S E P A C

Le GM-METER
vis-à-vis des autorités et des règlements

Trois textes fondent la justification administrative de l'utilisation du GM-METER

- **La résolution A/ES.IV/168** de l'OMCI maintenant OMI, en novembre 1968.
- **La résolution MSC 12 (56)** de l'OMI adoptée le 18-10-88
- **Le chapitre III/29 de la Convention SOLAS**

● Le premier texte (**annexe 4 du document [1]**) explicite le principe de la méthode de détermination du GM à partir de la mesure de la période propre de roulis et fournit des coefficients statistiques pour des navires inférieurs à 70 m de longueur, permettant de passer de la période de roulis au GM. Cette résolution est restée sous la forme d'une proposition de méthode à destination des administrations nationales et de conseils aux capitaines, à cause des difficultés pratiques de mise en œuvre.

Elle a été reprise dans le règlement français uniquement comme méthode de substitution à l'expérience classique de stabilité, pour les petites unités pour lesquels l'absence de documents hydrostatiques rend impossible la détermination du GM à l'aide d'une expérience d'inclinaison.

Les difficultés de mise en œuvre et d'interprétation des résultats, qui sont toutes résolues par notre GM-METER, sont bien explicitées par l'analyse des US Coast Guard (**ROLL PERIOD TEST comments from UNITED STATES COAST GUARD** [2]) :

- Il est difficile de mesurer une période de roulis qui soit vraiment la période propre dés qu'il y a de la houle.
- Le GM n'est qu'un des éléments d'appréciation de la stabilité, et sa seule mesure est insuffisante pour vraiment apprécier la stabilité.
- Les coefficients réglementaires indiqués pour calculer le GM à partir de la période propre sont relatifs à des navires typés européens et ne sont pas applicables à d'autres types de navire.
- Ces coefficients ne tiennent compte que trop grossièrement du chargement des navires.

Malgré ces objections, L'OMI maintient la recommandation de cette méthode. On trouvera dans le descriptif du GM-METER comment notre appareil corrige ces défauts et la justification de l'application de cette méthode aux plus grands navires.

● Le second texte s'est traduit par un amendement à la convention SOLAS modifiant le paragraphe 7.4 de la règle 8 :
On completion of loading of the ship and prior to its departure, the master shall determine the ship's trim and stability and also ascertain and record that the ship is in compliance with stability criteria in relevant regulation. The Administration may accept the use of an electronic loading and stability computer or equivalent means for this purpose.

Dans le cadre de l'application de la convention SOLAS, **l'Administration Française a accepté le 9 mai 1990** [3] le GM-METER, comme appareil dont l'usage satisfait a l'amendement ci-dessus, et à sa demande l'OMI a pris en compte cette équivalence.

● Le dernier texte fait obligation au commandant de disposer d'une aide à la décision en cas d'avarie qui lui permette de rester maître de la stabilité de son navire. Le GM-METER fournissant le suivi en temps réel de la stabilité, indiquant les actions appropriées pour rétablir une situation sécurisée et testant leur efficacité, répond parfaitement à cette demande.

Ces textes ont été repris comme l'ensemble des annexes de la convention SOLAS dans le **Règlement Français** [4].

D'autre part, dans les délibérations des différents comités de l'OMI, il est fait souvent référence aux avantages d'une surveillance automatique de la stabilité pour certains types de navire comme les navires RO-RO, les navires de pêche ou les vraquiers. A titre d'exemple, on pourra se reporter au Compte rendu de la session OMI à Londres du 5 au 9 juillet 2004 pour les vraquiers (**Mouvements ou attitudes inhabituels** [5])

S E P A C

Le GM-METER TEST
vis-à-vis des autorités et des règlements

L'usage du GM-METER TEST pour effectuer les expériences de stabilité est conforme à la norme ASTM F 1321 – 90. Celle-ci précise au paragraphe 5.6.9 qu'un tel système est autorisé mais recommande l'emploi en parallèle d'un pendule traditionnel.

L'utilisation en parallèle avec un pendule est confirmée par les règlements des sociétés de classification et en particulier par le **Règlement Unifié de l'IASC** [6] de janvier 2004 qui demande pour les expériences de stabilité, l'utilisation d'au moins deux moyens de mesure d'inclinaison, dont un soit un pendule ou un tube en U.

La résolution MSC.75(69) de l'OMI, adoptée le 14-05-1998 (**annexe 2 du document [1]**) admet aussi l'utilisation d'inclinomètres dans les mêmes conditions et précise au paragraphe 2.6 de son annexe les caractéristiques qu'ils doivent présenter. On rapprochera avec intérêt ces caractéristiques de celles du GM-METER TEST.

Dans tous les cas, le pendule doit être regardé comme un moyen grossier de vérification pour déceler un déréglage flagrant du GM-METER, bien improbable d'ailleurs, surtout si un contrôle préalable a été effectué à l'aide de la cale de contrôle.

Le Bureau Veritas a délivré un **Certificat d'Approbation de Type** [7] pour le GM-METER TEST où il atteste de sa conformité à la norme Européenne IEC 60945 qui définie les caractéristiques de fiabilité des équipements de sécurité des navires, et la validité des performances annoncées, dans les conditions d'exploitation.

DOCUMENT 1

INTERNATIONAL MARITIME ORGANIZATION

IMO

E

SUB-COMMITTEE ON STABILITY AND LOAD LINES AND ON FISHING VESSELS SAFETY
48th session
Agenda item 4

SLF 48/4/3
10 June 2005
Original: ENGLISH

REVIEW OF THE INTACT STABILITY CODE

Report of the Intersessional Correspondence Group (part 3)

Submitted by Germany

SUMMARY	
Executive summary:	This document contains the report of the intersessional Correspondence Group on Intact Stability
Action to be taken:	Paragraph 2
Related documents:	SLF 48/4, SLF 48/4/1, SLF 48/4/2, SLF 47/6/3, SLF 47/6/4, SLF 47/6/8, SLF 47/6/10, SLF 47/6/12, SLF 47/6/15, SLF 47/6/18, SLF 47/6/19, SLF 47/6/20, SLF 47/6/22, SLF 47/6/23, SLF 47/6/25, SLF 47/WP.2 and SLF 47/WP.3

1 Parts of the draft revised text of the IMO resolution A.749(18) (IS Code) is attached at annex (only Annexes are included. Part A is attached to document SLF 48/4/1 and Parts B and C are attached to document SLF 48/4/2).

Action requested of the Sub-Committee

2 The Sub-Committee is invited to consider the information provided and to take action as appropriate.

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Annex 2 – Detailed guidance for the conduct of an inclining test		
1	**Introduction** This annex supplements the inclining standards put forth in chapter 7 of this Code. This annex contains important detailed procedures for conducting an inclining test in order to ensure that valid results are obtained with maximum precision at a minimal cost to owners, shipyards and the Administration. A complete understanding of the correct procedures used to perform an inclining test is imperative in order to ensure that the test is conducted properly and so that results can be examined for accuracy as the inclining experiment is conducted.	
2	**Preparations for the inclining test**	
2.1	**Free surface and tankage**	
2.1.1	If there are liquids on board the ship when it is inclined, whether in the bilges or in the tanks, they will shift to the low side when the ship heels. This shift of liquids will exaggerate the heel of the ship. Unless the exact weight and distance of liquid shifted can be precisely calculated, the metacentric height (GM) calculated from the inclining test will be in error. Free surface should be minimized by emptying the tanks completely and making sure all bilges are dry; or by completely filling the tanks so that no shift of liquid is possible. The latter method is not the optimum because air pockets are difficult to remove from between structural members of a tank, and the weight and centre of the liquid in a full tank should be accurately determined in order to adjust the light-ship values accordingly. When tanks must be left slack, it is desirable that the sides of the tanks be parallel vertical planes and the tanks be regular in shape (i.e. rectangular, trapezoidal, etc.) when viewed from above, so that the free surface moment of the liquid can be accurately determined. For example, the free surface moment of the liquid in a tank with parallel vertical sides can be readily calculated by the formula:	

$M_{fs} = lb3/12Q$ (mt)

where:

l = length of tank (m)

b = breadth of tank (m)

Q = specific volume of liquid in tank (m^3/t)

(Measure Q directly with a hydrometer).

$$\text{Free surface correction} = \frac{\sum M_{fs}(1) + M_{fs}(2) + \ldots + M_{fs}(x)}{displ.} \quad (m)$$

where:

M_{fs} = free surface moment (mt)

displ = displacement (t)

Free surface correction is independent of the height of the tank in the ship, location of the tank, and direction of heel. As the width of the tank increases, the value of free surface moment increases by the third power. The distance available for the liquid to shift is the predominant factor. This is why even the smallest amount of liquid in the bottom of a wide tank or bilge is normally unacceptable and should be removed prior to the inclining experiment. Insignificant amounts of liquids in V-shaped tanks or voids (e.g. a chain locker in the bow), where the potential shift is negligible, may remain if removal of the liquid would be difficult or would cause extensive delays.

When ballast water is used as inclining weight, the actual transverse and vertical movements of the liquid should be calculated taking into account the change of heel of the ship. Free surface corrections as defined in this paragraph should not apply to the inclining tanks.

2.1.2	Free surface and slack tanks - The number of slack tanks should normally be limited to one port/ starboard pair or one centreline tank of the following:	
2.1.2.1	fresh water reserve feed tanks;	
2.1.2.2	fuel/diesel oil storage tanks;	
2.1.2.3	fuel/diesel oil day tanks;	
2.1.2.4	lube oil tanks;	
2.1.2.5	sanitary tanks; or	
2.1.2.6	potable water tanks.	
	To avoid pocketing, slack tanks should normally be of regular (i.e. rectangular, trapezoidal, etc.) cross section and be 20% to 80% full if they are deep tanks and 40% to 60% full if they are double-bottom tanks. These levels ensure that the rate of shifting of liquid remains constant throughout the heel angles of the inclining test. If the trim changes as the ship is inclined, then consideration should also be given to longitudinal pocketing. Slack tanks containing liquids of sufficient viscosity to prevent free movement of the liquids, as the ship is inclined (such as bunker at low temperature), should be avoided since the free surface cannot be calculated accurately. A free surface correction for such tanks should not be used unless the tanks are heated to reduce viscosity. Communication between tanks should never be allowed. Cross-connections, including those via manifolds, should be closed. Equal liquid levels in slack tank pairs can be a warning sign of open cross connections. A bilge, ballast, and fuel oil piping plan can be referred to, when checking for cross connection closures.	
2.1.3	Pressed-up tanks - "Pressed up" means completely full with no voids caused by trim or inadequate venting. Anything less than 100% full, for example the 98% condition regarded as full for operational purposes, is not acceptable. Preferably, the ship should be rolled from side to side to eliminate entrapped air before taking the final sounding. Special care should be taken when pressing fuel oil tanks to prevent	

accidental pollution. An example of a tank that would appear "pressed up", but actually contains entrapped air, is shown in figure A2-2.1.3.

