How many tons of buoyancy have been lost?

Strandings still occur more often as one would think of, given the today's electronic navigation aids. Fatigue and Look-out, covered in an other section of this web-site, does play a not negligible role.

This paper will give some assistance to the reader when trying to solve a stranding case.

To assist a vessel in such an emergency reliable information on the circumstances of the stranding is a must. Such information should be obtained from the ship or the owners/manager's office by utilising the VHT questionnaire „Action to be taken when a ship is aground" (a respective pdf document is available for downloading on this web-site). Again it is emphasised that any and all information has to be *reliable information*, anything else is a waste of time and will lead to a wrong decision making process.

If the judgement of the ship's command is that any refloating attempts by own means will be to no avail or that any such attempts have already failed the question is, what further measures have to be taken to increase the chances for success.

Such as:

1. How many tons traction power will be needed to refloat the vessel by towing assistance and possible use of the own engine power.
2. How many tons traction power will be needed to refloat the vessel by towing assistance and possible use of the own engine power if "x" t (cargo and/or ballast water and/or Fuel oil) will be lightened?

To answer this question one has to establish how many tons buoyancy the vessel has lost by loss of draft.

In the course of this monograph two ways of calculating the loss of buoyancy are introduced for two different situations:

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Firstly, when the vessel is laying to some extent on its flat bottom and is not trimmed excessively.

Secondly, when the vessel is aground on some sort of pinnacle or the edge of an reef and is excessively trimmed.

Case no. 1 the loss of buoyancy by loss of draft is found by comparing the medium draft of the vessel prior to the grounding with the mean draft after the grounding. By multiplying the difference in cm with the vessel's mean TPC (t/cm) the number of tons is found by which the vessel is laying aground.

In case no. 2 the vessel is laying aground rather punctual (on a rock or edge of a reef, etc.) on a known section of the vessel's bottom and there is an excessive trim to the aft. In such a case the number of tons the vessel is laying aground is found by the aid of the vessel's MTC (Moment to the change trim by 1 cm) and the distance of the point of support to the mainframe (midships) in meter.

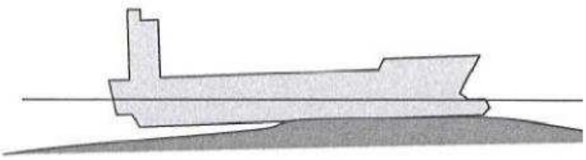
To perform the necessary calculations for both cases EXEL spreadsheets have been made available on our web-site.

Case no.: 1

Approximate calculation of "Ground Reaction" when a ship is aground over quite a distance of its flat-bottom and is not heavily trimmed

Length in previous waterline:	120,00	m
Length in new waterline:	115,00	m
Width:	20,80	m
Coefficient of shape:	0,68	
Coefficient of previous waterplane:	0,70	
Coefficient of new waterplane:	0,79	
Displacement:	11.431,18	m³
Specific gravity of the water:	1,03	
Total weight:	11.716,96	t
mean TPC:	18,64	t/cm
The ship is laying aground with:	438	t
Coefficient of friction:	0,50	
Coefficient for bottom-damage:	0,00	
Mud-Factor:	0,00	
Loss of buoyancy by ingress of water:	0,00	t

Drafts afloat before grounding:		
Forward:	5,86	m
Aft:	7,61	m
Mean:	6,74	m
Drafts aground:		
Forward:	5,00	m
Aft:	8,00	m
Mean:	6,50	m
Trim:	23,50	cm



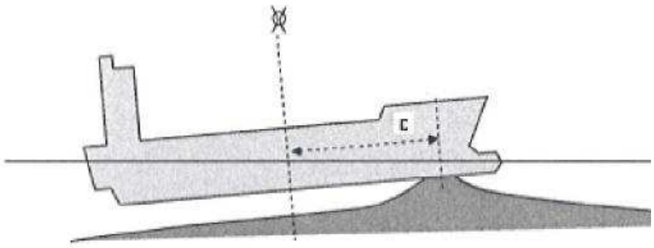
219 t **have to be overcome either by traction force and/or ligthening**

