/sq.ft.	met-ton/m2
0-5	0-1.524	4.5	(0.04)	8.888 x10-3	0.09721
-10	-3.048	9.5	(0.11)	11.58x10-3	0.12663
15	-4.572	14.5	(0.20)	13.79x10-3	0.15085
20	-6.096	19.5	(0.30)	15.38x10-3	0.16825
25	-7.62	24.5	(0.40)	16.33x10-3	0.17855
30	-9.144	29.5	(0.50)	16.95x10-3	0.18536
35	-10.668	34.5	(0.61)	17.68x10-3	0.19337
40	-12.192	39.5	(0.72)	18.23x10-3	0.19935
45	-13.716	44.5	(0.83)	18.65x10-3	0.20398
50	-15.240	49.5	(0.95)	19.19x10-3	0.20989
55	-16.764	54.5	(1.06)	19.45x10-3	0.21271
60	-18.288	59.5	(1.18)	19.83x10-3	0.21689
65	-19.812	64.5	(1.30)	20.16x10-3	0.22042
70	-21.336	69.5	(1.41)	20.29x10-3	0.22188
75	-22.860	74.5	(1.54)	20.67x10-3	0.22607
80	-24.384	79.5	(1.66)	20.88x10-3	0.22836
85	-25.908	84.5	(1.79)	21.18x10-3	0.23167
90	-27.432	89.5	(1.91)	21.34x10-3	0.23339
95	-28.956	94.5	(2.02)	21.38x10-3	0.23377
100	-30.48	99.5	(2.14)	21.51x10-3	0.23522

1 ton/sq.ft. =2240 lb/sq.ft. =2240 x 47.88 N/m2 =2240 x 47.88 x 0.10197 x 10-3 ton/m2 =10.9364 ton/m2

501 v_{ref} is reference wind speed at which the wind pressure is given. For calculation of the wind pressure at other wind speed (v), the pressure is multiplied by the factor (v/***vref***)^2

print code =1 printing of intermediate results

print code =0 no printing of intermediate results

Wind elements

Wind elements are polygons parallel to xz plane or to the xy plane. Constant coordinate (y_0 and z_0) for an element is given once. Frame no., dx and the third coordinate are given for each point of the polygon. The points can be given clockwise or counterclockwise.

51 ***ident*** is identification number

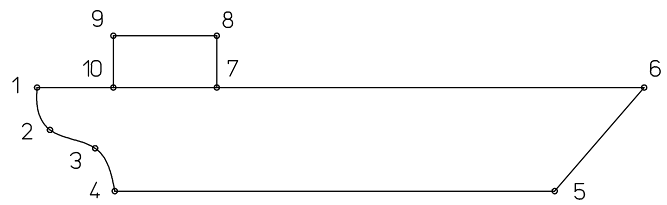
type =1 polygon is parallel to the xz plane

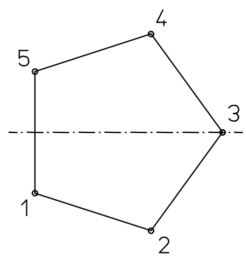
type =2 polygon is parallel to the xy plane

coeff is shape coefficient e.g. according to the MODU code

y_0, z_0 is the constant coordinate for the plane of the element (y_0 could be omitted)

frame no+dx is the longitudinal coordinate





The polygon can start in any point and the input sequence can be clockwise or counterclockwise.

Restrictions

Max number of input lines for wind pressure is 30.

Max number of polygon points for one wind element is 49.

Max number of polygon points totally is 1000.

Default wind pressure

If default wind pressure is wanted, give one blank line instead of pressure levels and pressures. The reference wind speed for these pressures is 51.5 m/s (100 knots).

The program prints a table of wind heeling moment around the following three reference points:

1. Around the waterline
2. Around the half draft (d/2)
3. Around the center of lateral area below the waterline (C.O.A.)

The reason for these three alternatives is variety of national regulations definitions.

An example of output is shown below:

```
 WIND HEELING MOMENT FOR TRIM=  0.000 IN UPRIGHT CONDITION
 =========================================================

 VF = ANGLE AT WHICH LOWEST OPENING IS IMMERSED
 VD = ANGLE AT WHICH LOWEST POINT OF DECK IS IMMERSED
 ***  INDICATES THAT NO POINT FLOODED FOR CALC. RANGE OF ANGLES

 WINDHEELING LEVER IS STATED AROUND WATERLINE (WL), HALF DRAFT(D/2) AND
 CENTRE OF LATERAL AREA BELOW WATERLINE (COA) AND THE CORRESPONDING
 HEELING MOMENT ARM GIVEN (WINDMOMENT/DISPLACEMENT)
         VF    VD    WIND   WIND    HEELING LEVER AROUND     HEELING MOMENT ARM
DISPL                AREA  FORCE     WL     D/2  C.O.A.      WL     D/2  C.O.A.
30500  63.8  34.6  2327.8  388.6   7.917  11.372  11.331   0.101  0.145  0.144
35500  58.1  30.9  2152.1  359.1   7.444  11.429  11.385   0.075  0.116  0.115
40500  53.0  27.8  1977.7  329.9   6.995  11.502  11.451   0.057  0.094  0.093
45500  48.3  24.8  1803.4  300.8   6.579  11.599  11.535   0.043  0.077  0.076
50500  43.8  21.8  1629.1  271.6   6.201  11.725  11.644   0.033  0.063  0.063
55500  39.6  18.7  1456.6  242.7   5.860  11.883  11.785   0.026  0.052  0.052
```

Data sheet stb3

This sheet specifies which drafts-trims or displacements have to be evaluated. Also, the layout of printout is specified here.

52-**54** specify output for range of drafts or displacement. If not required, leave three blank lines. Draft range or displacement range is defined with min., max. value and interval. For example:
hmin =4, ***hmax*** =8, ***Δh*** =0.2 provides result between 4 and 8m draft with the step of 0.2m.
light ship data, if stated, are used in calculation of max. deadweight moment about the BL to meet required criteria. Also, maximum possible KG of the ship that meets the stated criteria is calculated for each draught or displacement. By subtracting the lightship data, program can print max. allowable deadweight moment as function of the deadweight.
trim, if stated, refers to upright position. Depending on the chosen method, the trim will then vary or be kept constant in heeled conditions.
print codes, which can be stated in any order, indicate which result is printed. The table describes each of the available print codes.

55-**57** ***special conditions to be printed*** offer a possibility to print stability for special conditions in addition to the stability for the draught/displacement range defined in data sets **52** through **54**. Special conditions can be specified in three different ways:

- alternative 1: draught and trim are stated
- alternative 2: displacement and trim are stated
- alternative 3: displacement and LCG are stated

All of these three alternatives can be used in any order in the same run. For the special conditions KG and ρsw can be varied.

Data sheet lcond is used if free surface effect on GZ-curves has to be taken into consideration. (This sheet is normally used for description of loading conditions for damage stability). However, the criteria evaluation does not take the effect of free surface into consideration.

The result for the special conditions is more extensive. Data set **55** gives the possibility to skip parts of the results in order to get a shorter printout. If 1 is entered instead of 0, the corresponding line/lines in the result will be skipped.