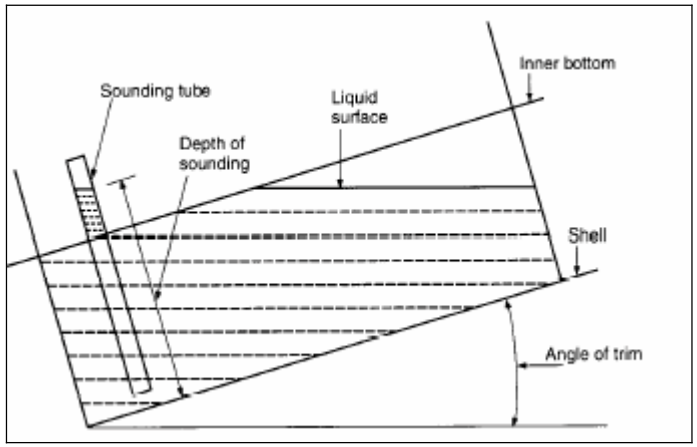


Figure A2-2.1.3

2.1.4 Empty tanks – It is generally not sufficient to simply pump tanks until suction is lost. Enter the tank after pumping to determine if final stripping with portable pumps or by hand is necessary. The exceptions are very narrow tanks or tanks where there is a sharp deadrise, since free surface would be negligible. Since all empty tanks should be inspected, all manholes should be open and the tanks well ventilated and certified as safe for entry. A safe testing device should be on hand to test for sufficient oxygen and minimum toxic levels. A certified marine chemist's certificate certifying that all fuel oil and chemical tanks are safe for human entry should be available, if necessary.

2.2 Mooring arrangements

The importance of good mooring arrangements cannot be overemphasized. The arrangement selections will be dependent upon many factors. Among the most important are depth of water, wind and current effects. Whenever possible, the ship should be moored in a quiet, sheltered area free from extraneous forces such as propeller wash from passing ships, or sudden discharges from shore side pumps. The depth

of water under the hull should be sufficient to ensure that the hull will be entirely free of the bottom. The tide conditions and the trim of the ship during the test should be considered. Prior to the test, the depth of water should be measured and recorded in as many locations as necessary to ensure the ship will not contact the bottom. If marginal, the test should be conducted during high tide or the ship moved to deeper water.

2.2.1 The mooring arrangement should ensure that the ship will be free to list without restraint for a sufficient period of time to allow a satisfactory reading of the heeling angle, due to each weight shift, to be recorded.

2.2.2 The ship should be held by lines at the bow and the stern, attached to bollards and/or cleats on the deck. If suitable restraint of the ship cannot be achieved using deck fittings, then temporary padeyes should be attached as close as possible to the centreline of the ship and as near the waterline as practical. Where the ship can be moored to one side only, it is good practice to supplement the bow and stern lines with two spring lines in order to maintain positive control of the ship, as shown in figure A2.2.2.1. The leads of the spring lines should be as long as practicable. Cylindrical camels should be provided between the ship and the dock. All lines should be slack, with the ship free of the pier and camels, when taking readings.

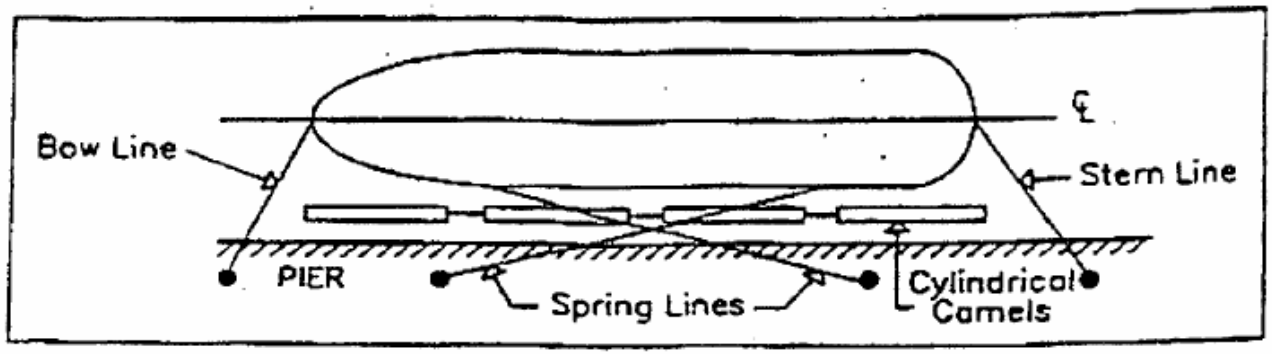


Figure A2-2.2.1

2.2.2.1 If the ship is held off the pier by the combined effect of the wind and current, a superimposed heeling moment will act on the ship throughout the test. For steady conditions this will not affect the results.

	Gusty winds or uniformly varying wind and/or current will cause these superimposed heeling moments to change, which may require additional test points to obtain a valid test. The need for additional test points can be determined by plotting test points as they are obtained.	
2.2.2.2	If the ship is pressed against the fenders by wind and/or current, all lines should be slack. The cylindrical camels will prevent binding but there will be an additional superimposed heeling moment due to the ship bearing against the camels. This condition should be avoided where possible but, when used, consideration should be given to pulling the ship free of the dock and camels and letting the ship drift as readings are taken.	
2.2.2.3	Another acceptable arrangement is where the combined wind and current are such that the ship may be controlled by only one line at either the bow or the stern. In this case, the control line should be led from on or near the centre line of the ship with all lines but the control line slack, the ship is free to veer with the wind and/or current as readings are taken. This can sometimes be troublesome because varying wind and/or current can cause distortion of the plot.	
2.2.3	The mooring arrangement should be submitted to the approval authority for review prior to the test.	
2.2.4	If a floating crane is used for handling inclining weights, it should not be moored to the ship.	
2.3	**Test weights**	
2.3.1	Weights, such as porous concrete, that can absorb significant amounts of moisture should only be used if they are weighed just prior to the inclining test or if recent weight certificates are presented. Each weight should be marked with an identification number and its weight. For small ships, drums completely filled with water may be used. Drums should normally be full and capped to allow accurate weight control. In such cases, the weight of the drums should be verified in the presence of the Administration representative using a recently calibrated scale.	
2.3.2	Precautions should be taken to ensure that the decks are not overloaded during weight movements. If deck strength is questionable then a structural analysis should be performed to determine if existing framing can support the weight.	

2.3.3	Generally, the test weights should be positioned as far outboard as possible on the upper deck. The test weights should be on board and in place prior to the scheduled time of the inclining test.	
2.3.4	Where the use of solid weights to produce the inclining moment is demonstrated to be impracticable, the movement of ballast water may be permitted as an alternative method. This acceptance would be granted for a specific test only, and approval of the test procedure by the Administration is required. As a minimal prerequisite for acceptability, the following conditions should be required:	
2.3.4.1	inclining tanks should be wall-sided and free of large stringers or other internal members that create air pockets. Other tank geometries may be accepted at the discretion of the Administration;	
2.3.4.2	tanks should be directly opposite to maintain ship's trim;	
2.3.4.3	specific gravity of ballast water should be measured and recorded;	
2.3.4.4	pipelines to inclining tanks should be full. If the ship's piping layout is unsuitable for internal transfer, portable pumps and pipes/hoses may be used;	
2.3.4.5	blanks must be inserted in transfer manifolds to prevent the possibility of liquids being "leaked" during transfer. Continuous valve control must be maintained during the test;	
2.3.4.6	all inclining tanks must be manually sounded before and after each shift;	
2.3.4.7	vertical, longitudinal and transverse centres should be calculated for each movement;	
2.3.4.8	accurate sounding/ullage tables must be provided. The ship's initial heel angle should be established prior to the incline in order to produce accurate values for volumes and transverse and vertical centres of gravity for the inclining tanks at every angle of heel. The draught marks amidships (port and starboard)should be used when establishing the initial heel angle;	
2.3.4.9	verification of the quantity shifted may be achieved by a flow meter or similar device; and	

2.3.4.10	the time to conduct the inclining must be evaluated. If time requirements for transfer of liquids are considered too long, water may be unacceptable because of the possibility of wind shifts over long periods of time.	
2.4	**Pendulums**	
2.4.1	The pendulums should be long enough to give a measured deflection, to each side of upright, of a least 15 cm. Generally, this will require a pendulum length of at least 3 m. It is recommended that pendulum lengths of 4-6 m be used. Usually, the longer the pendulum the greater the accuracy of the test; however, excessively long pendulums are used on a tender ship the pendulums may not settle down and the accuracy of the pendulums would then be questionable. On large ships with high GM, pendulum lengths in excess of the length recommended above may be required to obtain the minimum deflection. In such cases, the trough, as shown in figure A2-2.4.6, should be filled with high-viscosity oil. If the pendulums are of different lengths, the possibility of collusion between station recorders is avoided.	
2.4.2	On smaller ships, where there is insufficient headroom to hang long pendulums, the 15 cm deflection should be obtained by increasing the test weight so as to increase the heel. On most ships the typical inclination is between one and four degrees.	
2.4.3	The pendulum wire should be piano wire or other monofilament material. The top connection of the pendulum should afford unrestricted rotation of the pivot point. An example is that of a washer with the pendulum wire attached suspended from a nail.	
2.4.4	A trough filled with a liquid should be provided to dampen oscillations of the pendulum after each weight movement. It should be deep enough to prevent the pendulum weight from touching the bottom. The use of a winged plumb bob at the end of the pendulum wire can also help to dampen the pendulum oscillations in the liquid.	
2.4.5	The battens should be smooth, light-coloured wood, 1 to 2 cm thick, and should be securely fixed in position so that an inadvertent contact will not cause them to shift. The batten should be aligned close to the pendulum wire but not in contact with it.	

2.4.6 A typical satisfactory arrangement is shown in figure A2-2.4.6. The pendulums may be placed in any location on the ship, longitudinally and transversely. The pendulums should be in place prior to the scheduled time of the inclining test.

2.4.7 It is recommended that inclinometers or other measuring devices only be used in conjunction with at least one pendulum. The Administration may approve an alternative arrangement when this is found impractical.

