# Guidelines for Moonpool Assessment

**January 2016**

**Guidance Note**
**NI 621 DT R00 E**

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BUREAU VERITAS

# MARINE & OFFSHORE DIVISION

# GENERAL CONDITIONS

**ARTICLE 1**

**1.1.** - BUREAU VERITAS is a Society the purpose of whose Marine & Offshore Division (the "Society") is the classification (" Classification ") of any ship or vessel or offshore unit or structure of any type or part of it or system therein collectively hereinafter referred to as a "Unit" whether linked to shore, river bed or sea bed or not, whether operated or located at sea or in inland waters or partly on land, including submarines, hovercrafts, drilling rigs, offshore installations of any type and of any purpose, their related and ancillary equipment, subsea or not, such as well head and pipelines, mooring legs and mooring points or otherwise as decided by the Society.

The Society:

- "prepares and publishes Rules for classification, Guidance Notes and other documents (" Rules ");
- "issues Certificates, Attestations and Reports following its interventions (" Certificates ");
- "publishes Registers.

**1.2.** - The Society also participates in the application of National and International Regulations or Standards, in particular by delegation from different Governments. Those activities are hereafter collectively referred to as " Certification ".

**1.3.** - The Society can also provide services related to Classification and Certification such as ship and company safety management certification; ship and port security certification, training activities; all activities and duties incidental thereto such as documentation on any supporting means, software, instrumentation, measurements, tests and trials on board.

**1.4.** - The interventions mentioned in 1.1., 1.2. and 1.3. are referred to as " Services ". The party and/or its representative requesting the services is hereinafter referred to as the " Client ". **The Services are prepared and carried out on the assumption that the Clients are aware of the International Maritime and/or Offshore Industry (the "Industry") practices.**

**1.5.** - The Society is neither and may not be considered as an Underwriter, Broker in ship's sale or chartering, Expert in Unit's valuation, Consulting Engineer, Controller, Naval Architect, Manufacturer, Shipbuilder, Repair yard, Charterer or Shipowner who are not relieved of any of their expressed or implied obligations by the interventions of the Society.

**ARTICLE 2**

**2.1.** - Classification is the appraisement given by the Society for its Client, at a certain date, following surveys by its Surveyors along the lines specified in Articles 3 and 4 hereafter on the level of compliance of a Unit to its Rules or part of them. This appraisement is represented by a class entered on the Certificates and periodically transcribed in the Society's Register.

**2.2.** - Certification is carried out by the Society along the same lines as set out in Articles 3 and 4 hereafter and with reference to the applicable National and International Regulations or Standards.

**2.3.** - **It is incumbent upon the Client to maintain the condition of the Unit after surveys, to present the Unit for surveys and to inform the Society without delay of circumstances which may affect the given appraisement or cause to modify its scope.**

**2.4.** - The Client is to give to the Society all access and information necessary for the safe and efficient performance of the requested Services. The Client is the sole responsible for the conditions of presentation of the Unit for tests, trials and surveys and the conditions under which tests and trials are carried out.

**ARTICLE 3**

**3.1.** - **The Rules, procedures and instructions of the Society take into account at the date of their preparation the state of currently available and proven technical knowledge of the Industry. They are a collection of minimum requirements but not a standard or a code of construction neither a guide for maintenance, a safety handbook or a guide of professional practices, all of which are assumed to be known in detail and carefully followed at all times by the Client.**

Committees consisting of personalities from the Industry contribute to the development of those documents.

**3.2.** - **The Society only is qualified to apply its Rules and to interpret them. Any reference to them has no effect unless it involves the Society's intervention.**

**3.3.** - The Services of the Society are carried out by professional Surveyors according to the applicable Rules and to the Code of Ethics of the Society. Surveyors have authority to decide locally on matters related to classification and certification of the Units, unless the Rules provide otherwise.

**3.4.** - **The operations of the Society in providing its Services are exclusively conducted by way of random inspections and do not in any circumstances involve monitoring or exhaustive verification.**

**ARTICLE 4**

**4.1.** - The Society, acting by reference to its Rules:

- "reviews the construction arrangements of the Units as shown on the documents presented by the Client;
- "conducts surveys at the place of their construction;
- "classes Units and enters their class in its Register;
- "surveys periodically the Units in service to note that the requirements for the maintenance of class are met.