Stability data result part

	|←		normally blank		→|
ship no	meth	omitp	prin1	prin2	prin3
47					

meth =0 const LCB at heel
meth =1 const. trim at heel

description text for included parts (like poop forecastle and opening

Stacking input
EXEC STABR
Data sheet stb1
stb2 or 2 blank cards
stb3
lcond if requested
EXEC STAB8

Coordinates for special points on the ship (usually openings)
Type =1 indicates openings. (These points are used for calculation of vf for criteria evaluation)
Type =2 indicates deck edges

48 (max 15 points)

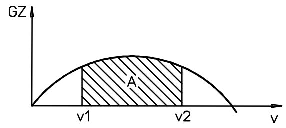
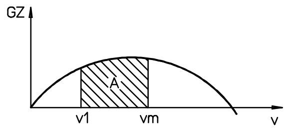
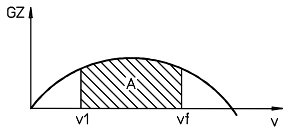
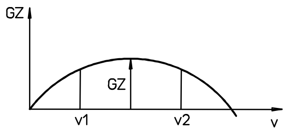
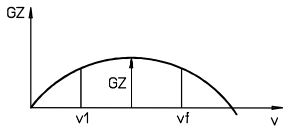
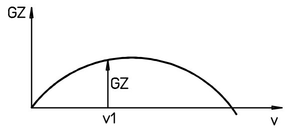
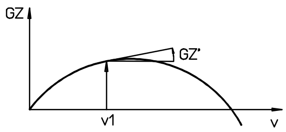
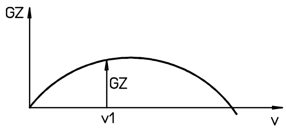
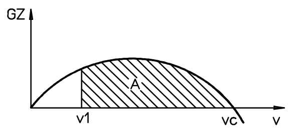
point no	frame no	distance dx	y coord	z coord	type no	text (max 40 characters)
one blank line						

Stability criteria
This table contains one or more items.
KG - GM requirement is calculated for each item

49 (max 15 criteria)

criteria	parameters			
type	p1	p2	p3	p4
one blank line				

Abbreviations:
GZ righting arm in m or ft
v angle of heel in degrees
A area in mrad or ftrad
vm angle at which GZ has its max. value
vf angle of heel when any of "type1" is flooded
vc capsizing angle (angle of vanishing stability)
vr upper limit for calculation angles of heel (range)

Criteria type	p1	p2	p3	p4	
1	A	v1	v2		
2	A	v1	(a)		
3	A	v1			
4	GZ	v1	v2		
5	GZ	v1			
6	GZ	v1			
7	GZ'	v1			
8	M	v1			 M = GZ*displacement
9	A	v1			
10	0 / 1	VCG1	VCG2	ΔVCG	Allowable grain heeling moment. p1 =0 for m, p1 =1 for ft. VCG1, VCG2 and ΔVCG state range and step for VCG
11	0	v1	(a)		max value of righting arm at an angle not less than v1
12	v20	v30	A20	A30	UK requirement. Usually v20 =20°; v30 =30°. A20 and A30 state required area to the angles v20 and v30
13	0	A_k	0	0	Weather criteria A562. A_K is the total area of bilge keels or area of the lateral projection of the bar keel or sum of these two.
101					Complete IMO criteria 167

14	7	0	0	0	Maximum angle of heel 15° or half angle of deck immersion

500

type of wind input	text for the identification of wind data
1, 2 or 3	

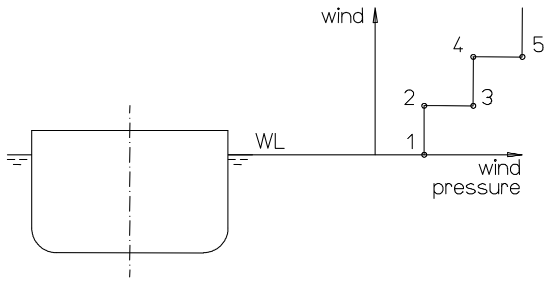
501

v_{ref}	print code

v_{ref} wind speed for which the stated wind pressure applies
print code =0 normally
print code =1 print the intermediate results from the wind calculation

50

level above WL	wind pressure



Restrictions
Max number of input lines for wind pressure is 30.
Max number of polygon points for one wind element is 49.
Max number of polygon points totally is 1000.

Data sequence **500** **501** **50** is followed by any number of **51** **510** in any sequence.
The same units are used as for the other input (for example m and ton a 1000 kg)
Wind area data are described below but to be filled in on the next sheet, sheet2

Element parallel to xz-plane

51

ident	type	coeff	y_0	text
	1			

510

frame no dx z
all polygon points
one blank line

Element parallel to xy-plane

51

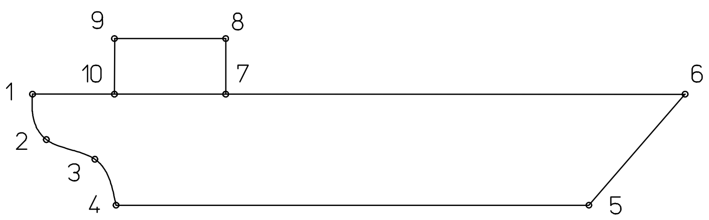
ident	type	coeff	z_0	text
	2			

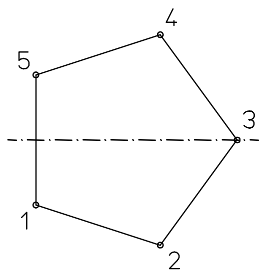
510

frame no dx z
all polygon points
one blank line

As seen above each element is followed by a blank line. One extra blank line has to be given after the last element.

ident		Identification number
type	=1	Polygon parallel to the xz plane
	=2	Polygon parallel to the xy plane
coeff		Shape coeff. e.g. according to the MODU code.
y_0, z_0		Constant coordinate fro the element. (y_0 could be omitted.)
fr no+dx		states the longitudinal coordinate





The polygon can start in any point and input sequence clockwise or counter clockwise.

51	ident	type	coeff	y_0/z_0	text (max 64 symbols)
510					

Each polygon has to be ended by one blank line followed by the identification for the next element etc.
Last polygon has to be followed by two blank lines.

Example of input file ‘stab.in’ with wind data and user definition of wind pressure:

```
460

1 0 -4.800 13.782 21.386 2 main deck at side
2 0 3.345 17.334 21.196 2 main deck at side
3 0 11.490 19.515 21.079 2 main deck at side
4 0 19.636 20.559 21.024 2 main deck at side
5 0 27.781 20.925 21.004 2 main deck at side
7 0 38.600 21.000 21.000 2 main deck at side
8 0 171.100 21.000 21.000 2 main deck at side
9 0 179.593 20.998 21.000 2 main deck at side
10 0 193.748 20.539 21.025 2 main deck at side
11 0 205.072 19.284 21.092 2 main deck at side
12 0 228.138 11.964 21.483 2 main deck at side
13 0 237.694 4.539 21.650 2 main deck at side
14 0 239.482 0.000 21.650 2 main deck at side
15 20 0.185 6.56 26.435 1 eng.room ventilation
16 25 -0.185 6.56 26.435 1 eng.room ventilation

1 0.055 0 30
1 0.09 0 40
3 0.09 0
1 0.03 30 40
3 0.03 30
6 0.2 30
7 0.15
11 0 25
13 0 1 0 0
14 7 0 0 0

2        ( type =2 with user defined pressures )
29        ( Vref )
0 0.0514        ( levels above waterline with corresponding wind pressure; 504 Pa = 0.514 t/m2 )
1 0.0514
1 0.0514
40 0.0514

1 1 1
0 -4.8 21.65
0 -4.8 13.1
6 0.00 10.864
8 0.00 10.223
9 0.00 9.732
10 0.00 8.959
11 -0.293 8.25
11 -0.172 7.500
10 0.00 5.397
8 0.3 3.9
9 0.00 3.324
11 0.00 2.105
14 0.00 1.031
. . .
```

Calculation to be performed for the following draft range and trim values

	alt =1	hmin	hmax	Δh	ρsw	lightship	
	alt =2	Dmin	Dmax	ΔD	ρsw	displ.	KG
52							

ρsw is the density of seawater. Light ship data are optional. Calculation range can be defined with drafts (alt =1) or with displacements (alt =2).

trim for unheeled ship (max 20 values)

53							

		i	p	i	p	i	p	i	p	i	p	i	p	
54	0													← print codes for the calculation requested above (maximum 14)
		1	KG	2	0	4	0	5	0	6	0	7	0	← example

Code	Parameter		Code	Parameter	
i	p	Result printed	i	p	Result printed
1	0	print KN values	4	0	messages about criteria evaluation
1	KG	if KG≥0, print GZ curves for stated KG	5	0	flooding angle for stated points
1	-1	print MS values	6	0	permissible heeling moment for grain
1	-2	print SMS values i.e. $\int MS\, d\varphi$	7	0	indicators for permissible heeling moment
1	-3	GZ corresponding to required GM	8	0	trim at heel
1	-4	SGZ corresponding to required GM	9	0	LCB at heel
2	0	GM requirements	10	0	draft at heel
2	1	allowable deadweight moment	11	0	wind heeling moment
3	0	(obtained values)	12	0	evaluation of weather criterion