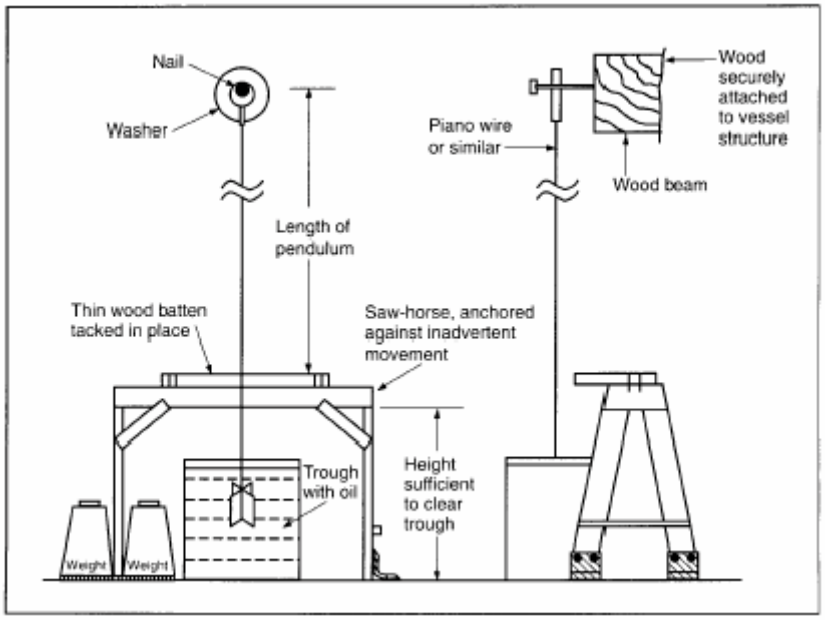


Figure: A2-2.4.6

2.5 U-tubes

2.5.1 The legs of the device should be securely positioned as far as outboard as possible and should be parallel to the centreline plane of the ship. The distance between the legs should be measured perpendicular to the centreline plane. The legs should be vertical, as far as practical.

2.5.2	Arrangements should be made for recording all readings at both legs. For easy reading and checking for air pockets, clear plastic tube or hose should be used throughout. The U-tube should be pressure-tested prior to the inclining test to ensure watertightness.	
2.5.3	The horizontal distance between the legs of the U-tube should be sufficient to obtain a level difference of at least 15 cm between the upright and the maximum inclination to each side.	
2.5.4	Normally, water would be used as the liquid in the U-tube. Other low-viscosity liquids may also be considered.	
2.5.5	The tube should be free of air pockets. Arrangements should be made to ensure that the free flow of the liquid in the tube is not obstructed.	
2.5.6	Where a U-tube is used as a measuring device, due consideration should be given to the prevailing weather conditions (see 4.1.1.3):	
2.5.6.1	if the U-tube is exposed to direct sunlight, arrangements should be made to avoid temperature differences along the length of the tube;	
2.5.6.2	if temperatures below 0°C are expected, the liquid should be a mixture of water and an anti-freeze additive; and	
2.5.6.3	where heavy rain squalls can be expected, arrangements should be made to avoid additional water entering the U-tube.	
2.6	**Inclinometers** The use of inclinometers should be subject to at least the following recommendations:	
2.6.1	the accuracy should be equivalent to that of the pendulum;	
2.6.2	the sensitivity of the inclinometer should be such that the non-steady heeling angle of the ship can be recorded throughout the measurement;	

2.6.3	the recording period should be sufficient to accurately measure the inclination. The recording capacity should be generally sufficient for the whole test;	
2.6.4	the instrument should be able to plot or print the recorded inclination angles on paper;	
2.6.5	the instrument should have linear performance over the expected range of inclination angles;	
2.6.6	the instrument should be supplied with the manufacturer's instructions giving details of calibration, operating instructions, etc.; and	
2.6.7	it should be possible to demonstrate the required performance to the satisfaction of the Administration during the inclining test.	
3	**Equipment required** Besides the physical equipment necessary such as the inclining weights, pendulums, small boat, etc., the following are necessary and should be provided by or made available to the person in charge of the inclining:	
3.1	engineering scales for measuring pendulum deflections (rules should be subdivided sufficiently to achieve the desired accuracy;	
3.2	sharp pencils for marking pendulum deflections;	
3.3	chalk for marking the various positions of the inclining weights;	
3.4	a sufficiently long measuring tape for measuring the movement of the weights and locating different items on board;	
3.5	a sufficiently long sounding tape for sounding tanks and taking freeboard readings;	

3.6	one or more well maintained specific gravity hydrometers with range sufficient to cover 0.999 to 1.030, to measure the specific gravity of the water in which the ship is floating (a hydrometer for measuring specific gravity of less than 1.000 may be needed in some locations;	
3.7	other hydrometers as necessary to measure the specific gravity of any liquids on board;	
3.8	graph paper to plot inclining moments versus tangents;	
3.9	a straight edge to draw the measured waterline on the lines drawing;	
3.10	a pad of paper to record data;	
3.11	an explosion-proof testing device to check for sufficient oxygen and absence of lethal gases in tanks and other closed spaces such as voids and cofferdams;	
3.12	a thermometer; and	
3.13	draught tubes (if necessary).	
4	**Test procedure** The inclining experiment, the freeboard/draught readings and the survey may be conducted in any order and still achieve the same results. If the person conducting the inclining test is confident that the survey will show that the ship is in an acceptable condition and there is the possibility of the weather becoming unfavourable, then it is suggested that the inclining be performed first and the survey last. If the person conducting the test is doubtful that the ship is complete enough for the test, it is recommended that the survey be performed first since this could invalidate the entire test, regardless of the weather conditions. It is very important that all weights, the number of people on board, etc., remain constant throughout the test.	
4.1	**Initial walk through and survey** The person responsible for conducting the inclining test should arrive on board the ship well in advance of the scheduled time of the test to ensure that the ship is properly prepared for the test. If the ship to be inclined is large, a preliminary walk through may need to be done the day preceding the actual incline.	

	To ensure the safety of personnel conducting the walk through, and to improve the documentation of surveyed weights and deficiencies, at least two persons should make the initial walk through. Things to check include: all compartments are open, clean, and dry, tanks are well ventilated and gas-free, movable or suspended items are secured and their position documented, pendulums are in place, weights are on board and in place, a crane or other method for moving weights is available, and the necessary plans and equipment are available. Before beginning the inclining test, the person conducting the test should:	
4.1.1	consider the weather conditions. The combined adverse effect of wind, current and sea may result in difficulties or even an invalid test due to the following:	
4.1.1.1	inability to accurately record freeboards and draughts;	
4.1.1.2	excessive or irregular oscillations of the pendulums;	
4.1.1.3	variations in unavoidable superimposed heeling moments. In some instances, unless conditions can be sufficiently improved by moving the ship to a better location, it may be necessary to delay or postpone the test. Any significant quantities of rain, snow, or ice should be removed from the ship before the test. If bad weather conditions are detected early enough and the weather forecast does not call for improving conditions, the Administration representative should be advised prior to departure from the office and an alternative date scheduled;	
4.1.2	make a quick overall survey of the ship to make sure the ship is complete enough to conduct the test and to ensure that all equipment is in place. An estimate of items which will be outstanding at the time of the inclining test should be included as part of any test procedure submitted to the Administration. This is required so that the Administration representative can advise the shipyard/ naval architect if in their opinion the ship will not be sufficiently complete to conduct the incline and that it should be rescheduled. If the condition of the ship is not accurately depicted in the test procedure and at the time of the inclining test the Administration representative considers that the ship is in such condition that an accurate incline cannot be conducted, the representative may refuse to accept the incline and require that the incline be conducted at a later date;	

4.1.3	enter all empty tanks after it is determined that they are well ventilated and gas-free to ensure that they are dry and free of debris. Ensure that any pressed-up tanks are indeed full and free of air pockets. The anticipated liquid loading for the incline should be included in the procedure required to be submitted to the Administration;	
4.1.4	survey the entire ship to identify all items which need to be added to the ship, removed from the ship, or relocated on the ship to bring the ship to the light-ship condition. Each item should be clearly identified by weight and vertical and longitudinal location. If necessary, the transverse location should also be recorded. The inclining weights, the pendulums, any temporary equipment and dunnage, and the people on board during the inclining test are all among the weights to be removed to obtain the light-ship condition. The person calculating the light-ship characteristics from the data gathered during the incline and survey and/or the person reviewing the inclining test may not have been present during the test and should be able to determine the exact location of the items from the data recorded and the ship's drawings. Any tanks containing liquids should be accurately sounded and the soundings recorded;	
4.1.4.1	it is recognized that the weight of some items on board, or that are to be added, may have to be estimated. If this is necessary, it is in the best interest of safety to be on the safe side when estimating, so the following rules of thumb should be followed:	
4.1.4.1.1	when estimating weights to be added: - estimate high for items to be added high in the ship. - estimate low for items to be added low in the ship.	
4.1.4.1.2	when estimating weights to be removed: - estimate low for items to be removed from high in the ship. - estimate high for items to be removed from low in the ship.	
4.1.4.1.3	when estimating weights to be relocated: - estimate high for items to be relocated to a higher point in the ship. - estimate low for items to be relocated to a lower point in the ship.	

4.2	**Freeboard/draught readings**	
4.2.1	Freeboard/draught readings should be taken to establish the position of the waterline in order to determine the displacement of the ship at the time of the inclining test. It is recommended that at least five freeboard readings, approximately equally spaced, be taken on each side of the ship or that all draught marks (forward, midship, and aft) be read on each side of the ship. Draught mark readings should be taken to assist in determining the waterline defined by freeboard readings, or to verify the vertical location of draught marks on ships where their location has not been confirmed. The locations for each freeboard reading should be clearly marked. The longitudinal location along the ship should be accurately determined and recorded since the (moulded) depth at each point will be obtained from the ship's lines. All freeboard measurements should include a reference note clarifying the inclusion of the coaming in the measurement and the coaming height.	
4.2.2	Draught and freeboard readings should be read immediately before or immediately after the inclining test. Weights should be on board and in place and all personnel who will be on board during the test, including those who will be stationed to read the pendulums, should be on board and in location during these readings. This is particularly important on small ships. If readings are made after the test, the ship should be maintained in the same condition as during the test. For small ships, it may be necessary to counterbalance the list and trim effects of the freeboard measuring party. When possible, readings should be taken from a small boat.	
4.2.3	A small boat should be available to aid in the taking of freeboard and draught mark readings. It should have low freeboard to permit accurate observation of the readings.	
4.2.4	The specific gravity of the flotation water should be determined at this time. Samples should be taken from a sufficient depth of the water to ensure a true representation of the flotation water and not merely surface water, which could contain fresh water from run-off of rain. A hydrometer should be placed in a water sample and the specific gravity read and recorded. For large ships, it is recommended that samples of the flotation water be taken forward, midship, and aft and the readings averaged. For small ships, one sample taken from midships should be sufficient. The temperature of the water should be taken and the measured specific gravity corrected for deviation from the standard, if necessary. A correction to water specific gravity is not necessary if the specific gravity is determined at the inclining experiment site.	