**The Client is to inform the Society without delay of circumstances which may cause the date or the extent of the surveys to be changed.**

**ARTICLE 5**

**5.1.** - **The Society acts as a provider of services. This cannot be construed as an obligation bearing on the Society to obtain a result or as a warranty.**

**5.2.** - **The certificates issued by the Society pursuant to 5.1. here above are a statement on the level of compliance of the Unit to its Rules or to the documents of reference for the Services provided for.**

**In particular, the Society does not engage in any work relating to the design, building, production or repair checks, neither in the operation of the Units or in their trade, neither in any advisory services, and cannot be held liable on those accounts. Its certificates cannot be construed as an implied or express warranty of safety, fitness for the purpose, seaworthiness of the Unit or of its value for sale, insurance or chartering**.

**5.3.** - **The Society does not declare the acceptance or commissioning of a Unit, nor of its construction in conformity with its design, that being the exclusive responsibility of its owner or builder.**

**5.4.** - The Services of the Society cannot create any obligation bearing on the Society or constitute any warranty of proper operation, beyond any representation set forth in the Rules, of any Unit, equipment or machinery, computer software of any sort or other comparable concepts that has been subject to any survey by the Society.

**ARTICLE 6**

**6.1.** - The Society accepts no responsibility for the use of information related to its Services which was not provided for the purpose by the Society or with its assistance.

**6.2**. - **If the Services of the Society or their omission cause to the Client a damage which is proved to be the direct and reasonably foreseeable consequence of an error or omission of the Society, its liability towards the Client is limited to ten times the amount of fee paid for the Service having caused the damage, provided however that this limit shall be subject to a minimum of eight thousand (8,000) Euro, and to a maximum which is the greater of eight hundred thousand (800,000) Euro and one and a half times the above mentioned fee. These limits apply regardless of fault including breach of contract, breach of warranty, tort, strict liability, breach of statute, etc.**

**The Society bears no liability for indirect or consequential loss whether arising naturally or not as a consequence of the Services or their omission such as loss of revenue, loss of profit, loss of production, loss relative to other contracts and indemnities for termination of other agreements.**

**6.3.** - All claims are to be presented to the Society in writing within three months of the date when the Services were supplied or (if later) the date when the events which are relied on of were first known to the Client, and any claim which is not so presented shall be deemed waived and absolutely barred. Time is to be interrupted thereafter with the same periodicity.

**ARTICLE 7**

**7.1.** - Requests for Services are to be in writing.

**7.2.** - **Either the Client or the Society can terminate as of right the requested Services after giving the other party thirty days' written notice, for convenience, and without prejudice to the provisions in Article 8 hereunder.**

**7.3.** - The class granted to the concerned Units and the previously issued certificates remain valid until the date of effect of the notice issued according to 7.2. here above subject to compliance with 2.3. here above and Article 8 hereunder.

**7.4.** - The contract for classification and/or certification of a Unit cannot be transferred neither assigned.

**ARTICLE 8**

**8.1.** - The Services of the Society, whether completed or not, involve, for the part carried out, the payment of fee upon receipt of the invoice and the reimbursement of the expenses incurred.

**8.2.** - **Overdue amounts are increased as of right by interest in accordance with the applicable legislation.**

**8.3.** - **The class of a Unit may be suspended in the event of non-payment of fee after a first unfruitful notification to pay.**

**ARTICLE 9**

**9.1.** - The documents and data provided to or prepared by the Society for its Services, and the information available to the Society, are treated as confidential. However:

- "Clients have access to the data they have provided to the Society and, during the period of classification of the Unit for them, to the **classification file** consisting of survey reports and certificates which have been prepared at any time by the Society for the classification of the Unit ;
- "copy of the documents made available for the classification of the Unit and of available survey reports can be handed over to another Classification Society, where appropriate, in case of the Unit's transfer of class;
- "the data relative to the evolution of the Register, to the class suspension and to the survey status of the Units, as well as general technical information related to hull and equipment damages, may be passed on to IACS (International Association of Classification Societies) according to the association working rules;
- "the certificates, documents and information relative to the Units classed with the Society may be reviewed during certificating bodies audits and are disclosed upon order of the concerned governmental or inter-governmental authorities or of a Court having jurisdiction.

The documents and data are subject to a file management plan.

**ARTICLE 10**

**10.1.** - Any delay or shortcoming in the performance of its Services by the Society arising from an event not reasonably foreseeable by or beyond the control of the Society shall be deemed not to be a breach of contract.

