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Classification and Damage Stability of Flotel Ships

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ABSTRACT

This paper considers the mono-hull vessels (i.e. ships) used today in the maritime and ocean industries to accommodate people in semi-permanent accommodation at sea: the floating hotels, or flotels ships.

Together with other type of marine structures (mono-hull and semisubmersible barges, jack-ups,...) they have mainly been developed to support the activities of the offshore oil & gas industry. But there is a dilemma when the Classification Societies try to give a Class Notation to this type of vessels as they are a very recent concept. We can find two main options: as Passenger Phip (same as cruises of ferries) or as Special Purpose Ships (used by most of the offshore support vessels). The objective of the paper is to show how the market and the Classification Societies are responding to this dilemma. We will show that with the new 2008 SPS Code the recommendation of DNV is the better option: to design this flotel ships as passenger ship from the very beginning of the shipbuilding project.

And in relation with that, the paper also enters in the problem that these different ways of classifying the flotel ships suppose for their design, as the rules applied when calculating the damage stability are totally different.

Offshore ships (i.e. flotel ships) industry is one of the greatest developments and activity has occurred in recent times within the naval sector. For this reason, all the movements in the market and the rules governing the technical aspects of it are very important to anticipate the problems that may arise. Recently, the Maritime Safety Committee of IMO (International Maritime Organization) adopted a new Code of Safety for Special Purpose Ships covering most of the vessels in this industry. This new code includes the obligation to perform a probabilistic damage stability study.

1. Introduction

Mono-hull barges and semisubmersibles barges are the traditional accommodation vessels (or Floating Hotels, *Flotels*) that are offered in the market. The first ones are mainly used in benign waters like West Africa and South Asia, while the semisubmersible units are used in more harsh environments like the North Sea, or in medium environments like Mexican Gulf. Both of the designs can keep the position moored (and they are not self-propelled) or dynamically with thrusters, giving the possibility of being self-propelled at low speeds. And there are not doubts about how they are classified by the class societies:

- Mono-hull Barges: the notation BARGE is present in almost all classification societies.
- Semisubmersibles: they are normally classified as COLUMN STABILIZED UNITS, a class notation present in DNV or ABS.

Also some accommodation vessels are of the jack-up type, but they are only a few units. But recently, some operators have realized that traditional mono-hull ships are a competitive alternative when comparing to barges and semisubmersibles, mainly due to its versatility.

Figure 1: Floatel Superior Semi-Submersible Offshore Flotel on Bayo Undan Oil Field

2. Flotel Ships

In 2004, Østensjø (Norway) converted Edda Fjord, a multipurpose PSV, to provide quarters for 330 personnel working on the offshore hookup and commissioning of Shell's Bonga FPSO off Nigeria. Afterwards the vessel moved to the Gulf of

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Mexico to provide accommodation for 450 people working on BP's Thunder Horse production platform. Both are deepwater locations. "*Both jobs worked out very well*," said Johan Rokstad, managing director of *Edda Accommodation*. "*At Bonga, the vessel proved its ability to sit in dynamic positioning mode connected to the FPSO by a gangway. During 11 months, it disconnected for a total of only 10.5 hours due to weather reasons*."

Therefore, the use of ships as offshore flotel ships is quite recent, with *M/V Edda Fjord* being the first flotel ship, and with performance good enough to prompt several other projects since. Those projects include new buildings and conversions of old type of ships: cable layers, ferries, icebreakers. And most of them planned in 2007, when oil price reached the highest values. During 2008 and 2009 the financial crisis and the decrease in oil price has led to delays and even cancelations of some of those projects, but those still in development will begin operation in late 2010/early 2011. The Table 1 shows some of these projects, some of them covered previously in *Offshore Support Journa l* (Lamas and Pérez, 2011a). It can be seen that most of them are not pure accommodation vessels, but they also have other features mainly related to offshore support and subsea construction, like any other construction vessel.

So the advantages of flotel ships compared to semisubmersible flotels can be summarized in the following points:

- Ability to move under own propulsion.
- Increased flexible as vessel can move between several client units in the same offshore oil field freely.
- Ability to disconnect and move away in response to hurricane danger.
- Cheaper mobilization/demobilization.
- Generally lower capital cost.
- Conversion candidates offer room for contractors' unique layout and design solutions.

Alternative mono-hull solutions to flotel ships, such as barges, only work in very benign weather conditions, and they are not self-propelled. On the other side, harsh weather alternatives, such as large crane vessels, are very expensive compared to ships, if you only need accommodation duties (Mather, 1995).

But as flotel ships are a recent development in the offshore industry, it seems that authorities are still not agree on how to class these type of vessels. Are they *passenger ships* or *special purpose ships*? In Table 1 we can find examples of both types. In following lines we will try to answer it.