	Correction is necessary if specific gravity is measured when sample temperature differs from the temperature at the time of the inclining (e.g., if check of specific gravity is done at the office).	
4.2.5	A draught mark reading may be substituted for a given freeboard reading at that longitudinal location if the height and location of the mark have been verified to be accurate by a keel survey while the ship was in dry-dock.	
4.2.6	A device, such as a draught tube, can be used to improve the accuracy of freeboard/draught readings by damping out wave action.	
4.2.7	The dimensions given on a ship's lines drawing are normally moulded dimensions. In the case of depth, this means the distance from the inside of the bottom shell to the inside of the deck plate. In order to plot the ship's waterline on the lines drawing, the freeboard readings should be converted to moulded draughts. Similarly, the draught mark readings should be corrected from extreme (bottom of keel) to moulded (top of keel) before plotting. Any discrepancy between the freeboard/draught readings should be resolved.	
4.2.8	The mean draught (average of port and starboard readings) should be calculated for each of the locations where freeboard/draught readings are taken and plotted on the ship's lines drawing or outboard profile to ensure that all readings are consistent and together define the correct waterline. The resulting plot should yield either a straight line or a waterline which is either hogged or sagged. If inconsistent readings are obtained, the freeboards/draughts should be retaken.	
4.3	**The incline**	
4.3.1	Prior to any weight movements the following should be checked:	
4.3.1.1	the mooring arrangement should be checked to ensure that the ship is floating freely. (This should be done just prior to each reading of the pendulums.)	
4.3.1.2	the pendulums should be measured and their lengths recorded. The pendulums should be aligned so that when the ship heels, the wire will be close enough to the batten to ensure an accurate reading but will not come into contact with the batten. The typical satisfactory arrangement is shown in figure A2-2.4.6.	

4.3.1.3 the initial position of the weights is marked on the deck. This can be done by tracing the outline of the weights on the deck.

4.3.1.4 the communications arrangement is adequate.

4.3.1.5 all personnel are in place.

4.3.2 A plot should be run during the test to ensure that acceptable data are being obtained. Typically, the abscissa of the plot will be heeling moment (weight times distance) and the ordinate will be the tangent of the heel angle (deflection of the pendulum divided by the length of the pendulum). This plotted line does not necessarily pass through the origin or any other particular point for no single point is more significant than any other point. A linear regression analysis is often used to fit the straight line. The weight movements shown in figure A2-4.3.2-1 give a good spread of points on the test plot.

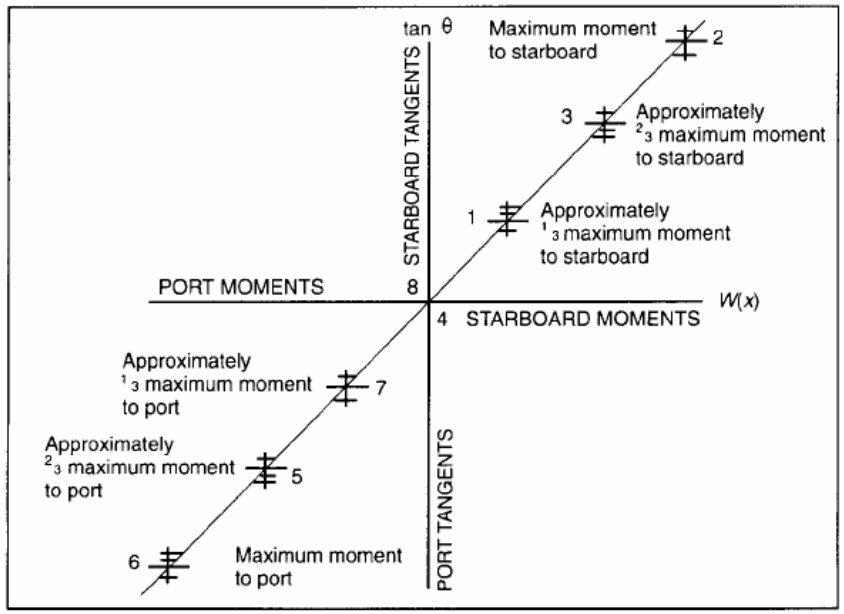


Figure: A2-4.3.2.1

Plotting all of the readings for each of the pendulums during the inclining experiment aids in the discovery of bad readings. Since W(x)/tan 0 should be constant, the plotted line should be straight. Deviations from a straight line are an indication that there were other moments acting on the ship during the inclining. These other moments should be identified, the cause corrected, and the weight movements repeated until a straight line is achieved. Figures A2-4.3.2-2 through A2-4.3.2-5 illustrate examples of how to detect some of these other moments during the inclining, and a recommended solution for each case. For simplicity, only the average of the readings is shown on the inclining plots.

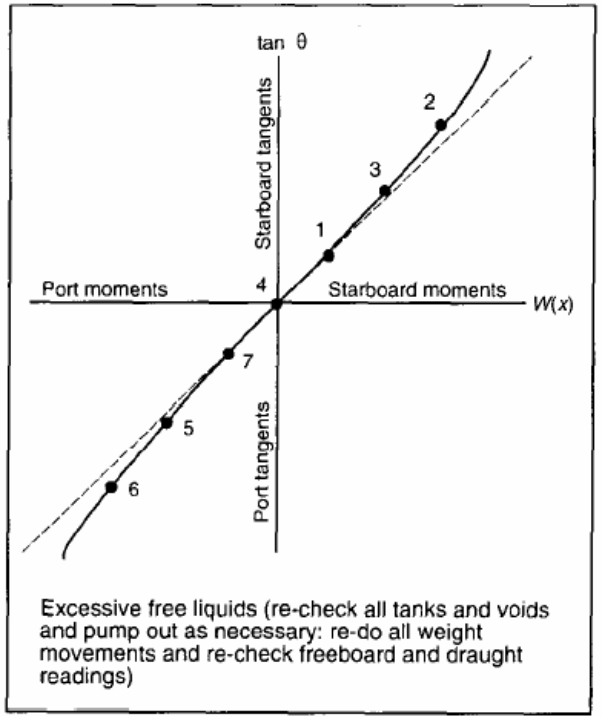


Figure: A2-4.3.2.2

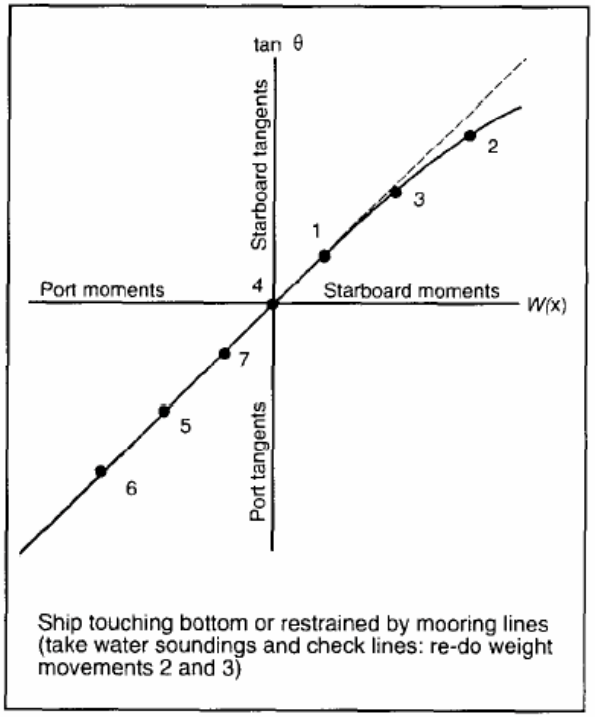
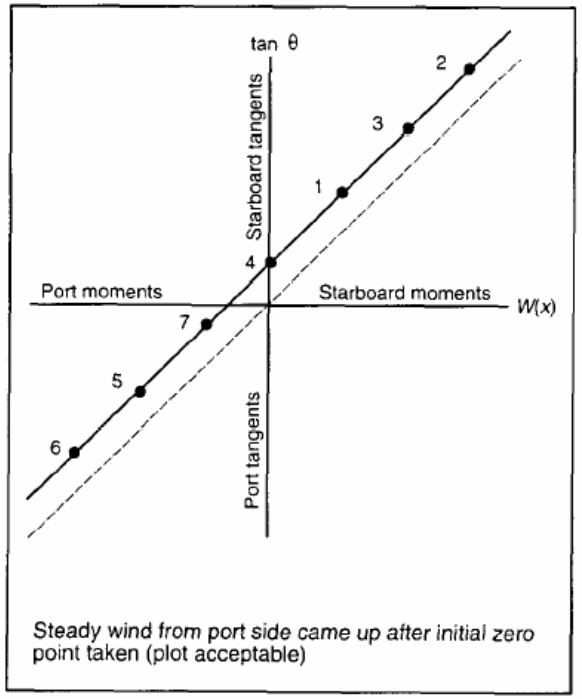
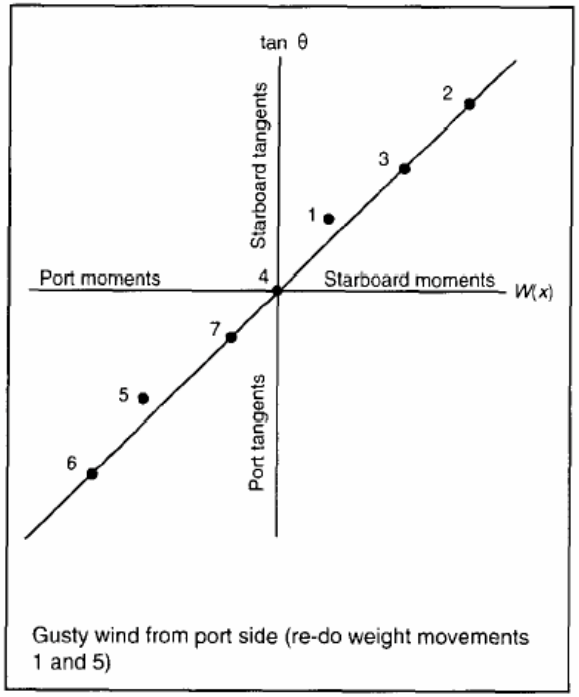


Figure: A2-4.3.2.3



Steady wind from port side came up after initial zero point taken (plot acceptable)

Figure: A2-4.3.2.4



Gusty wind from port side (re-do weight movements 1 and 5)

Figure: A2-4.3.2.5

4.3.3 Once everything and everyone is in place, the zero position should be obtained and the remainder of the experiment conducted as quickly as possible, while maintaining accuracy and proper procedures, in order to minimize the possibility of a change in environmental conditions during the test.