**ARTICLE 11**

**11.1.** - In case of diverging opinions during surveys between the Client and the Society's surveyor, the Society may designate another of its surveyors at the request of the Client.

**11.2.** - Disagreements of a technical nature between the Client and the Society can be submitted by the Society to the advice of its Marine Advisory Committee.

**ARTICLE 12**

**12.1.** - Disputes over the Services carried out by delegation of Governments are assessed within the framework of the applicable agreements with the States, international Conventions and national rules.

**12.2.** - Disputes arising out of the payment of the Society's invoices by the Client are submitted to the Court of Nanterre, France, or to another Court as deemed fit by the Society.

**12.3.** - **Other disputes over the present General Conditions or over the Services of the Society are exclusively submitted to arbitration, by three arbitrators, in London according to the Arbitration Act 1996 or any statutory modification or re-enactment thereof. The contract between the Society and the Client shall be governed by English law.**

**ARTICLE 13**

**13.1.** - **These General Conditions constitute the sole contractual obligations binding together the Society and the Client, to the exclusion of all other representation, statements, terms, conditions whether express or implied. They may be varied in writing by mutual agreement. They are not varied by any purchase order or other document of the Client serving similar purpose.**

**13.2.** - The invalidity of one or more stipulations of the present General Conditions does not affect the validity of the remaining provisions.

**13.3.** - The definitions herein take precedence over any definitions serving the same purpose which may appear in other documents issued by the Society.

BV Mod. Ad. ME 545 L - 7 January 2013

GUIDANCE NOTE NI 621

# Guidelines for Moonpool Assessment

## SECTION 1 GUIDELINES FOR MOONPOOL ASSESSMENT

January 2016

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## 1 General

### 1.1 Application

**1.1.1** This Note provides guidance to be considered for any vessel fitted with a moonpool (drilling ship, OSV, FPSO, scientific vessel,...) in addition to the other applicable Rules.

### 1.2 Definition

**1.2.1** A moonpool is a vertical well extending through the vessel from deck to bottom, providing a direct access to the sea and allowing safe and easy deployment of equipment used for drilling, diving, cable laying or any other subsea operation.

## 2 Nominal scantling assessment

### 2.1 Hull girder strength

#### 2.1.1 Strength continuity

As a rule, the required longitudinal strength of the unit is to be maintained in way of the moonpool, inducing possible reinforcements compared to the full sections aft and fore of the moonpool opening. The transition of aft and fore members being developed so as to provide continuity of longitudinal material.

#### 2.1.2 Moonpool corners

Moonpool corners in way of bottom and deck, which are stress concentration regions, are generally reinforced with corner plates (insert plates) or brackets.

#### 2.1.3 Finite elements

Whenever finite elements analysis is required, the moonpool region is to be modeled, extending at least 0,2 L aft and fore of moonpool transversal bulkheads.

### 2.2 Local wave loads

**2.2.1** As a rule, and in addition to the specific loads defined in [3], sea pressures on moonpool bulkheads are to be calculated as side shell sea pressures according to the Rules applicable to the vessel, considering the actual coordinates of the calculation point.

**2.2.2** The Society may accept to consider pressures on moonpool bulkheads taken from direct calculations or model tests, provided that relevant documentation on calculations or test procedure is submitted to the Society for review.

### 2.3 Local scantling criteria

**2.3.1** The plating and stiffeners of the moonpool may be assessed using the above pressure combined with the applicable Rule scantling criteria for side shell under sea pressures.

## 3 Typical hydrodynamic phenomenon

### 3.1 General

**3.1.1** The moonpool may induce the following hydrodynamic phenomenon, having potential undesireable effects to be considered in the design of the vessel.

### 3.2 Resonant pumping mode

#### 3.2.1 Definition

Pumping mode is generated by vertical oscillation of the water column within the moonpool. When waves period enters in resonance with moonpool natural period, the water column may be "pumped" above the upper part of the moonpool with undesireable effects on personnel and equipments installed on deck.

#### 3.2.2 Risk assessment

As a rule, the risk of resonant pumping mode is to be considered when:

$$0,6 < \frac{T_m}{T_w} < 1,3$$

where:

$T_m$ : Natural period of the moonpool, in s

$T_w$ : Wave peak period, in s.