Formats for codes 6 and 7:

code .1	choosing vertical A4 format
code .2	choosing sideway format
no decimal	automatic choice of format

	input	v	sin v	cos v	draft	trim	KN	MS	SKN	SMS	spec. points	GZ	
55													← print codes for the calculation below
		1	KG	2	0	4	0	5	0	6	0	7	← recommended values

Special conditions to be calculated (max 20 including number of data sheet 9)

alt =1	draft	trim	KG	ρsw	text (max 60 characters)
alt =2	displ	trim	KG	ρsw	text (max 60 characters)
alt =3	displ	LCG	KG	ρsw	text (max 60 characters)

56

Optional → subconditions which shall be described with single resultant line

					0	*no. cond.	text
					0	1	
					0	2	
					0	3	
one blank line							

*no. cond. - number of loading condition from cond.in which shall be printed in short - with only one resultant line

	n		
57			

n = number of loading conditions described on data sheet 9. For conditions described on that sheet the program evaluates the free surface effect on the GZ curves from liquids in tanks.

Loading conditions

	loading case number	description text for the loading case
61		

loading condition before damage

		ρ	d	t	CCG	KG	n
62	1				0.		

		ρ	D	t	CCG	KG	n
62	2				0.		

← use only one of these three alternatives

		ρ	D	LCG	CCG	KG	n
62	3				0.		

Description of symbols:
ρ = density of the sea water (ex. ton/m^3, or ton/cubft)
D = displacement
d = draft moulded
t = trim
LCG = longitudinal centre of gravity
KG = centre of gravity above BL
n = number of compartments with specified fluid cargo ≤ 50

		compartments with fluid cargo			
		comp no.	weight of cargo	density	% filling
63	1				
	2				
	3				
	4				
	5				
	6				
	7				
	8				
	9				
	10				
	11				
	12				
	13				
	14				
	15				
	16				
	17				
	18				
	19				
	20				
	21				
	22				
	23				
	24				

Stability curves are corrected for free surface effects arising from fluid cargo.
Fluid cargo can be defined as follows:
1. weight and density are stated (% filling is calculated)
2. weight and % filling are stated (density is calculated)
3. weight, density and % filling are stated. The % is used only to calculate the centre of gravity and moment of inertia

N.B: Values not stated are indicated by 0 on the data sheet.

CCG is the centre of gravity from CL.
Not included in all calculations.
(put CCG =0)

3.5 Floodable length curves

Data sheet flood1

Although floodable length curves will be of less interest in the future, the program that obtains these curves is enclosed in the package. The calculation is very straightforward and the explanation on sheet "flood1" will ensure sufficient explanation for the calculation. There are, however, a few restrictions.
Any appendages in hull form description and compartment on sheet sth are neglected.
The factor "subadd" does not operate for floodable length curves.
The whole ship must to be calculated with the same spacing of calculation sections. For that purpose, on Data sheet sth, in lines Fr and dx, only the aft and fore-most section of the ship has to be entered. Maximum number of calculation sections is 59. Longitudinal discontinuities will not in this case influence the accuracy of the calculation. (It is recommended to use maximum number of calculation sections).

Note

Special hydrostatic calculation (sthyd+hydfl) is needed as basis for floodable length calculation. Following applies:

- Equal spacing between calculation sections is required (i.e. only one number to be stated in lines B and C)
- Appendages are not allowed
- Input as follows:
  hmin =0
  hmax = highest margin point
  nvl ≤60 ,recommended value 60
  tmin = max trim aft for any damage condition (- sign)
  tmax = corresponding max trim forward
  ntr ≤100 ,recommended value 100
  i =3

Floodable length curves

ship no

70 | |
|---|

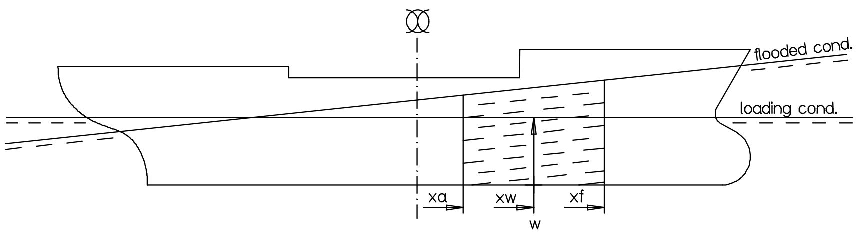
Margin line

71

fr. no	dx	z

Margin line has to be defined with so many points to ensure that the straight-line polygon passing through these points describes the margin line with sufficient accuracy.
The calculation is made for all given permeability's for each initial condition.
Before executing this program, programs sthyd and hydfl have to be executed with special data from Data sheet sth in order to get the basic hydrostatic data.
Important:
Maximum number of points on margin line is 100.
Maximum number of permeability's is 10.
Maximum number of initial conditions is 10.

Calculation method
Calculation is made in three steps:
1. For each of the specified trims on sheet sth the corresponding WL touching the margin line is calculated. Displacement and LCB for these WLS are also calculated.
2. Weight w and its longitudinal position xw that change the floating position from the loading condition to the above mentioned WL (flooded condition) are calculated.
3. By means of iteration the boundary xa, xf of a compartment is calculated in such a way that the flooded water for given permeability corresponds to w and xw.



permeability's (to be given in decreasing order (max 10 values)

72

Initial conditions

73

draft	trim
one blank line	

Before execution of this program hydrostatic data must be calculated with following special restrictions for data on sheet sth:
equal spacing between calc.-sections is required (i.e. only one number in lines B abd C)
hmin =0
hmax = highest margin point
nvl ≤60, recommended value 60
tmin = mac trim aft for any damage cond (- sign)
tmax = corresp. max trim forward
ntr ≤100, recommended value 100

Example of hydrostatic calc. before the floodable length curves

	hmin	hmax	nvl	tmin	tmax	ntr
	0	9	60	-6	6	100
Fr	-8	132				
dx	0	0				
B	45					
C	1					

Example of input file for flood:

```
402
-7.000  0.000  17.741
0.000  0.000  17.669
10.000  0.000 17.587
20.000  0.000 17.526
30.000  0.000 17.503
40.000  0.000 17.500
120.000  0.000 17.500
165.000  0.000 17.503
175.000  0.000 17.508
185.000  0.000 17.523
195.000  0.000 17.571
204.000  0.000 17.663
210.000  0.000 20.600
218.000  0.156 20.700

0.98 0.8
11.8 0
```

Example of output file for flood:

```
FLOODABLE LENGTH CURVES

PERMAEBILITY 0.9800

CONDITION     DRAFT 11.800 M     TRIM  0.000

X      LONG COORD FROM LPP/2 (MIDDLEPOINT)
FR     FRAME NO CORRESPONDING TO X
LENGTH FLOODABLE LENGTH
DRAFT  DRAFT AMIDSHIP AFTER FLOODING
TRIM   TRIM ON PERPEND LENGTH AFTER FLOODING
W      FLOODED WATER (VOLUME*PERM)
XW     LONG CENTRE OF FLOODED WATER

       X        FR    LENGTH     DRAFT      TRIM         W        XW

  -47.999    48.626    22.796    13.759    -7.586   10684.3   -47.784
  -30.882    70.022    28.896    14.483    -6.207   14104.0   -30.990
  -20.566    82.918    35.252    15.207    -4.828   17489.0   -20.738
  -13.355    91.931    40.950    15.931    -3.448   20859.4   -13.523
   -7.865    98.794    45.684    16.626    -2.069   24023.2    -7.984
   -3.735   103.956    49.144    17.237    -0.690   26276.8    -3.735
   -3.495   104.256    49.095    17.227     0.690   26250.7    -3.495
    0.992   109.865    45.199    16.598     2.069   23614.5     1.115
    6.516   116.769    40.265    15.969     3.448   20391.2     6.687
   13.768   125.835    34.610    15.340     4.828   17124.3    13.949
   23.943   138.553    28.344    14.710     6.207   13892.7    24.098
   39.341   157.801    21.843    14.081     7.586   10742.4    39.341
   65.829   190.911    19.378    13.452     8.966    7698.0    65.064
```