4.3.4 Prior to each pendulum reading, each pendulum station should report to the control station when the pendulum has stopped swinging. Then, the control station will give a "standby" warning and then a "mark" command. When "mark" is given, the batten at each position should be marked at the location of the pendulum wire. If the wire was oscillating slightly, the centre of the oscillations should be taken as the mark. If any of the pendulum readers does not think the reading was a good one, the reader should

	advise the control station and the point should be retaken for all pendulum stations. Likewise, if the control station suspects the accuracy of a reading, it should be repeated for all the pendulum stations. Next to the mark on the batten should be written the number of the weight movement, such as zero for the initial position and one through seven for the weight movements.	
4.3.5	Each weight movement should be made in the same direction, normally transversely, so as not to change the trim of the ship. After each weight movement, the distance the weight was moved (centre to centre) should be measured and the heeling moment calculated by multiplying the distance by the amount of weight moved. The tangent is calculated for each pendulum by dividing the deflection by the length of the pendulum. The resultant tangents are plotted on the graph. Provided there is good agreement among the pendulums with regard to the tan ‘theta' value, the average of the pendulum readings may be graphed instead of plotting each of the readings.	
4.3.6	Inclining data sheets should be used so that no data are forgotten and so that the data are clear, concise, and consistent in form and format. Prior to departing the ship, the person conducting the test and the Administration representative should initial each data sheet as an indication of their concurrence with the recorded data.	

Annex 4 – Determination of ship's stability by means of rolling Period tests (for ships up to 70 m in length)		
1	Recognizing the desirability of supplying to masters of small ships instructions for a simplified determination of initial stability, attention was given to the rolling period tests. Studies on this matter showed that the rolling period test may be recommended as a useful means of approximately determining the initial stability of small ships when it is not practicable to give approved loading conditions or other stability information, or as a supplement to such information.	
2	Investigations comprising the evaluation of a number of inclining and rolling tests according to various formulae showed that the following formula gave the best results and it has the advantage of being the simplest: $GM_0 = (\frac{fB}{T_r})^2$ where: f = factor for the rolling period (rolling coefficient) as given in 1.6.4; B = breadth of the ship in metres; T_r = time for a full rolling period in seconds (i.e. for one oscillation "to and fro" port - starboard - port, or *vice versa*).	
3	The factor "f" is of the greatest importance and the data from the above tests were used for assessing the influence of the distribution of the various masses in the whole body of the loaded ship.	
4	For coasters of normal size (excluding tankers) and fishing vessels, the following average values were observed:	

	f values
Empty ship or ship carrying ballast	f ~ 0.88
Ship fully loaded and with liquids in tanks comprising the following percentage of the total load on board (i.e. cargo, liquids, stores, etc.)	
20% of total load	f ~ 0.78
10% of total load	f ~ 0.75
5% of total load	f ~ 0.73
Double boom shrimp fishing boats	f ~ 0.95
Deep sea fishing boats	f ~ 0.80
Boats with live fish well	f ~ 0.60

The stated values are mean values. Generally, observed f values were within $\pm$ 0.05 of those given above.

5 The above f-values were based upon a series of limited tests and, therefore, Administrations should re-examine these in the light of any different circumstances applying to their own ships.

6 It should be noted that the greater the distance of masses from the rolling axis, the greater the rolling coefficient will be. Therefore it can be expected that:

6.1 the rolling coefficient for an unloaded ship, i.e. for a hollow body, will be higher than that for a loaded ship; and

6.2 the rolling coefficient for a ship carrying a great amount of bunkers and ballast - both groups are usually located in the double bottom, i.e. far away from the rolling axis - will be higher than that of the same ship having an empty double bottom.

7 The above recommended rolling coefficients were determined by tests with ships in port and with their consumable liquids at normal working levels; thus, the influences exerted by the vicinity of the quay, the limited depth of water and the free surfaces of liquids in service tanks are covered.

8 Experiments have shown that the results of the rolling test method get increasingly less reliable the nearer they approach GM-values of 0.20 m and below.

9 For the following reasons, it is not generally recommended that results be obtained from rolling oscillations taken in a seaway:

9.1 exact coefficients for tests in open waters are not available;

9.2 the rolling periods observed may not be free oscillations but forced oscillations due to seaway;

9.3 frequently, oscillations are either irregular or only regular for too short an interval of time to allow accurate measurements to be observed; and

9.4 specialized recording equipment is necessary.

10 However, sometimes it may be desirable to use the ship's period of roll as a means of approximately judging the stability at sea. If this is done, care should be taken to discard readings which depart appreciably from the majority of other observations. Forced oscillations corresponding to the sea period and differing from the natural period at which the ship seems to move should be disregarded. In order to obtain satisfactory results, it may be necessary to select intervals when the sea action is least violent and it may be necessary to discard a considerable number of observations.

11 In view of the foregoing circumstances, it needs to be recognized that the determination of the stability by means of the rolling test in disturbed waters should only be regarded as a very approximate estimation.

12 The formula given in paragraph 2 above can be reduced to:

$$GM_0 = \frac{F}{T_r^2}$$

and the Administration should determine the F-value(s) for each ship.

13	The determination of the stability can be simplified by giving the master permissible rolling periods, in relation to the draughts, for the appropriate value(s) of *F* considered necessary.	
14	The initial stability may also be more easily determined graphically by using the attached sample nomogram (figure A3-14) as described below:	
14.1	The values for *B* and *f* are marked in the relevant scales and connected by a straight line (1). This straight line intersects the vertical line (mm) at the point M.	
14.2	A second straight line (2) which connects this point M and the point on the T_r scale corresponding with the determined rolling period, intersects the GM scale at the requested value.	
15	Section 16 shows an example of a recommended form in which these instructions might be presented by each Administration to the masters. It is considered that each Administration should recommend the *F*-value or values to be used.	
16	**Test procedure**	
16.1	The rolling period required is the time for one complete oscillation of the ship and to ensure the most accurate results in obtaining this value the following precautions should be observed:	
16.1.1	The test should be conducted with the ship in harbour, in smooth water with the minimum interference from the wind and tide.	
16.1.2	Starting with the ship at the extreme end of a roll to one side (say port) and the ship about to move towards the upright, one complete oscillation will have been made when the ship has moved right across to the other extreme side (i.e. starboard) and returned to the original starting point and is about to commence the next roll.	
16.1.3	By means of a stop-watch, the time should be taken for not less` than about 5 of these complete oscillations; the counting of these oscillations should begin when the ship is at the extreme end of a roll.	

	After allowing the roll to completely fade away, this operation should be repeated at least twice more. If possible, in every case the same number of complete oscillations should be timed to establish that the readings are consistent, i.e. repeating themselves within reasonable limits. Knowing the total time for the total number of oscillations made, the mean time for one complete oscillation can be calculated.	
16.1.4	The ship can be made to roll by rhythmically lifting up and putting down a weight as far off middle-line as possible; by pulling on the mast with a rope; by people running athwartships in unison; or by any other means. However, and this is most important, as soon as this forced rolling has commenced the means by which it has been induced should be stopped and the ship allowed to roll freely and naturally. If rolling has been induced by lowering or raising a weight it is preferable that the weight is moved by a dockside crane. If the ship's own derrick is used, the weight should be placed on the deck, at the middle-line, as soon as the rolling is established.	
16.1.5	The timing and counting of the oscillations should only begin when it is judged that the ship is rolling freely and naturally and only as much as is necessary to accurately count these oscillations.	
16.1.6	The mooring should be slack and the ship "breasted off" to avoid making any contact during its rolling. To check this, and also to get some idea of the number of oscillations that can be reasonably counted and timed, a preliminary rolling test should be made before starting to record actual times.	
16.1.7	Care should be taken to ensure that there is a reasonable clearance of water under the keel and at the sides of the ship.	
16.1.8	Weights of reasonable size which are liable to swing (e.g. a lifeboat), or liable to move (e.g. a drum), should be secured against such movement. The free surface effects of slack tanks should be kept as small as is practicable during the test and the voyage.	
16.2	Limitations to the use of this method	
16.2.1	A long period of roll corresponding to a GM_O of 0.20 m or below indicates a condition of low stability. However, under such circumstances, accuracy in determination of the actual value of GM_O is reduced.	

16.2.2	If, for some reason, these rolling tests are carried out in open, deep but smooth waters, inducing the roll, for example, by putting over the helm, then the GM_O calculated by using the method and coefficient of paragraph 1.6.16.1 above should be reduced by (figure to be estimated by the Administration) to obtain the final answer.	
16.2.3	The determination of stability by means of the rolling test in disturbed waters should only be regarded as a very approximate estimation. If such test is performed, care should be taken to discard readings which depart appreciably from the majority of other observations. Forced oscillations corresponding to the sea period and differing from the natural period at which the vessel seems to move should be disregarded. In order to obtain satisfactory results, it may be necessary to select intervals when the sea action is least violent and it may be necessary to discard a considerable number of observations.	

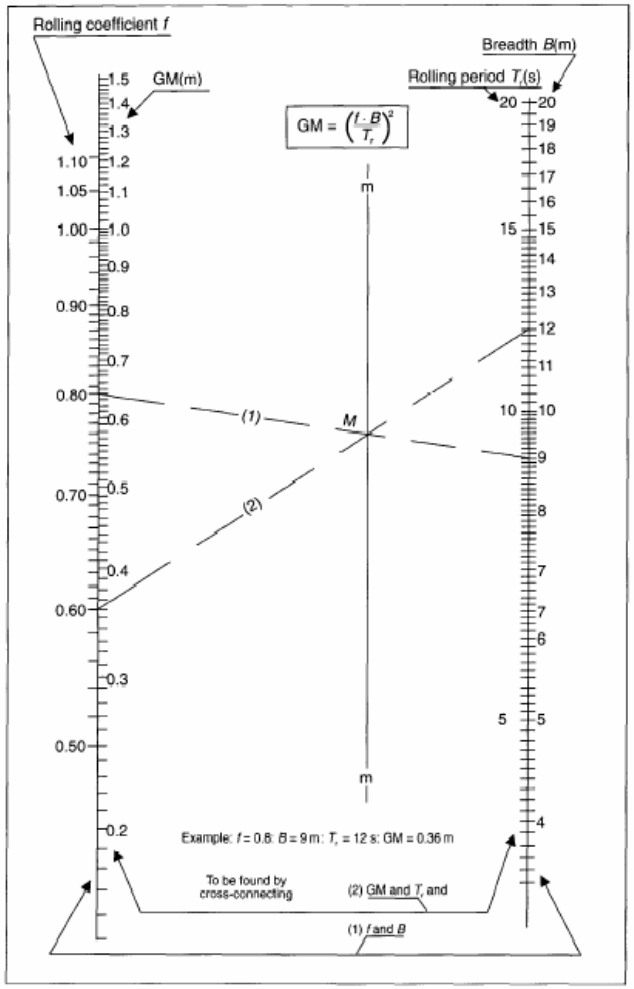


DIAGRAM Figure 14

Document 2

DEPARTMENT OF TRANSPORTATION
UNITED STATES COAST GUARD

NVIC 5-86
1 Aug 1986

NAVIGATION AND VESSEL INSPECTION CIRCULAR NO. 5-86

Subj: Voluntary Standards for U.S. Uninspected Commercial Fishing Vessels

1. PURPOSE. The purpose of this circular is to establish voluntary minimum standards for U.S. uninspected commercial fishing vessels.