The natural period of a constant cross-section moonpool can be evaluated as follow:

$$T_m = 2\pi\sqrt{\frac{h + K\sqrt{A}}{g}}$$

where:

h : Water column height in the moonpool, in m

A : Cross-sectional area of the moonpool, in $m^2$

g : Gravity acceleration, in $m/s^2$

K : Factor depending on the moonpool cross-sectional shape, to be taken equal to:

- 0,479 for a circle
- 0,460 for a rectangle (b/l = 0,5)
- 0,473 for a square

obtained by linear interpolation for rectangle shape with b/l values between 1 and 0,5.

l : Moonpool dimension parallel to the considered direction, in m

b : Moonpool dimension perpendicular to the considered direction, in m.

The natural period of a varying cross-section moonpool can be evaluated as follows:

$$T_m = 2\pi\sqrt{\frac{M_{eq}}{\rho A(0) g}}$$

where:

$\rho$ : Sea water density, taken equal to 1,025 t/m$^2$

$A(z)$ : Cross section area at z level, in m$^2$

$A(h)$ : Cross section area at water level, in m$^2$

$A(0)$ : Cross section area at moonpool bottom level, in m$^2$

$M_{eq}$ : Equivalent mass, in t, to be taken equal to:

$$M_{eq} = \rho A(0)\left\{\int_0^h \frac{A(h)}{A(z)}dz + \frac{A(h)}{A(0)}K\sqrt{A(0)}\right\}$$

### 3.2.3 Pumping loads

Where there is a risk of resonant pumping mode, the moonpool structure may be checked considering the water column inside the moonpool up to the deck level. The pumping pressure $p_{pump}$ in kN/m$^2$ at any point is expressed as follows:

$$p_{pump} = 1{,}025\ g\ (D - z)$$

where:

D : Height of the moonpool, in m

z : Vertical distance from the bottom of the moonpool to the calculation point, in m.

### 3.2.4 Scantling criteria

The plating and stiffeners of the moonpool may be assessed using the above pressure combined with the applicable Rule scantling criteria for side shell under sea pressures.

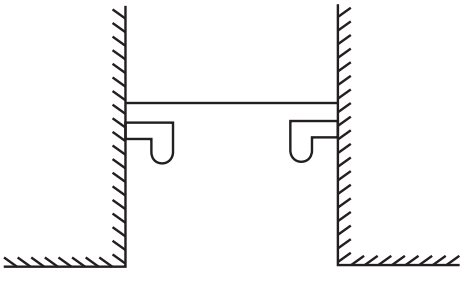
### 3.2.5 Alternative means of assessment

The Society may accept that the risk of resonant pumping mode and the associated overpressures acting on the moonpool walls are evaluated on the basis of hydrodynamic calculations or model tests. Detailed documentation on calculations or model tests is to be submitted. See also Article [4] for guidance.

### 3.2.6 Means for reduction of pumping

Constructive measures for the reduction of pumping mode may be accepted by the Society in order to prevent resonance occuring. A solution could be to fit horizontal damping plates inside the moonpool walls, just below the water line (see Fig 1).

**Figure 1 : Damping plates illustration**



## 3.3 Sloshing

### 3.3.1 Definition

Sloshing motion may occur in large moonpools when there is a resonance between the natural sloshing periods of the moonpool and the pitch or roll period, inducing additional dynamic loads on structural elements and disturbing the use of equipments through the moonpool.

### 3.3.2 Risk assessment

As a rule, the risk of sloshing is to be considered when:

- Longitudinaly:

$$0,6 < \frac{T_l}{T_p} < 1,3$$

$T_l$ : Longitudinal natural resonance period of the moonpool, in s

$T_p$ : Pitch period of the vessel, in s

- Transversaly:

$$0,8 < \frac{T_t}{T_r} < 1,2$$

$T_t$ : Transversal natural resonance period of the moonpool, in s

$T_r$ : Roll period of the vessel, in s.

As a first approximation, the resonance periods $T_n$ of the moonpool, in s, may be evaluated as follow:

$$T_n = 2\pi / \omega_n$$

with:

$$\omega_n^2 = g\lambda_n \frac{1 + J_n \tanh(\lambda_n h)}{J_n + \tanh(\lambda_n h)}$$

where:

$\omega$ : Moonpool natural angular frequency, in rad/s

h : Water column height in the moonpool, in m

g : Gravity acceleration, in m/s$^2$

$$\lambda_n = \frac{n\pi}{l}$$

n : Number of wave length contained by the moonpool (to be taken equal to 1 or 2)

$J_n$ : To be obtained from Fig 2 (lower curve for n = 1 and upper curve for n = 2).