FLOODABLE LENGTH CURVES

PERMAEBILITY 0.8000

CONDITION DRAFT 11.800 M TRIM 0.000

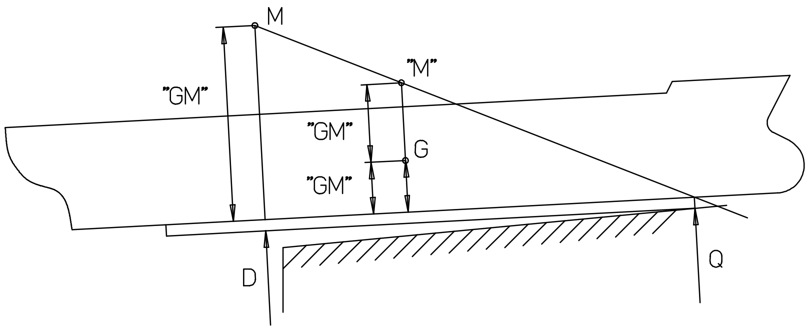
X LONG COORD FROM LPP/2 (MIDDLEPOINT)
FR FRAME NO CORRESPONDING TO X
LENGTH FLOODABLE LENGTH
DRAFT DRAFT AMIDSHIP AFTER FLOODING
TRIM TRIM ON PERPEND LENGTH AFTER FLOODING
W FLOODED WATER (VOLUME*PERM)
XW LONG CENTRE OF FLOODED WATER

X	FR	LENGTH	DRAFT	TRIM	W	XW
-48.151	48.436	28.219	13.759	-7.586	10684.3	-47.784
-30.850	70.063	35.495	14.483	-6.207	14104.0	-30.990
-20.492	83.011	43.232	15.207	-4.828	17489.0	-20.738
-13.275	92.031	50.188	15.931	-3.448	20859.4	-13.523
-7.811	98.861	55.988	16.626	-2.069	24023.2	-7.984
-3.735	103.956	60.212	17.237	-0.690	26276.8	-3.735
-3.495	104.256	60.152	17.227	0.690	26250.7	-3.495
0.926	109.783	55.376	16.598	2.069	23614.5	1.115
6.429	116.661	49.330	15.969	3.448	20391.2	6.687
13.677	125.721	42.405	15.340	4.828	17124.3	13.949
23.871	138.464	34.745	14.710	6.207	13892.7	24.098
39.341	157.801	26.850	14.081	7.586	10742.4	39.341
66.415	191.644	24.586	13.452	8.966	7698.0	65.064

3.6 Launching calculation

Data sheet launch

The traditional data for the launching of a ship are calculated. Most data are explained on the data sheet and therefore only a few complementary notes are necessary:
KG is vertical centre of gravity. If this value is stated the virtual GM in accordance with Techel's method is printed. If the value is omitted corresponding virtual KM is printed. (For free floating positions the real GM and KM respectively.)



The GM is calculated only for the period of launching when the ship is lifting aft.
D = displacement
Q = force on fore poppet
For a small heeling angle dφ the moment equation (if the transverse moment from the fore poppet is omitted) is:

$$\mathrm{W} \times "\mathrm{GM}" \times \mathrm{d}\varphi = \mathrm{D} \times \mathrm{KM} \times \mathrm{d}\varphi - \mathrm{W} \times \mathrm{KG} \times \mathrm{d}\varphi$$

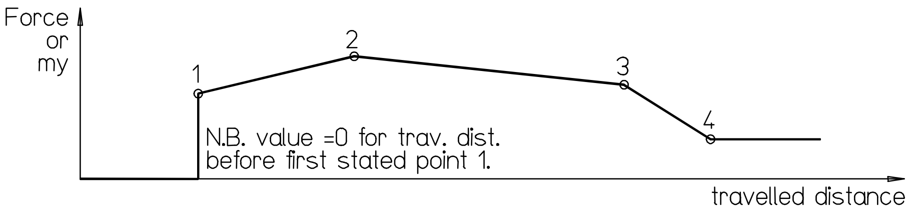
$$"\mathrm{GM}" = \frac{\mathrm{D}}{\mathrm{W}} \times \mathrm{KM} - \mathrm{KG}$$

$$\mathrm{KM} = \frac{\mathrm{D}}{\mathrm{W}} \times \mathrm{KM}$$

These formulas are taken from:
"Buoyancy and Stability of ships", I R R F Scheltema De Heere, drs A. R. Bakker

"KM" and "GM" denote the virtual metacentrum and metacentric height respectively. "KM" and "GM" are of course not interesting if there are two cradles.

crdh1, crdh2 are cradle-heights at the aft and fore ends of the cradle but with correction so that value stated is the height from underside cradle to the BL used in the definition of the hull form. The reason for this is the need to link the calculation with the hydrostatic calculation.
popp1 is the poppet length. If this value is left blank calculation is made on the assumption of a point force at the fore end of the cradle when the ship is lifting aft. If the value is stated, the calculation is made for a uniformly distributed pressure over the length of the fore poppet when the ship is lifting aft.
way1 is the length of the way.
wayh is the height difference of the way over the stated length 'wayl'.
wayc is the camber of the way for the stated length 'wayl'. If the way is straight enter 'wayc' =0.
step is the calculation step. The calculation as well as the printing of the results will be made for these steps. The format of the result gives 40 steps on each page. Choose step ⦸ 0.02*Lpp.
speed calc. - if the card is left blank, the speed-calc. is omitted. The subsequent cards for the friction coefficient and dragging forces are omitted in this case.
g =9.81 if meters and 32.18 if feet are used.
cr is coefficient of resistance. The value is used as coeff. in the formula: P = cr*displacement*v^2
my is the friction coefficient
dragging forces are optional. A maximum of ten dragging forces can be stated. For each dragging force 10 points can be stated. The same restriction of 10 points applies also to friction coeff. Stated data for the friction coeff. and dragging forces are interpreted as shown in the following sketch.



Water levels - a complete calculation is made for each one of the stated water lines. Maximum 8 waterlines can be stated.

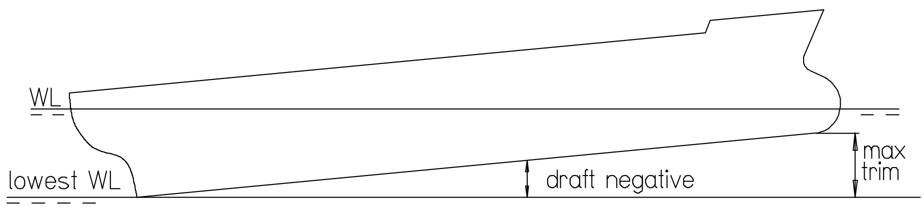
Units

Feet or metres, English or metric tons can be used.
Time is always expressed in seconds.
Dragging forces have to be stated in the same units as for the weight, W, of the ship i.e. ton of 1000 kg or 1016 kg. The water resistance has to be defined in the same way.
$P = cr*D*v^2$ gives P in tons when D is stated in tons and v in m/sec or feet/sec.
The result is stated in the same units as input data i.e. acceleration in m/sec^2 or $feet/sec^2$ etc.