…

B. Roll Period Test - The Coast Guard declines to endorse the use of a roll period test in IMO Resolution A/ES.IV/168 for several reasons.

1. First, a roll period test may be used by the operator to evaluate the vessel's stability while underway by operators who do not fully understand the limitations of measuring the roll period to evaluate stability. Measuring the roll period in still water is a case of free oscillation where the measured roll period is the vessel's natural roll period. This may or may not be the case when the vessel rolls in a seaway. If waves of a constant period act upon the vessel for a sufficiently long period of time, the measured roll period will be that of the waves. If waves of a constant period are not experienced, the measured roll period may be the natural period of the vessel or, more likely, a combination of the vessel's natural period of roll and the period of the seaway.

2. Second, the roll period is only indicative of the vessel's metacentric height (GM) and not the area under the righting arm curve or other important stability characteristics such as the maximum righting arm, the angle at which the maximum righting arm occurs or the range of stability.

3. Third, the data used to develop the nomogram shown in IMO Resolution A/ES.IV/168 was taken from European fishing vessels and coastal freighters. The Coast Guard is not convinced that the roll coefficients recommended are appropriate for U.S. fishing vessels considering the number of fisheries that U.S. fishermen are engaged in and the diversity of hull forms and arrangements used.

4. Finally, the Coast Guard is concerned that the roll coefficients do not accurately account for the changes in the roll gyradius as the vessel operates between full load and burned out conditions. A significant change in the roll gyradius means that the actual GM may be much different than that indicated from measuring the roll period and calculating the GM based in the equations given.

…

Document 3

REPUBLIC OF FRANCE

NAVY DEPARTMENT

PORT AND NAVIGATION AUTHORITIES

SUBDEPARTMENT OF SHIP SAFETY

DEPARTMENT OF REGULATIONS

Paris, 9 May 1990

DPNM/No 875/90
SN1

Subject : GM-METER manufactured by the company SEPAC.

Reference : Your letter TEC/CAZ/900012 dated January 17, 1990

Dear Sir,

I hereby acknowledge receipt of the test report containing information on the test performance of the GM-METER device, manufactured by the company SEPAC, and succesfully tested on board the car ferry "COTE D'AZUR" from the 1-15/12/89.

In view of the fact that the GM can be measured four minutes after the departure of the ship and that the measured GM value corresponds approximately to the calculated value (the true value of the measurement lies within approximately 10% of the measured value), I beg to inform you that I authorise the use of the GM-METER manufactured by the company SEPAC as a proven means to determineship stability according to the terms of paragraph 7.4 of provision 8 of the SOLAS Convention, amended by resolution MSC 12 (56) and adopted on 28/10/88.

Yours faithfully,

Director of Port and Navigation Autorities

Signed: Thierry LEHUERDU KERISEL

SEALINK FERRIES-SNCF
Service de l'Armement Naval
For the attention of the
Head of the Technical Department
3 rue Ambroise Paré
75475 PARIS CEDEX 10

REPUBLIC OF FRANCE

OFFICE OF NAVAL AFFAIRS

PORT AND NAVIGATION AUTHORITIES

SUBDEPARTMENT OF SHIP SAFETY

DEPARTMENT OF REGULATIONS

PARIS, 28 October 1991

SN1/DPNM/No 1294/91

The Honorable Secretary-General,

I would be grateful if you could send the enclosed letter of the French Government with regard to the approved use of the device GM-METER SEPAC as a means to determine ship stability pursuant to paragraph 7.4 of provision 8 laid down in chapter II of the amended SOLAS 74/78 Convention to other contracting governments for the information of the competent government officials.

I beg to remain,

The Honorable Secretary-General of IMO

4 Albert Embankment
London SE1 7SR
(Great Britain)

CERTIFICATE OF APPROVED USE BY VIRTUE OF PARAGRAPH 7.4 OF PROVISION 8 AS LAID DOWN IN CHAPTER II OF THE SOLAS CONVENTION 74/78.

FRENCH DECLARATION

1. Having regard to the terms of provision 5 laid down in Chapter I of the 74/78 SOLAS Convention, the French Government informs the organisation that by virtue of paragraph 7.4 of provision 8 laid down in Chapter II of the Convention and duly amended by resolution MSC 12 (56) adopted on 28 October 1988, it has approved the use of the measuring device GM-METER manufactured in France by the company SEPAC as a means of determining the stability of passenger ships prior to departure.

2- The GM-METER is a device which determines the global GM value from the ship's natural rolling period with the aid of a built-in inclinometer. An automatic analysis is carried out for a period of three minutes in order to identify the natural rolling period.

3- Measurements should be taken immediately after departure or at berth provided that residual motions are sufficient and the ramp has been drawn in. The first results are obtained after three minutes. Subsequently, updated values appear on the screen at five second intervals for a period of one minute. The entire procedure is completed when the final result flashes on the screen.

4 - Hydrostatic and geometrical ship characteristics, which are stored in the memory of the device, allow the GM value to be derived from the natural rolling period of the ship. The parameters used in these calculations are based on the mean draft value which is entered into the device immediately after it has been switched on.

If the GM value is measured while the ship is at berth, then the user should take the effect of the hawsers on ship motions into account by entering the height of the bollards above the water level.

5 - Appendices

- Report on the presentation of the GM-METER device by Mr. A. COTA (Association Technique Maritime et Aéronautique - Session 1985).

- Overview of the use of the GM-METER on board of passenger ferries by A. COTA (Association Technique Maritime et Aéronautique - Session 1991).

- Latest test report on the use of the GM-METER on board the passenger ferry "COTE D'AZUR" (12 January 1990).

INTERNATIONAL MARITIME ORGANIZATION

4 Albert Embankment
London SE1 7SR

Ref: T1/2.08
VYS/jnt/3929x

Dear Sir,

I hereby acknowledge receipt of your letter SN1/DPNM/No.1294/91 of 28 October 1991 addressed to the Secretary-General and the accompanying statement of the French Government with regard to the approved use of the GM-METER SEPAC device as a means of determining ship stability by virtue of paragraph 7.4 of provision II-1/8 of the SOLAS convention.

I thank you kindly for the information which will be sent to all member states in circular SLS.14. At the same time, I regret to inform you that the contents of the three documents referred to in paragraph 5 of the aforementioned letter cannot be attached to said circular in view of their volume. Instead of attaching these documents to the letter, a footnote will be added informing the reader that the documents are available at the OMI library.

Yours faithfully,

W.S. MORRISON
Head of the Naval Safety Department

M.G. Cadet
Head Engineer of Defense
Assistant Director of Ship Safety
Department of Naval Affairs
Port and Navigation Authorities
Subdepartment of Ship Safety
Department of Regulations
3 Place de Fontenoy
75700 Paris 07
France

Document 4

Extraits du Règlement français

Navires à passagers effectuant des voyages internationaux et navires de charge de jauge brute supérieure à 500 *(volume 2)*

Article 221-II-1/08
(modifié par arrêté du 09/10/02)
Stabilité des navires à passagers après avarie

(Sous réserve des dispositions de l'article 221-II-1/08-1, les dispositions des paragraphes 2.3.1 à 2.3.4, 2.4, 5 et 6.2 s'appliquent aux navires à passagers construits le 29 avril 1990 ou après cette date.
Les dispositions des paragraphes 7.2, 7.3 et 7.4 s'appliquent à tous les navires à passagers).
…
7.1 Le capitaine doit être en possession des données nécessaires pour assurer dans les conditions d'exploitation une stabilité à l'état intact suffisante pour permettre au navire de satisfaire aux conditions ci-dessus dans les hypothèses d'avarie les plus défavorables restant dans le cadre défini plus haut. Dans le cas de navires pourvus de traverses d'équilibrage, le capitaine du navire doit être informé des conditions de stabilité dans lesquelles les calculs de la bande ont été effectués, et il doit être averti que si le navire se trouvait, à l'état intact, dans des conditions moins avantageuses, il pourrait prendre une bande trop importante en cas d'avarie.

7.2 Les données destinées à permettre au capitaine d'assurer une stabilité à l'état intact suffisante, dont il est question au paragraphe 7.1 doivent comprendre des renseignements donnant soit la hauteur maximale admissible du centre de gravité du navire au-dessus de la quille (KG), soit la distance métacentrique minimale admissible (GM), pour une gamme de tirants d'eau ou de déplacements suffisante pour couvrir toutes les conditions d'exploitation. Ces renseignements doivent refléter l'influence de diverses assiettes compte tenu des limites d'exploitation.

7.3 Les échelles de tirants d'eau doivent être marquées de façon bien lisible à l'avant et à l'arrière de chaque navire. Lorsque les marques de tirants d'eau ne sont pas placées à un endroit où elles sont facilement lisibles, ou lorsqu'il est difficile de les lire en raison des contraintes d'exploitation liées au service particulier assuré, le navire doit aussi être équipé d'un dispositif fiable de mesure du tirant d'eau permettant de déterminer les tirants d'eau à l'avant et à l'arrière.

7.4 Après le chargement du navire et avant son appareillage, le capitaine doit déterminer l'assiette et la stabilité du navire et aussi vérifier et indiquer par écrit que le navire satisfait aux critères de stabilité énoncés dans les articles pertinents. La stabilité du navire doit toujours être déterminée au moyen de calculs. A cette fin, l'administration peut accepter l'utilisation d'un calculateur électronique de chargement et de stabilité ou d'un dispositif équivalent.

8.1 L'administration ne peut accorder de dérogation aux exigences concernant la stabilité en cas d'avarie, à moins qu'il ne soit démontré que, dans toute condition d'exploitation, la hauteur métacentrique, à l'état intact, résultant de ces exigences est trop élevée pour l'exploitation envisagée.