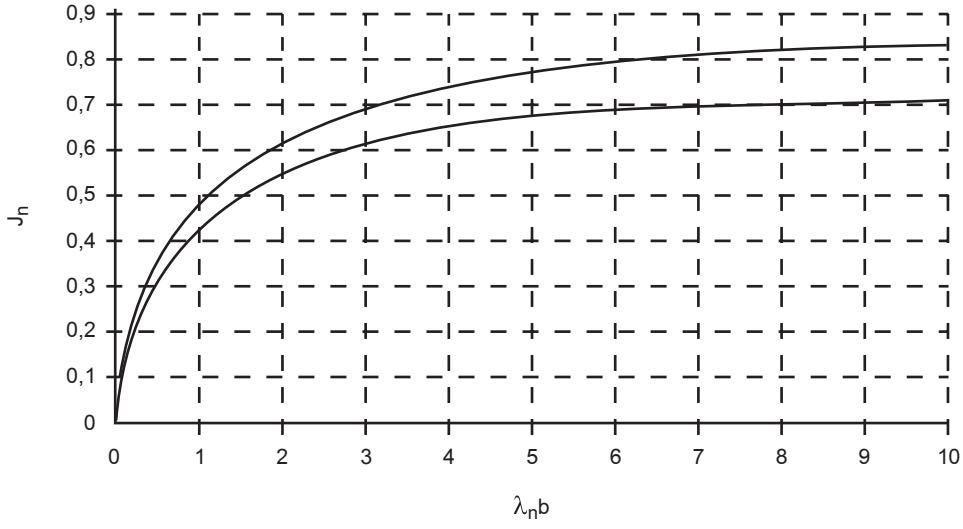
It is to be noted that the procedure given in Pt B, Ch 5, Sec 6 of the Ship Rules for risk evaluation cannot be applied as it is only applicable to partly filled tanks with closed bottom.

The Society may accept that the risk of sloshing is evaluated on the basis of hydrodynamic caluclations or model tests. Detailed documentation on calculations or model tests is to be submitted. See also [4] for guidance.

### 3.3.3 Sloshing loads

When the risk of sloshing cannot be excluded, the maximum sloshing pressure determined through direct calculations, model tests or other recognized approaches may be taken into account for the checking of moonpool boundaries.

**Figure 2 : Determination of $J_n$ coefficient**




#### 3.3.4 Scantling criteria

The plating and stiffeners of the moonpool may be assessed using the previously determined sloshing loads combined with the applicable Rule scantling criteria for tanks subject to sloshing pressures.

#### 3.3.5 Means of reduction of sloshing

Constructive measures for the reduction of sloshing may be accepted by the Society. Some solutions are given below for guidance purpose:

- fitting of horizontal damping plates inside the moonpool (as per [3.2.6])
- fitting of damping chambers in the upper part of the moonpool (similar to swash bulkheads).

### 3.4 Vortex generation in calm water transit conditions

#### 3.4.1 Definition

When the vessel is sailing in calm sea, the water flow is disrupted in way of the moonpool bottom, which could result in the creation of a vortex at its edge. This leads to water motions in the moonpool (with sensible rise of the water level), and to a sensible reduction of the vessel's performances.

#### 3.4.2 Assessment method

Designers should keep in mind the influence of the moonpool on the vessel's propulsion performances and the possible overloads generated inside the moonpool by the forward motion of the vessel. Calculation or model tests may be used to assess these effects and to optimize the water flow around the moonpool opening. See also [4] for guidance.

#### 3.4.3 Means of improvement

The above assessment could lead to improved moonpool design. Some examples of possible means of improvement are given below for guidance:

- Wedges fitted either on the bottom of the hull (fore or aft edge of the moonpool) or on the inside of the moonpool (lower part of the aft wall). See Fig 3.
- Retractable flaps. See Fig 4.
- Improved bottom opening (more narrow on the aft part for instance). See Fig 5.

The geometry of these fittings is to be determined through calculation or model tests.