Case no.: 2

Approximate calculation of "Ground Reaction" when a ship is aground rather punctual on a rock or reef and is heavily trimmed

Length in new waterline:	115,00 m	Drafts aground at High Water:	
Width:	20,80 m	Forward:	5,00 m
		Aft:	9,00 m
Coefficient of new waterplane:	0,65	Mean:	7,00 m
Specific gravity of water:	1,025		
		Trim (t):	400,00 cm
MCT:	105,88 tm/cm	D:	50 m

Ground-Reaction (R)	847 t
Friction coefficeint (0,2 -1.0):	0,50
Coefficient for bottom damage:	0,50
Mud-Factor:	0,00
Loss of buoyancy by ingress of water:	150,00 t



997 t have to be overcome either by traction force and/or lightening

Attention has to be paid to the fact that for calculating the TPC and the MTC (Moment to change the trim by 1 cm) estimated values and rules of thumb have been utilised. If the correct values of the ship are available the calculations can obviously be improved.

When calculating the “Ground-Reaction” as well as the necessary amount of cargo, ballast and bunker which will have to be lightered from the vessel, additional factors have to be taken into consideration.

These factors are:

a. The friction which, subject to the type of sea bottom underneath the ship, will have to be considered by a certain coefficient in the calculation.

   These factors are born from the experience of many salvors will say that about:

   a. 20 – 30% of the lost buoyancy in tons (t) will be required when the bottom is mud.
   b. 30-40% of the lost buoyancy in tons (t) will be required when the bottom is sand.
   c. 50-80% of the lost buoyancy in tons (t) will be required when the bottom is coral.
   d. 80-150% of the lost buoyancy in tons (t) will be required when the bottom is rock.

These coefficients are approximated values and hold good for calm weather conditions. Seastate and swell, if not too heavy, could have a positive influence on these coefficients.

b. Damages to the underwater hull of the vessel which by shape and appearance will increase the resistance of the vessel during refloating. There are no firm recommendations available, but applying an additional coefficient in order of 10 – 50% subject to the assumed shape and appearance of the damage to the vessel's bottom seems to be acceptable.

c. The mud coefficient. When a ship grounds on silt or mud one gets the impression that it is drawn into the bottom and that additional force will be required to overcome this "suction effect". This effect is caused by the high weight pressure which is exerted to the layers of silt and mud underneath by the body of the ship. The water contained inside these layers will be pressed out and what remains is a type of tenacious clay, which causes the "suction effect". (Anyone will recall when playing in mud as a child when stepping forward all of a sudden the shoe or rubber boot got stuck and could only be loosened with difficulty and with a smacking sound). 20% of the lost buoyancy as an extra traction force may be reasonable under such circumstances.

d. The loss of buoyancy caused by water ingress into the body of the ship. If bottom tanks which were empty or partly filled only prior to the grounding are found filled or partly filled (up to the outside waterline), these spaces now have to be considered as lost buoyancy sources. When calculating the total freeing forces for refloating these circumstances have to be taken into account.

The EXEL Spreadsheets are constructed in a way that the user can fill in the respective data/coefficients to calculate the value for the force necessary to refloat the vessel. I urge the reader to keep in mind that the achieved result is an approximation and has to be looked at as such.

To conclude, one word in respect of the selection of one or more tugs for a refloating operation. The total resistance of a vessel will be bigger than the available bollard pull in most of the cases, however by skilfully employing the tug(s) the active traction force can be increased above the certified bollard pull of the tug(s). Here I am referring to the so called "sheering", i.e. swinging the tug on its towline from one side of the stranded vessel to the other. Experience tells the traction force is at its greatest in the pivot point (when the tug is altering course) and further that a moment of force will be effective which does not exist when the traction force is applied straight ahead only. Whenever the difference between the Ground Reaction and the available traction force is too big, additional measures have to be considered.