8.2 Des dérogations aux prescriptions relatives à la stabilité en cas d'avarie ne doivent être accordées que dans des cas exceptionnels et sous réserve que l'administration estime que les proportions, les dispositions et autres caractéristiques du navire, susceptibles d'être pratiquement et raisonnablement adoptées dans des circonstances d'exploitation particulières propres au navire, sont les plus favorables possible du point de vue de la stabilité en cas d'avarie.

Article 221-II-1/22
(modifié par arrêté du 09/10/02)

Renseignements sur la stabilité des navires à passagers et des navires de charge[1]

Il est fait application des dispositions du chapitre 211-I.

1 Tout navire à passagers, quelles que soient ses dimensions et tout navire de charge d'une longueur, telle que définie dans la convention sur les lignes de charge en vigueur, égale ou supérieur à 24 m, doivent subir, après achèvement, un essai permettant de déterminer les éléments de leur stabilité. Le capitaine doit recevoir tous les renseignements jugés satisfaisants par l'administration qui lui sont nécessaires pour lui permettre d'obtenir, d'une manière simple et rapide, les caractéristiques précises de stabilité du navire dans les diverses conditions de service; une copie de ces renseignements sur la stabilité doit être remise à l'administration.
Il peut être accepté que l'essai de stabilité soit effectué peu avant l'achèvement du navire.

2 Si un navire subit des modifications ayant pour effet de modifier de façon appréciable les renseignements sur la stabilité fournis au capitaine, des renseignements mis à jour doivent être fournis. Si nécessaire, un nouvel essai de stabilité est effectué.

3 A des intervalles périodiques ne dépassant pas cinq ans, tous les navires à passagers doivent être soumis à une visite à l'état lège qui doit permettre de vérifier tout changement du déplacement à l'état lège ou de la position du centre longitudinal de gravité. Le navire doit subir un nouvel essai de stabilité chaque fois que l'on constate ou que l'on prévoit un écart de plus de 2% pour le déplacement à l'état lège ou de plus de 1% de L pour la position du centre longitudinal de gravité par rapport aux renseignements de stabilité approuvés.

[1] Se reporter à la Recommandation relative à l'état intact des navires couverts par les instruments réglementaires de l'OMI, adoptée par l'Organisation (résolution A. 749(18)) et telle qu'amendée par la Résolution MSC.75(69). Se reporter aussi à la circulaire MSC/Circ. 456 sur les directives pour l'élaboration des renseignements sur la stabilité à l'état intact, à la circulaire MSC/Circ. 706 sur les directives sur la stabilité à l'état intact des navires-citernes au cours des opérations de transfert de liquides, et à la circulaire MSC/Circ. 707 sur les directives destinées à permettre au capitaine d'éviter les situations dangereuses par mer de l'arrière et par mer oblique.

Article 221-III/29

Système d'aide à la décision destiné aux capitaines des navires à passagers

1 Le présent article s'applique à tous les navires à passagers. Les navires à passagers construits avant le ler juillet 1997 doivent satisfaire aux prescriptions du présent article au plus tard à la date de la première visite périodique effectuée après le ler juillet 1999.

2 A bord de tous les navires à passagers, un système d'aide à la décision pour la gestion des situations critiques doit être prévu à la passerelle de navigation.

3 Le système doit, au minimum, consister en un ou plusieurs plans d'urgence imprimés[1]. Le ou les plans d'urgence doivent mentionner toutes les situations critiques susceptibles de se produire, y compris mais sans toutefois s'y limiter, les principaux groupes de situations critiques ci-après :

.1 incendie ;
.2 avarie du navire ;
.3 pollution ;
.4 actes illicites menaçant la sécurité du navire et la sécurité de ses passagers et de son équipage ;
.5 accidents du personnel ;
.6 accidents liés à la cargaison ; et
.7 assistance d'urgence à d'autres navires.

4 Les procédures d'urgence énoncées dans le ou les plans d'urgence doivent fournir aux capitaines une aide à la décision dans toutes les combinaisons possibles de situations critiques.

5 Le ou les plans d'urgence doivent avoir une structure uniforme et être faciles à utiliser. Lorsque cela est applicable, l'état de chargement effectif calculé pour assurer la stabilité du navire à passagers pendant le voyage doit être indiqué aux fins de la maîtrise des avaries.

6 En plus du ou des plans d'urgence imprimés, l'administration peut accepter l'utilisation, à la passerelle de navigation, d'un système informatisé d'aide à la décision qui fournisse toutes les informations contenues dans le ou les plans, procédures, listes de contrôle d'urgence, etc., et qui puisse présenter une liste des mesures recommandées à exécuter dans les situations critiques susceptibles de se produire.

Document 5

Session OMI à Londres du 5 au 9 Juillet 2004

Compte-rendu du Sous-Comité NAV 50

Après l'allocution de bienvenue et d'ouverture du Sous-Comité NAV 50 par Mr MITROPOULOS Secrétaire Général, les tâches attribuées au Sous -Comité ainsi que les recommandations provenant des autres Comités sont passées en revue . Deux groupes de travail (WG) et 3 groupes de rédaction (DG) sont établis, les points qui ne sont pas étudiés par les WG ou les DG sont examinés en plénière.

Les documents qui sont adoptés par le sous-comité NAV seront présentés au MSC (Marine Safety Committee) de Décembre 2004 pour approbation.

CONSEILS SUR L'ABANDON RAPIDE DES VRAQUIERS

I. **Evaluation rapide :**

- **Mouvement ou attitude inhabituels :**
  En cas d'assiette ou d'inclinaison inhabituelle du navire, ou de changement de mouvement, il faudrait suspecter immédiatement une avarie de coque.
  Des accumulations d'eau inhabituelle sur les ponts peuvent indiquer une assiette ou une inclinaison anormales.
  Un soudain changement d'inclinaison ou d'assiette indiquera l'envahissement ou peut-être, dans le cas des navires de plus petites dimensions transportant des cargaisons plus légères, un ripage de la cargaison.
  Des mouvements latéraux désordonnés peuvent indiquer un ballottement de grande ampleur, comme ce serait le cas si une cale était envahie.
  A bord des navires de petites dimensions, le ralentissement de la période de roulis du navire peut indiquer un excès d'eau à l'intérieur de la coque, qui est une grave menace pour la stabilité. **Les navires munis d'indicateurs GM devraient être en mesure d'identifier toute modification imprévue de la distance métacentrique.**
  L'augmentation du volume d'eau embarqué sur les ponts situés à l'avant du navire peut indiquer l'envahissement d'un compartiment avant. Il est notoire que les changements d'assiette et de franc-bord sont difficiles à évaluer depuis une passerelle située à l'arrière.

Document 6

IACS Rec. 1990/Corr.1 Jan 2004
No. 31

Inclining test unified procedure

1. Introduction

The purpose of this procedure is to achieve a satisfactory accuracy in the determination of the lightship weight and of the coordinates of its centre of gravity.

This general procedure is a recommendation. Alternative requirements which are considered to be equivalent to those specified by the following items may be accepted. Acceptance of such equivalents rests with the Society and, where the inclining test is performed to satisfy a statutory requirement, such equivalents also may be subject to the acceptance of the Flag Administration.

Where a surveyor of the Society is requested to attend the inclining test, his responsibility is to verify that the test is conducted according to accepted procedures and that all basic measurements and data are correctly taken and recorded.

2. General Preparation for the Test

2.1 Information to be submitted

The Instruction, containing the information of date and location of the test, responsible person, stability, inclining weight, schemes of inclining weight positions etc., should be presented to the Classification Society before the inclining test.

The following information should be available at the time of the inclining test as necessary:

– General arrangement drawing;
– Tank capacity plan;
– Hydrostatic curves;
– Draft marks locations.

2.2 The inclining test condition

2.2.1 The ship should be as near to completion as possible. Equipment used by the yard on board should be limited to the utmost extent possible. Prior to the inclining test, lists of all items which are to be added, removed, or relocated should be prepared. These weights and their locations should be accurately recorded.

Normally, the total value of missing weights should not exceed 2 percent and surplus weights, excluding liquid ballast, not exceed 4 percent of the light ship displacement. For smaller vessels, higher percentages may be allowed.

2.2.2 All objects should be secured in their regular positions. All weights which may swing or shift must be secured in their known position. If more than one sea stowage position is possible, the actual stowage position used during the test should be recorded.

2.2.3 The ship should be cleared of residues of cargo, tools, debris, scaffolding and snow. Icing of the inner and outer surfaces, the underwater hull included, is not permitted.

2.2.4 All bilge water and other extraneous standing liquids must be removed. When draining individual tanks is impracticable, allowances for such liquids should be at the discretion of the Society.

2.2.5 All service tanks and machinery plant pipings are to be filled as for the working condition.

2.2.6 In general, only the people participating in the inclining test should stay on board the ship.

2.3 Tank contents

2.3.1 Preferably, all tanks should be either full or empty. The number of tanks containing liquids should be kept to a minimum.

2.3.2 Soundings and density of liquids in tanks should be taken. Shapes of tanks which are partly filled are to be known in order to determine the free liquid surface effect.

2.3.3 Adequate measures are to be taken to preclude air pockets in completely full tanks. All connections between tanks are to be closed and all empty tanks are to be adequately dried.

2.4 Mooring Arrangements and Environmental Conditions

2.4.1 Mooring lines should be free of any tension in the transverse direction of the ship during the reading after each weight shift. No external moments should be brought upon the ship (from mooring lines, quay, etc.). If possible, the ship should be located in a calm, protected area free from external forces.

2.4.2 The depth of water under the hull should be sufficient to ensure that the hull will be entirely free of the bottom. Prior to the test the depth of water should be measured in as many locations as necessary to positively satisfy this requirement, taking into account tide differences, if applicable.

2.4.3 An ideal mooring arrangement would involve bow and stern lines on both sides of the ship attached at or near the centre-line. Longitudinal mooring lines should be as long as practicable. More commonly, a ship may be moored by bow and stern lines on one side only and supplemented by spring lines. Where a single bow or stern line is proposed, the surveyor should be assured that the ship's freedom of movement does not adversely effect the conduct of the experiment.

2.4.4 The ship may be moored by means of other special arrangement approved by the Society.

2.4.5 When tidal currents are present the experiment should normally be conducted at or around slack tide.

2.4.6 The ship's gangway should be in the stowed position and any shore gangway removed during the inclining test. As few cables, hoses, etc., as possible should be connected to shore. Those which are needed shall be slack.

2.4.7 The test should not be conducted under adverse wind, wave and current conditions where the accuracy of the results cannot be assured.