### 3.5 Collision with objects

**3.5.1** Moonpool walls should be suitably stiffened / reinforced to prevent damage due to possible collision with objects that may be trapped in the moonpool.

**3.5.2** The dynamic loads induced by such collision should be evaluated on a case-by-case basis, taking into account the mass and shape of the dropped object, as well as the ship motions and accelerations.

## 4 Hydrodynamic analysis guidance

### 4.1 Modelling

**4.1.1** A particular attention should be paid to the modelling of free surface inside the moonpool space, as well as to the water motion in the moonpool during hydrodynamic analysis.

**4.1.2** The discretization of wetted area within the moonpool is to be sufficiently fine, at the satisfaction of the Society, to capture the details of fluid flow.

**Figure 3 : Fitting of wedges**

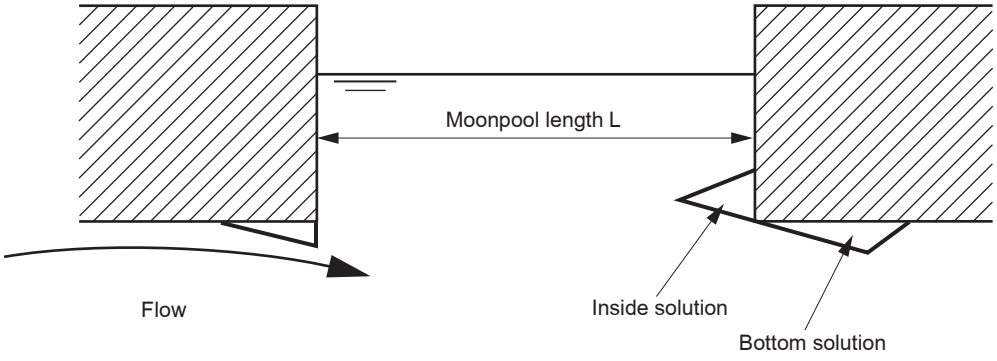



**Figure 4 : Retractable flap**

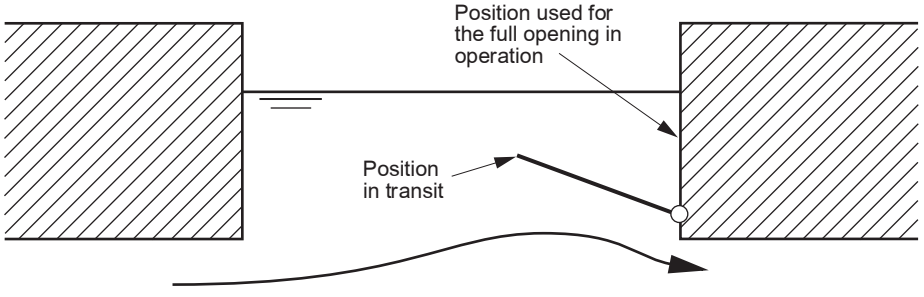
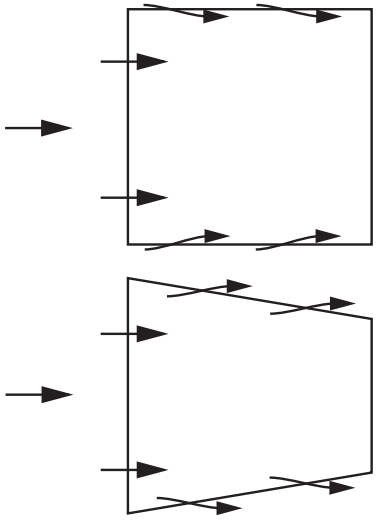



**Figure 5 : Bottom opening optimization**



**4.1.3** An additional damping factor of water motion within the moonpool should to be considered for hydrodynamic analysis. The purpose of this factor is to correct large motions and free surface elevation in the moonpool close to resonance, and also to provide an accurate heave motion transfer function. This factor may be calibrated from model tests, taking into account viscous scale effects.

### 4.2 Outputs

**4.2.1** As a rule, the hydrodynamic analysis is to provide the following outputs:

- natural period of the pumping mode
- natural periods of sloshing modes (longitudinal and transversal) in the moonpool
- maximum sloshing and/or pumping pressure on moonpool plating, when relevant
- data for water flow optimization in sailing mode.

## 5 Stability

### 5.1 Moonpool volume

**5.1.1** As a rule, the volume of the moonpool is not to be included in calculation of any hydrostatic properties.