Required hydrostatic calculation

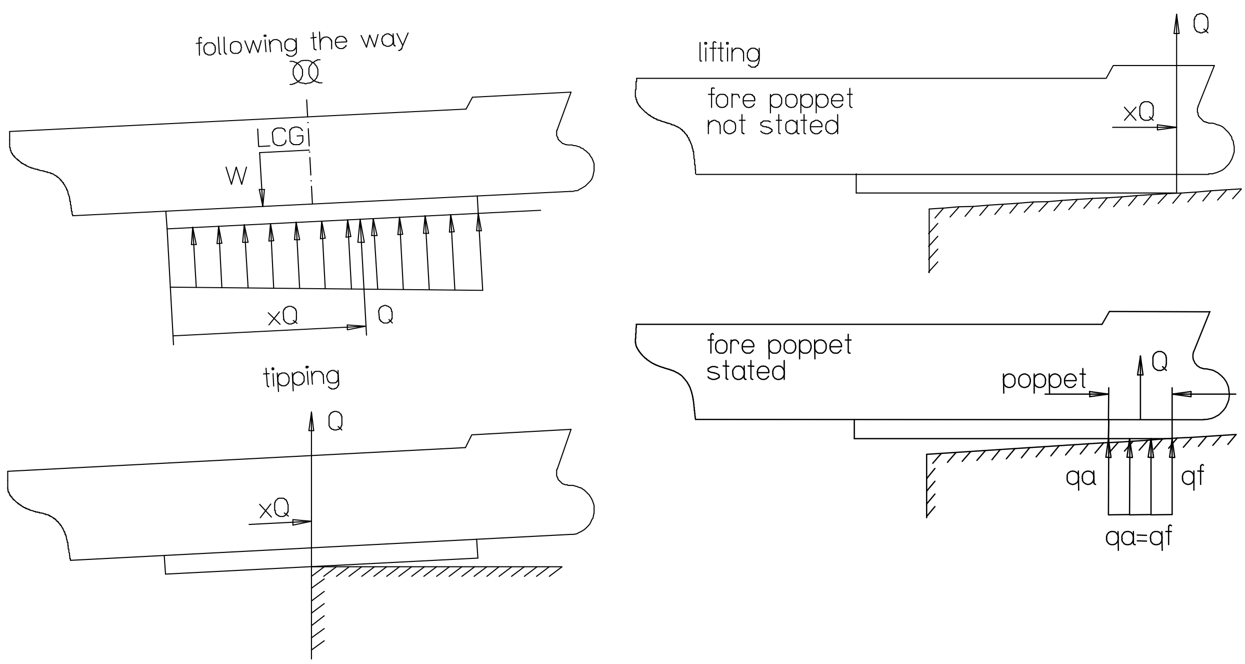
Before running the launching program, hydrostatics data covering the draft - trim range for the launching has to be calculated. This means that the trim range stated on Data sheet sth must be stated as follows.

tmin ≤ -(max aft trim)
tmax = max forward trim (normally =0)
hmin ≤ -(max aft trim)/2
hmax ≥ max mean draft expected after launching



N.B. It is recommended to make the range a little greater then the minimum required. Also, it is recommended to use the maximum allowed no of WLS and trim on the data sheet.

Comments of the results



First result page

Column 1 traveled distance

Column 2 position of the ship in relation to the way as follows:
way means that ship follows the way
tipp means that the ship is tipping
lift means that the ship is lifting aft
free means that the ship has left the way

Column 3, 4 draft at AP and FP. Draft is calculated to the BL (see coordinate system, page 1)

Column 5 buoyancy

Column 6 x-coord of the centre of buoyancy
(N.B. all x coordinates refer to amidships and are positive forward)

Column 7-11 forces from the way to the ship

Column 7 total force Q

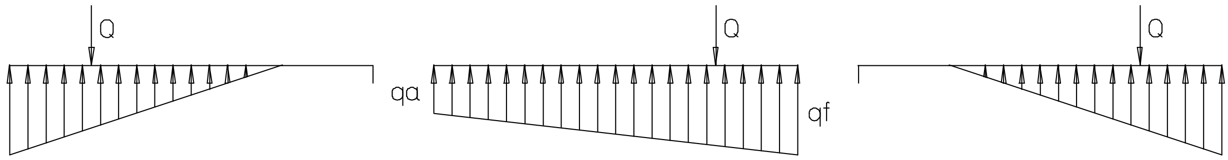
Column 8 corresponding longitudinal centre xQ

Column 9-11 calculated distribution of the force mentioned above. The distribution is done linear (i.e. trapezoid or triangle)

Three different cases might arise:

1. The ship is following the way

The force is linearly distributed and three cases can arise as seen in the sketch.



2. The ship is tipping

In this case the force is calculated as a "point force" acting on the ship at the way end. Corresponding coordinate for the ship is stated by xq. Columns 9-11 are left blank.

3. The ship is lifting

If no fore poppet length is stated, the force is calculated as "point force" acting at the fore end of the cradle (columns 9-11 are left blank). If fore poppet length is stated the force Q is constantly distributed over this length. This means that xQ equals the coordinate to the centre of the fore poppet length.

Second result page

Column 1 the traveled distance is repeated from page 1.

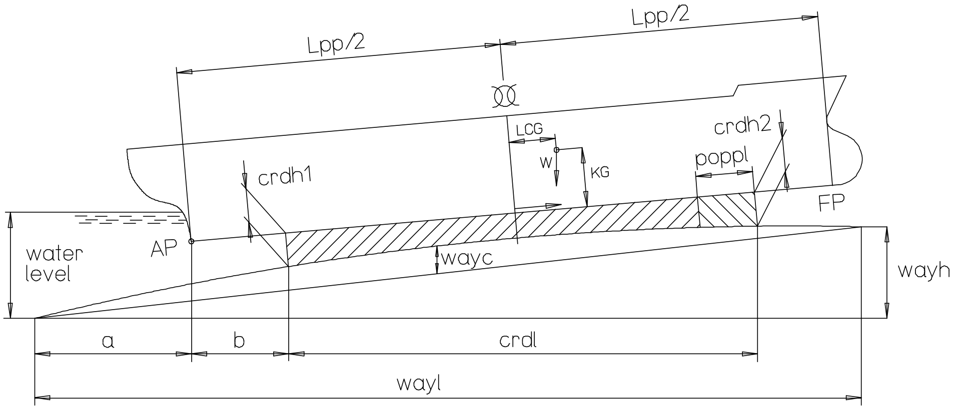
Column 2 anti-tipping moment. If negative the value represents the moment required to force the ship back on the way (the real tipped position is calculated on page 1).

Column 3-5 states the maximum pressure and its position in relation to the ship (in form of x-coord. and frame no.).

Column 6 if KG is stated, the virtual metacentric height is printed

Column 7-8 acceleration, speed and time if speed calculation is requested in the input data. In that the third printed page represents the data for the ship after it has left the way.

Launching calculation



N. B. before running this program a special hydrostatic calculation has to be done covering all draft-trim positions for launching.

ship no

identification text (printed in result

	a	W	LCG	KG	sw
ship					

	b	crdh1	crdh2	crdl	crdb	poppl
cradle						

	wayl	wayh	wayc	step
way				

	g	cr
speed calc.		

	my	trav	my	trav	my	trav	my	trav
friction								

dragging forces	force	trav	force	trav	force	trav	force	trav
1								
2								
3								
4								
	one blank line							

	max 8							
water levels								
	two blank lines							

These data can be replaced by one blank card.
In such a case, the speed calculation is omitted.
Maximum 10 points on friction curve.
Maximum 10 points for each dragging force.
Maximum 10, dragging forces.

Required hydrostatic calculation

Before running the launching program, hydrostatic data covering the draft-trim range, has to be calculated.

Trim range stated on Data sheet sth has to be as follows:

tmin ≤ -(max aft trim)

tmax = max forward trim (normally =0)

hmin ≤ -(max aft trim)/2

hmax ≥ max mean draft expected after launching

N.B. It is recommended to choose the range a little greater then minimum required. It is also recommended to use max allowed number of WLS and trims

Feet or m, English or metric tons can be used. The units have to be used consistently. Time units are seconds.