2.5 Inclining Weights

2.5.1 For the inclining test, solid inclining weights normally should be used.

2.5.2 Use of water ballast transfer to incline the vessel may be permitted only in cases where it is impractical to incline the vessel using solid weights. If the transfer of water ballast is to be used, a detailed procedure, including calculation procedure, is to be submitted to the society for approval prior to the experiment.

2.5.3 The total weight used should be sufficient to provide a minimum inclination of one degree and a maximum of four degrees of heel to each side of the initial position. However, in those cases where it is absolutely impractical to reach a minimum angle of 1 degree by use of solid weights or waterballast a lesser inclination angle may be accepted, provided that the requirements on pendulum deflection or U-tube difference in height in 2.6.1 are complied with.

2.5.4 Each weight is to be compact, impervious to water and shaped such that its centre of gravity may be accurately determined. It is recommended that not fewer than four weights (or sets of weights) be used, each approximately equal in mass, and that the inclining weights (or sets of weights) be positioned as symmetrically as possible and parallel to the centre line in places convenient for the shifting of weights and measurement of the arms.

2.5.5 Each inclining weight should be marked with an identification number. The inclining weights should have been weighed with a calibrated instrument to the satisfaction of the Surveyor.

2.6 Pendulums and Instruments

2.6.1 The use of three measuring devices is recommended to determine the vessel's inclination after each weight shift, however, a minimum of two devices should be used, one of which is to be a pendulum or U-tube arrangement. The length and arrangement of pendulum/U-tube are to be such as to ensure the accuracy of the readings of deflection/difference. The minimum deflection/difference, to each side of the initial position, corresponding to the total weight shift, should be 15cm.

2.6.2 The use of a stabilograph is also acceptable provided the calibration of the instrument has been verified to the Surveyor's satisfaction prior to the experiment. A trace of the recorded heel pattern is to be included in the test report.

2.7 Trim and Stability

2.7.1 The vessel should be upright prior to the inclining. However, an initial list of the ship not exceeding 0.5° is permissible.

2.7.2 Excessive trim should be avoided for certain hull forms where changes in waterplane shape

would occur in the region of the waterline when the ship is heeled. Such features should be taken into account to select a suitable draught and trim for the test.
2.7.3 The persons conducting the test should be satisfied that the vessel has adequate, positive stability and acceptable stress levels during the test. The estimated initial metacentric height should be at least 0.20 m.

3 Inclining Test and Record of Data

3.1 Person in Charge
A competent person should be designated in charge of the preparation and execution of the inclining test.

3.2 Accuracy of Data
Measurement of Inclining Test data is to be as accurate as possible and to the satisfaction of the attending Surveyor.

3.3 Draught and Water Density Measurements
3.3.1 Draught/freeboard should be measured immediately before and verified after the test, to ensure that no significant changes in vessel's condition have occurred during the test.
3.3.2 Draughts/freeboards should be measured at fore and aft and midship draught marks at both sides. If the freeboards are not measured from the upper edge of deck line at side of freeboard deck or at the same frame locations as the draught marks, the locations and vertical datum must be stated.
3.3.3 A suitable boat with low freeboard should be available for the draught measurements.
3.3.4 To control the correctness of draught measurements, it is recommended to plot two waterlines by draught readings and by measured values of the freeboard when the latter is available. With correct measurements, both waterlines are to coincide. In case of non-coincidence of separate points, additional measurements should be taken.
3.3.5 Sufficient water samples are to be taken at suitable locations and depths to enable and accurate assessment of water density to be made.

3.4 Weight shifts and Inclination Measurements.
3.4.1 Two recommended procedures of shifting weights are shown in table 1.

Table 1

Weight Shifts	No. of Weights or Weight Groups			
	Four		Six	
	PS	SB	PS	SB
No. 0	2, 4	1, 3	2, 4, 6	1, 3, 5
No. 1	4	1, 2, 3	4, 6	1, 2, 3, 5
No. 2		1, 2, 3, 4		1, 2, 3, 4, 5, 6
No. 3	1	2, 3, 4	6	1, 2, 3, 4, 5
No. 4	1, 3	2, 4	2, 4, 6	1, 3, 5
No. 5	1, 2, 3	4	1, 2, 3, 4, 6	5
No. 6	1, 2, 3, 4		1, 2, 3, 4, 5, 6	
No. 7	2, 3, 4	1	1, 2, 4, 6	3, 5
No. 8	2, 4	1, 3	2, 4, 6	1, 3, 5

PS and SB denotes port and starboard sides of ship respectively.
The underlined numbers indicate the last weights or weight groups shifted.

3.4.2 The inclining weight positions should be marked on the deck to ensure that consistency in placement is achieved. The transverse shift distance is to be as great as practicable and appreciable changes in longitudinal or vertical position when moving port to starboard and vice versa are to be avoided.
3.4.3 The pendulum length is to be measured from its point of suspension to the recording batten on which deflections are read.
3.4.4 Pendulum, or U-tube reading on the recording batten or scale can be registered by either of the following ways:
a) on the final stable position of the pendulum or liquid column after stopping of ship motions due to shifting of the inclining weight;
b) by marking the mean value within the range of residual oscillation.
3.4.5 When using other devices, angles of inclination are to be recorded according to instructions supplied with each device.
3.4.6 Checks should be made in the process of the inclining test for each measuring device. These will, generally, be a progressive plot of angles of heel against heeling moments which should give a series of points lying about a straight line passing through (or close to) the origin.
If there is a deviation of points, either between the points for a particular weight movement, or from the straight line, the deflections and moments should be checked and corrected prior to the next weight movement.
3.4.7 Personnel should be instructed to remain on their assigned positions while inclination readings are being taken and a check should be made that all mooring lines, etc., remain slack following each weight shift until all deflections have been taken and recorded.

3.5 Other Relevant Data
3.5.1 In the case where the inclinations are carried out by means of transfer of water, it has to be possible to evaluate accurately the weight and the centre of the shifted liquid in relation to the ship's heel and trim.
3.5.2 The weather conditions, i.e., wind speed and direction relative to the vessel, sea state, air and water temperatures, etc., during the test are to be recorded.

4 Postponement of the Test

If during the course of an inclining test circumstances arise such that the aforesaid requirements are not complied with the attending Surveyor should advise the Person in Charge that the results may not be accepted.

5. Test Report and Analysis of Lightship Data

5.1 The Builder/Owner should incorporate the data gathered during the test into a comprehensive test report, which may be combined with the analysis of the lightship data. Test readings not used in the final analysis should still be recorded in the report.

5.2 The Surveyor is to ensure that the data given in the report is consistent with that gathered during the test and to sign the report.

5.3 The inclining test report and analysis, combined with the report or separately, should be submitted to the Society for review and acceptance of results as the basis for approval of the stability information of the ship.

Document 7

MARINE DIVISION

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BUREAU VERITAS

Certificate number: 09414/B0 BV
File number : AP 2982
Product code : 3752H

This certificate is not valid when presented without the full attached schedule composed of 7 sections

TYPE APPROVAL CERTIFICATE

as per Bureau Veritas Classification Rules

This certificate is issued to

SEPAC (Société d'Exploitation des Procédés Alain Cota)

PARIS - FRANCE

for the type of product

GM METERS

GM-METER TEST

Regulations and standards :
SOLAS 74 as amended, Regulations II-1/22.1 and 2, Regulation II-1/8.7.4 - IEC 60945, IEC 60529.

This certificate is issued to attest that BUREAU VERITAS did undertake the relevant approval procedures for the product identified above which was found to comply with the relevant requirements of the Regulations and standards mentioned above.

This certificate is valid until : 21 Nov 2011

At Paris la Défense, on : 21 Nov 2006

For BUREAU VERITAS,
By order of the Secretary

J.BENOIT

Approval office

BUREAU VERITAS SURVEYORS AT PARIS 1828 PARIS INTERNATIONAL REGISTER

Local office : BV SAINT-OUEN L'AUMONE
Surveyor : J. Letellier

BUREAU VERITAS SURVEYORS AT PARIS 1828 SAINT OUEN L'AUMONE INTERNATIONAL REGISTER

THE SCHEDULE OF APPROVAL

1. PRODUCT DESCRIPTION :
The **GM-METER TEST** is a portable device to measure inclining angles during inclining test of new-buildings vessels and vessels already in operation.

It is particular well-suited for use at shipyards by shipbuilders and shipwrights, and experts who carry out inspections on board vessels.

The **GM-METER TEST** consists of three units:

- An electronic sensor in a box
- A control unit comprising a laptop with backup battery
- An interface link set (USB port)

Power supply:
Laptop: ship power supply 220V AC 50/60 IIz.
Sensor: 5V/100 mA via 2m USB cable.

Index of Protection = IP 44.

2. DOCUMENTS AND DRAWINGS :
As per documents filed in the Society under number AP 2982 .

3. TEST REPORTS :
Test reports N°s:
8110272/1 dated December 1998 issued by LNE
8110272 dated December 1998 issued by LNE
8050840 dated December 1998 issued by LNE.
P06 123 dated 17/Jul./2006 issued by AEMC Mesures.

4. APPLICATION / LIMITATION :
The GM-METER TEST allows to measure the angles of inclination of the ship during a stability experiment with a precision of 0.01 degrees, when the following conditions are satisfied:
4.1 - Cannot be used in bridge zone.
4.2 - The Laptop is to be compliant with IEC 60945 for conducted and radiated emissions.
4.3 - Solar radiations exposures should be avoided.
4.4 - The operation of the device shall be carried out by qualified personnel, used to perform stability experiments, such as specialised departments of yards or owners, or accredited experts.
4.5 - Recalibration and general inspection should be carried out at a metrological department on a periodic basis of 2 years at normal use, or following exposure to harsh conditions and sensor battery replacement, or when the tests controlling the reliable function of the device, provided for in the users' manual and carried out by the user, are not satisfactory.

5. PRODUCTION SURVEY REQUIREMENTS :
On special request, arrangements should be made for a Society's Surveyor to inspect at the Manufacturer's works, equipment of the type referred to in this certificate.

6. MARKING OF PRODUCT :
- Trade name
- Date of manufacture and serial number.
- Equipment type or model identification under which it was type-tested.
- ℬV or ℗ Society's brand / and if a special survey is required, certificate of inspection N° at works.
- Date of next recalibration / inspection.

7. OTHERS :

7.1 - This approval is given on the understanding that the Society reserves the right to require check tests to be carried out on the unit at any time and that **S E P A C, Paris - France,** will accept full responsibility for informing shipbuilders, shipowners or their sub-contractors of the proper methods of use and general maintenance of the units and the conditions of this approval.

7.2 - This certificate supersides the Type Approval Certificate N° 09414/A0 BV issued on 17/11/1999 by the Society.

***** END OF CERTIFICATE *****