LCG	positive forward from midship
KG	optional; if KG is stated GM during launching is calculated
SW	salt water density in ton/m^3 or ton/cubf
crdb	breadth of cradle (if there are more cradles, the sum of breadths is stated)
poppl	poppet length is optional
step	calculation step
g	9.81 m/s^2 or 32.18 ft/ s^2 ,depending on units
cr	coefficient of resistance; this value is used in the formula $p = cr*displ*v^2$; p and displ have to have the same value

Example for Data sheet launch – data for launching calculation:

```
402
Launching calculation
49.359 10500 -10 10.8 1.025
16.083 2.067 1.367 144.584 2.4 12
210.026 13.288 1.419 10
9.81 0.0002
0.03 0 0.025 75 0.023 150 0.023 225
50 200 100 300

3.895
```

Example of launching results:

LAUNCHING CALCULATION FOR WATER-LEVEL= 3.895 ABOVE THE LOWER WAY END

		DRAFT FROM BL AT		BUOYANCY		FORCE AND PRESSURE FROM THE WAY				
				BUOY-	LCB	FORCE	CENTRE	DISTRIBUTION OVER L		
TRAV	POS	AP	FP	ANCY	XCOORD	Q	XQ	L	QA	QF
0.00	WAY	-2.73	-11.18			10500.0	-10.54	144.58	48.36	12.16
10.00	WAY	-1.94	-10.82			10500.0	-10.57	144.58	48.40	12.12
20.00	WAY	-1.12	-10.44	0.0	-87.20	10500.0	-10.60	144.58	48.43	12.09
30.00	WAY	-0.28	-10.04	0.0	-87.20	10500.0	-10.62	144.58	48.46	12.05
40.00	WAY	0.58	-9.61	3.4	-78.64	10496.6	-10.63	144.58	48.46	12.04
50.00	WAY	1.48	-9.15	48.6	-66.10	10451.4	-10.42	144.58	47.99	12.25
60.00	WAY	2.39	-8.67	204.4	-62.39	10295.6	-9.68	144.58	46.36	12.98
70.00	WAY	3.34	-8.16	675.2	-55.77	9824.8	-7.64	140.03	46.51	11.96
80.00	WAY	4.31	-7.63	1542.9	-50.73	8957.1	-3.88	130.03	48.61	8.79
90.00	WAY	5.30	-7.07	2782.0	-47.00	7718.0	2.26	120.03	45.40	8.18
100.00	WAY	6.32	-6.48	4455.3	-43.33	6044.7	13.15	110.03	32.89	12.89
110.00	WAY	7.37	-5.87	6565.6	-39.75	3934.4	37.39	100.03	5.35	27.43
120.00	LIFT	7.78	-5.17	7919.0	-37.23	2581.0	70.17	12.00	89.62	89.62
130.00	LIFT	7.41	-4.37	8053.1	-35.34	2446.9	70.17	12.00	84.96	84.96
140.00	LIFT	7.01	-3.54	8223.7	-33.05	2276.3	70.17	12.00	79.04	79.04
150.00	LIFT	6.58	-2.68	8428.7	-30.44	2071.3	70.17	12.00	71.92	71.92
160.00	LIFT	6.08	-1.79	8775.6	-26.35	1724.4	70.17	12.00	59.88	59.88
170.00	LIFT	5.54	-0.86	9295.8	-20.85	1204.2	70.17	12.00	41.81	41.81
180.00	LIFT	4.97	0.10	10041.8	-13.98	458.2	70.17	12.00	15.91	15.91

THE SHIP IS FREE-FLOAT. BEFORE FORE POPET LEFT THE WAY

190.00 FREE 4.63 0.63 10500.0 -10.000

```
LAUNCHING CALCULATION FOR WATER-LEVEL=   3.895 ABOVE THE LOWER WAY END

 THE COLUMN METACENT STATES THE VIRTUAL METACENTREHEIGHT FOR KG=  10.800

        ANTITIPPING   MAXIMUM PREASSURE AT   METACENT  ACCEL. SPEED  TIME
   TRAV      MOMENT X-COORD FRAME NO PREASS.

   0.00             -68.42    23.10  48.360
+                                                      0.1963  0.00  0.00
  10.00             -68.42    23.10  48.395
+                                                      0.2236  2.05  9.97
  20.00             -68.42    23.10  48.430
+                                                      0.2554  3.01 13.94
  30.00             -68.42    23.10  48.465
+                                                      0.2872  3.81 16.88
  40.00             -68.42    23.10  48.457
+                                                      0.3189  4.54 19.28
  50.00             -68.42    23.10  47.988
+                                                      0.3489  5.23 21.32
  60.00             -68.42    23.10  46.361
+                                                      0.3738  5.89 23.12
  70.00   552346.69 -63.86    28.80  46.514
+                                                      0.3824  6.51 24.74
  80.00   447690.75 -53.86    41.30  48.611
+                                                      0.3646  7.06 26.21
  90.00   355954.12 -43.86    53.80  45.401
+                                                      0.3175  7.54 27.58
100.00   284130.75  -33.86    66.30  32.887
+                                                      0.2359  7.90 28.87
110.00   240964.58   76.17   203.83  27.432
+                                                      0.1169  8.12 30.12
120.00               76.17   203.83  89.616
+                                              12.026
+                                                      0.0371  8.20 31.34
130.00               76.17   203.83  84.962
+                                              13.254
+                                                      0.0337  8.24 32.56
140.00               76.17   203.83  79.037
+                                              14.609
+                                                      0.0272  8.28 33.77
150.00               76.17   203.83  71.921
+                                              16.356
+                                                      0.0174  8.31 34.98
160.00               76.17   203.83  59.875
+                                              18.470
+                                                     -0.0044  8.32 36.18
170.00               76.17   203.83  41.812
+                                              20.751
+                                                     -0.0404  8.29 37.38
180.00               76.17   203.83  15.911
+                                              22.379
+                                                     -0.0955  8.21 38.59
```

LAUNCHING CALCULATION FOR
WATER-LEVEL= 3.895 ABOVE THE LOWER WAY END

TRAV	ACCEL.	SPEED	TIME
190.00	-0.1277	8.07	39.82
200.00	-0.1695	7.91	41.07
210.00	-0.1676	7.69	42.35
220.00	-0.1657	7.47	43.67
230.00	-0.1639	7.25	45.03
240.00	-0.1622	7.02	46.43
250.00	-0.1605	6.78	47.88
260.00	-0.1589	6.54	49.38
270.00	-0.1574	6.30	50.94
280.00	-0.1559	6.04	52.56
290.00	-0.1545	5.78	54.25
300.00	-0.1531	5.51	56.02
310.00	-0.1472	5.23	57.89
320.00	-0.1416	4.95	59.85
330.00	-0.1361	4.66	61.94
340.00	-0.1309	4.36	64.15
350.00	-0.1258	4.06	66.53
360.00	-0.1210	3.74	69.10
370.00	-0.1163	3.41	71.90
380.00	-0.1118	3.05	74.99

LAUNCHING CALCULATION FOR
WATER-LEVEL= 3.895 ABOVE THE LOWER WAY END

TRAV	ACCEL.	SPEED	TIME
390.00	-0.1075	2.67	78.49
395.00	-0.1054	2.46	80.43
400.00	-0.1034	2.24	82.56
405.00	-0.1014	2.00	84.92
410.00	-0.0994	1.73	87.59
415.00	-0.0975	1.42	90.77
420.00	-0.0956	1.03	94.86
425.00	-0.0937	0.32	102.29
430.00	-0.0934	0.00	104.64

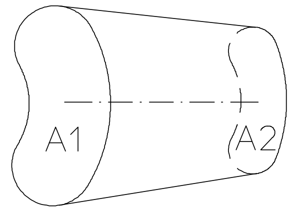
3.7 Tonnage calculation

Data sheet tonn1, tonn2

This program calculates Gross and Net Tonnages in accordance with the 1969 Tonnage Convention requirements. More detail comments are found in the Data sheets.
For input data basic volume for the ship, ***Vh***, and for the cargo spaces, ***Vc*** is stated. In order to complete the figures, items can be added or subtracted to stated volumes. These items are stated in data sheet tonn2.
As shown on data sheet tonn1, there are four alternatives for defining the volumes:

type =1 Volume is specified directly.

type =2-4 Common remarks. The length of the element can be specified either by stating two frame numbers or by stating the length, L, followed by a 0 in the text column.



type =2 This is used for description of circular and conic tanks (see the Data sheet)

type =3 Intended for any cylinder where the section dimension changes linearly i.e. area changes with the square.

type =2 The sketches on the Data sheet show the various possibilities. If B2 and H2 are given in input they define a box with linear change of breadth and depth along the length. L, B and h don't have to be oriented in accordance with the ship coordinates.

Elements above are intended for correction of both total hull volume, ***Vh***, or the compartment volume, ***Vc***. Value ***i***, which is stated after item number, controls this correction as follows:

i =1	the volume has to be added to ***Vh***
i =2	the volume has to be added to ***Vc***
i =3	the volume has to be added to ***Vh*** and ***Vc***
item no	any identification number
no of cards	number of following cards giving all geometry for the item.
text for the item	identification text

This program can be run separately if ***Vh*** and ***Vc*** are stated as input. It can also be run directly after programs that calculate ***Vh*** and ***Vc*** from defined hull form and compartments. In this case the data ***Vh*** and ***Vc*** are omitted on sheet tonn1.

Execution procedure

Alternative 1:	Run tonn1
	Data sheet tonn1 (***Vh*** and ***Vc*** stated)
	Data sheet tonn2
Alternative 2:	Run sthyd
	Data sheet sth
	Run hvol
	Run cvol
	Data sheet 7a (recommended input: inp =0 outp =1 ave =1 p1 =0)
	Run tonn
	Data sheet tonn1
	Data sheet tonn2

Tonnage calculation in accordance with 1969 Tonnage Convention

	ship no	Vh	Vc	Dt	dt	N1	N2	
80								
								ship name
								included in Vh
								included in Vc

Vh = calculated volume of the hull
Vc = calculated volume of cargo compartments
Dt = moulded depth in accordance with 1969 conference
dt = moulded draught in accordance with 1969 conference
N1 = no of passeng. in cabins with no more than 8 berths
N2 = number of other passengers
"included in Vh" Text example Poop and forecastle
"included in Vc" Text example Holds number 1-9

Execution procedure	
EXEC TONN	
Data sheet	1
	2
	2
	2
two blank cards	

Vh can be calculated by the program Hvol and Vc by the program Cvol.
It is possible to run Hvol, Cvol and tonnage in one run and leave Vh and Vc blank on this sheet. In such case, the data will be linked together by the program (the above texts should be also stated).

Extra items that are added or subtracted from the volume above

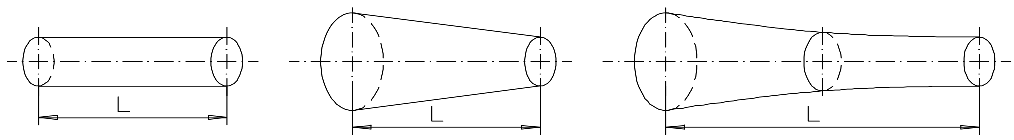
First card for each item contains the item number, “i” value (as described below) and text for that item. This card is followed by any number of data cards that define dimensions of the item.

i =1 volume has to be added to Vh
i =2 volume has to be added to Vc
i =3 volume has to be added to Vh and Vc

For element type 2, 3, 4, either length of the element or aft and forward frames (fr1 respectively fr2) can be entered. If defined length, L, is negative or forward end defined as fr1 and aft end as fr2, the effect will be subtraction instead of addition.

Type 2

stated D1 stated D1 and D2 stated D1, D2 and D3



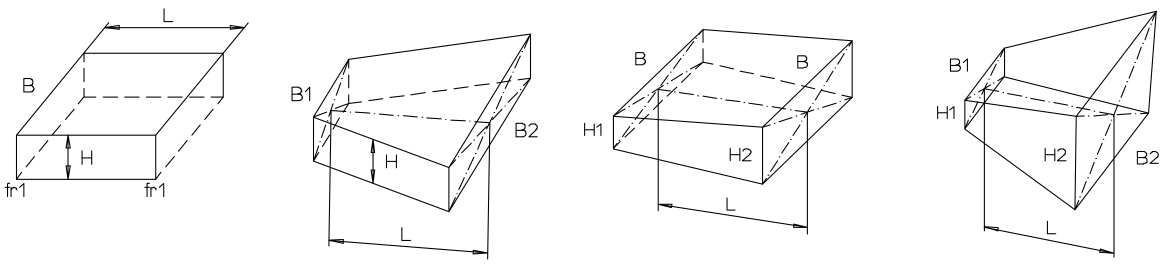
← Simpson's first rule is used

Type 3

Exactly as above but area instead of dimensions is stated. When A1 and A2 are entered, it is supposed that the area A varies between A1 and A2 with the square.

Type 4

V = B1*H1*L+0.5*B1*(H2-H1)*L+0.5*H1*(B2-B1)*L+1/3*(H2-H1)*(B2-B1)*L



If B2 and H2 are omitted, the program sets B2 = B1 and H2 = H1

First data card for each item.

item number	i value	no of cards	text for the item

followed by any number of data cards described below

type =1	volume					
type =2	fr1 or L	fr2 or 0	D1	D2	D3	
type =3	fr1 or L	fr2 or 0	A1	A2	A3	
type =4	fr1 or L	fr2 or 0	B1	H1	B2	H2

Example

130	3	2	Two circular tanks			
2	17	35	2.153			
2	40	64	3.25	2.11		
131	2	1	Space frame 104-120			
4	104	120	4.2	1.2	4.8	1.4

Tonnage calculation in accordance with 1969 Tonnage Convention

First data line for each item

81	item number	i value	no of lines	text for the item

Followed by any number of data lines described below

82	type =1	volume					
	type =2	fr1/L	fr2/0	D1	D2	D3	
	type =3	fr1/L	fr2/0	A1	A2	A3	
	type =4	fr1/L	fr2/0	B1	H1	B2	H2

two blank lines			

3.8 Bon – Jean data

Bon jean data contain section areas and their moments about baseline and amidships. Different options are available here. Data sheet bonj is shown on the next page follwed by an example of input and output. Usually ***i*** =0 in the input and the following data set **42** is omitted. However, in some cases it may be required to print the data for particular longitudinal position.

Input for the Bon - Jean curves

	ship no	hmin	hmax	dh	i	deck no
40						

41					levels for special WLS or a blank card

hmin lowest WL for Bon - Jean curves
hmax highest WL for Bon - Jean curves
dh distance between WLS for Bon - Jean curves
i =0 data for Bon - Jean curves is printed for stations 0, 0.5, 1, 1.5, 2, 3, 4, ...17, 18.5, 19, 19.5, 20.
i =1 data for Bon - Jean curves is printed for stations specified in the table below.
deck no if deck number is skipped the program calculates to the highest deck for the corresponding frame

Data are entered in the following table only if i =1 above.

		fr no	dx	id	deck no
41	1				
	2				
	3				
	4				
	5				
	6				
	7				
	8				
	9				
	10				
	11				
	12				
	13				
	14				
	15				
	16				
	17				
	18				
	19				
	20				
	21				
	22				
	23				
	24				
	25				
	26				
	27				
	28				
	29				
	30				
		one blank line			

id =1 fr no represents sections spaced for $L_{pp}/20$
Example
fr no =2.5 represents a section at a distance 2.5 - $L_{pp}/20$ from AP

id =2 fr no represents sections spaced for $L_{pp}/10$
Example:
fr no =2.5 represents a section at a distance 2.5 - $L_{pp}/10$ from AP

id =3 fr no represents actual frame number
Example:
fr no =63 means that data for Bon - Jean curves will be printed for fr 63

dw distance to be added to the longitudinal coordinate in accordance to the shown above

deck no explained above

Example of input data for the Bon - Jean calculation

```
402 0 17 0.5 0
```

Example of output data for the Bon - Jean calculation

SECTIONAREAS AND MOMENTS

STATION NO 0.0 DIST FROM LPP/2= -84.500

H	A	MBL	MLPP/2	H	A	MBL	MLPP/2
0.000	0.00	0.00	0.000	7.000	0.00	0.00	0.00
0.500	0.00	0.00	0.000	7.500	0.00	0.00	0.00
1.000	0.00	0.00	0.000	8.000	0.00	0.00	0.00
1.500	0.00	0.00	0.000	8.500	0.00	0.00	0.00
2.000	0.00	0.00	0.000	9.000	0.00	0.00	0.00
2.500	0.00	0.00	0.000	9.500	0.01	0.07	-0.64
3.000	0.00	0.00	0.000	10.000	1.13	11.08	-95.43
3.500	0.00	0.00	0.000	10.500	3.87	39.24	-327.02
4.000	0.00	0.00	0.000	11.000	7.94	83.07	-671.20
4.500	0.00	0.00	0.000	11.500	13.09	141.00	-1106.00
5.000	0.00	0.00	0.000	12.000	19.16	212.41	-1619.28
5.500	0.00	0.00	0.000	12.500	26.03	296.51	-2199.20
6.000	0.00	0.00	0.000	13.000	33.54	392.37	-2834.32
6.500	0.00	0.00	0.000	13.500	41.61	499.23	-3515.68

STATION NO 0.5 DIST FROM LPP/2= -80.275

H	A	MBL	MLPP/2	H	A	MBL	MLPP/2
0.000	0.00	0.00	0.000	7.000	0.00	0.00	0.00
0.500	0.00	0.00	0.000	7.500	0.00	0.00	0.00
1.000	0.00	0.00	0.000	8.000	0.00	0.00	0.00
1.500	0.00	0.00	0.000	8.500	0.36	3.06	-29.20
2.000	0.00	0.00	0.000	9.000	2.49	21.74	-199.94
2.500	0.00	0.00	0.000	9.500	6.26	56.71	-502.88
3.000	0.00	0.00	0.000	10.000	11.46	107.43	-920.03
3.500	0.00	0.00	0.000	10.500	17.79	172.34	-1428.05
4.000	0.00	0.00	0.000	11.000	25.06	250.58	-2012.01
4.500	0.00	0.00	0.000	11.500	33.15	341.55	-2660.93
5.000	0.00	0.00	0.000	12.000	41.95	445.03	-3367.68
5.500	0.00	0.00	0.000	12.500	51.38	560.60	-4124.88
6.000	0.00	0.00	0.000	13.000	61.35	687.71	-4925.03
6.500	0.00	0.00	0.000	13.500	71.77	825.80	-5761.56

STATION NO 1.0 DIST FROM LPP/2= -76.050

H	A	MBL	MLPP/2	H	A	MBL	MLPP/2
0.000	0.00	0.00	0.000	7.000	19.52	78.33	-1484.13
0.500	0.00	0.00	-0.003	7.500	21.87	95.43	-1663.24
1.000	0.59	0.48	-44.992	8.000	25.19	121.25	-1916.07
1.500	1.73	1.92	-131.722	8.500	29.87	159.88	-2271.61
2.000	3.16	4.42	-239.993	9.000	36.21	215.39	-2753.47
2.500	4.75	8.00	-360.869	9.500	43.76	285.33	-3328.19
3.000	6.42	12.62	-488.427	10.000	52.25	368.09	-3973.45
3.500	8.12	18.14	-617.708	10.500	61.49	462.87	-4676.43
4.000	9.79	24.41	-744.879	11.000	71.38	569.18	-5428.32
4.500	11.41	31.26	-867.581	11.500	81.84	686.91	-6224.06
5.000	12.94	38.56	-984.432	12.000	92.83	816.07	-7059.87
5.500	14.45	46.49	-1099.291	12.500	104.30	956.52	-7931.68
6.000	15.98	55.23	-1214.920	13.000	116.18	1108.03	-8835.29
6.500	17.62	65.49	-1339.625	13.500	128.42	1270.32	-9766.71

STATION NO 1.5 DIST FROM LPP/2= -71.825

H	A	MBL	MLPP/2	H	A	MBL	MLPP/2
0.000	0.00	0.00	0.000	7.000	47.62	196.90	-3420.29
0.500	0.90	0.28	-64.993	7.500	53.72	241.20	-3858.75
1.000	2.74	1.68	-196.539	8.000	61.08	298.26	-4387.02
1.500	5.14	4.71	-369.397	8.500	69.60	368.60	-4999.06
2.000	7.96	9.66	-571.855	9.000	79.11	451.86	-5682.16
2.500	11.08	16.68	-795.795	9.500	89.41	547.18	-6422.08
3.000	14.41	25.86	-1035.310	10.000	100.37	654.02	-7208.94
3.500	17.92	37.26	-1287.072	10.500	111.88	771.99	-8035.49
4.000	21.56	50.91	-1548.427	11.000	123.86	900.83	-8896.21
4.500	25.33	66.93	-1818.970	11.500	136.26	1040.38	-9787.05
5.000	29.22	85.44	-2098.906	12.000	149.04	1190.49	-10704.55
5.500	33.30	106.87	-2391.882	12.500	162.14	1351.03	-11645.75
6.000	37.63	131.76	-2702.606	13.000	175.54	1521.90	-12608.26
6.500	42.33	161.17	-3040.433	13.500	189.21	1703.02	-13590.01

STATION NO 1.5 DIST FROM LPP/2= -71.825

H	A	MBL	MLPP/2	H	A	MBL	MLPP/2
0.000	0.00	0.00	0.000	7.000	78.45	330.92	-5302.99
0.500	1.59	0.47	-107.567	7.500	88.17	401.46	-5960.32
1.000	4.40	2.62	-297.664	8.000	98.68	482.93	-6670.70
1.500	8.02	7.17	-542.368	8.500	109.89	575.42	-7428.34
2.000	12.27	14.63	-829.660	9.000	121.71	678.90	-8227.62
2.500	17.03	25.35	-1151.062	9.500	134.06	793.13	-9062.26
3.000	22.20	39.59	-1500.685	10.000	146.85	917.89	-9927.15
3.500	27.75	57.65	-1876.064	10.500	160.03	1053.00	-10818.11
4.000	33.66	79.82	-2275.475	11.000	173.55	1198.29	-11731.67
4.500	39.93	106.50	-2699.498	11.500	187.36	1353.67	-12665.29
5.000	46.59	138.12	-3149.286	12.000	201.43	1519.04	-13616.62
5.500	53.68	175.37	-3628.690	12.500	215.73	1694.29	-14583.67
6.000	61.28	219.11	-4142.677	13.000	230.25	1879.36	-15564.85
6.500	69.50	270.48	-4697.952	13.500	244.95	2074.20	-16558.88

3.9 Hydrostatics for parabolic waterline

Data sheet hydr

For parabolic (curved) waterline the following hydrostatic data are calculated:

- Displacement, DISPL
- Tonnes per centimeter of immersion, TPCI
- Moment to change trim (MCT / CM)
- Longitudinal center of buoyancy, LCB (from midship)
- Longitudinal center of flotation, LCF (from midships)
- Transverse metacentric radius, KMT
- Longitudinal metacentric radius, KML
- Vertical center of buoyancy, VCB

User defines three longitudinal positions with corresponding drafts and density of the sea water at the end.
x1, ***x2***, ***x3*** are longitudinal positions of the observed drafts
draft1, ***draft2***, ***draft3*** are observed drafts
ρsw is denisity of the sea water

Calculation of hydrostatics for parabolic waterline

x1	draft1	x2	draft2	x3	draft3	ρsw

x1, x2, x3	longitudinal positions of the observed drafts from $L_{PP}/2$
draft1, draft2, draft3	drafts
ρsw	density of the sea water

Example of input data for the calculation of hydrostatics for the parabolic waterline

```
-84.5 5 0 4.99 84.5 5 1
```

Example of output data

```
                    HYDROSTATIC REPORT FOR ONE WATERLINE


     DEFINITION OF THE WATERLINE

     POINT 1
     -------
     POSITION FROM LPP/2:  -84.500 (m)
     MEASURED DRAFT:         5.000 (m)

     POINT 2
     -------
     POSITION FROM LPP/2:    0.000 (m)
     MEASURED DRAFT:         4.990 (m)

     POINT 3
     -------
     POSITION FROM LPP/2:   84.500 (m)
     MEASURED DRAFT:         5.000 (m)

     DENSITY OF THE WATER:  1.000 (t/m3)


     CALCULATED VALUES
     -----------------
     DISPL=   21068.896 (t)
     TPCM=       44.877 (t)
     MCT/CM=     453.82 (tm)
     LCB=         5.425 (m)
     LCF=         4.268 (m)
     KMT=        18.763 (m)
     KML=       366.598 (m)
     VCB=         2.578 (m)
```