Figure 2: M/V Dan Swift Offshore Flotel Ship with Gangway on oil rig Peregrino-B

3. Flotel Passenger Ship

The class notation *passenger ships* is only applied to cruise and ferries ships, and it would not be possible to apply it to other structures such as barges, semi-submersibles or any other innovative structure, as they are not a "ships" (Hancox, 1998). Below we present a table showing typical DNV class notations for Passenger Ships. So we find Coastal Express, Cruise Ship, Ferry and Ropax. The notations ensure the transportation of passengers and cars in compliance with SOLAS Passenger ship for RoRo and DNV steel ship rules (DNV, 2009).

		Coastal Express	Cruise Ship	Ferry	Ropax
Main Class	✠				
	1A1				
Service-, Type- and Additional Notations	Passenger Ship				
	Car Ferry A				
	Car Ferry B				
	Train Ferry A				
	Train Ferry B				
	General Cargo Carrier				

Table 1: Typical DNV class notations for Passenger Ships

But lately, some offshore accommodation vessels are included in this category; see Table-1, as flag authorities have not accepted them inside the class *Special Purpose Ships*. The only possibility was classified them as *passenger ships*.

4. Flotel Special Purpose Ship (SPS)

Special Purpose Ships (SPS) is the main certificated issued by IMO for ships giving services to Offshore Oil Platforms, such us Construction Vessels, Supply Vessels, Anchor Handlers, Seismic Vessels, etc. and including recently some Accommodation Vessels as *Edda Fidies* or *Polycastle* (see table 1). As a resume, we can say that "*A SPS is carrying a special personnel that is neither crew members nor passengers as defined in SOLAS because of the specialized nature of the work undertaken by these ships*". For example, scientific personnel onboard of a seismic vessel.

But the SPS Code has recently been revised by IMO and this has lead to some changes in the application. The original SPS Code was adopted in 1983 (Res. A.534(13)). The 2008 SPS Code (MSC.266(84)) supersedes the previous SPS Code from 13 May 2008 "for special purpose ships certified on or after" that date. Also DNV has created the SPS Class Notation, covering all the aspects included in IMO Code. We will not explain it here, as it has been treated largely by experts in other forums. As a resume, we only say that the 2008 SPS Code have a higher built in/inherent safety standard in affect to following:

1. Damage stability.
2. Subdivision, e.g. watertight doors and Double bottom.
3. Bilge pumping-
4. Fire safety and escape.
5. But lesser standard in LSA: As for passenger ships (>60 P)
6. Emergency Source of power.

7. Steering Gear.

In these aspects, a SPS carrying more than 240 persons is considered a *passenger ship*.

In the part that we are studying, the accommodation mono-hull ships or flotels that obviously carry more than 240 persons, there has been some controversy inside IMO and the classification societies about the use of the new SPS Code. In principle, the SPS Code should be a voluntary code and it is up to each administration to decide how it should be applied. When delegated by Flag, the classification society should follow the instruction from Flag with Statutory Certificates (MODU, 1989). However, the 2008 SPS Code clearly states that *"the code is not intended for ships used to transport and accommodate industrial personnel that are not working on board"*. With basis in this, an accommodation vessel only operating with Cargo Ship Certificates supported with a SPS Certificate could run into problems with local authorities and future changes of flag. For this reason, DNV clearly recommend that a *Passenger Ship Safety Certificate* or *MODU Code* Certificate would be better options for statutory certificates.

An example of this, is the case of *M/V ARV1* (Accommodation Repair Vessel) of *Equinox Offshore*, which was planned to be converted from an original Ropax ship to a *special purpose ship*, but was lately delivered as a *RoRo passenger ship*, without changing the original certificate issued by Bureau Veritas before being converted. Other vessels like *Dan Swift* of *Ice Maiden* were already designed as *Passenger Ships* when converted from cable layer and ice breaker respectively (Pérez and Lamas, 2011).

Of the seven points mentioned before where a SPS carrying more than 240 persons is considered a passenger ship, the first two points are the most important ones as affect the vessel design in the very preliminary phase:

- Damage stability: is should be considered as a passenger ship in accordance with SOLAS Ch. II-1, where the ship is considered a passenger ship and special personnel are considered passengers. R-value calculated in accordance with II-1/6.2.3 assigned as R.
- Subdivision, e.g. watertight doors and Double bottom: the hull, superstructure and deckhouses shall be subdivided into Main Vertical Zones by "A-60" class divisions.

Name		Owner	Yard		Description
Polycastle		Polycrest AS	Factorias Vulcano (Spain)	Newbuilding	Multipurpopse offshore flotel vessel
Edda Fides		Østensjø Group	Barreras Shipyard (Spain)	Newbuilding	Accommodation vessel with construction support
Ice Maiden		Adams Offshore Ltd.	A&P Tyne Ltd. (UK)	Converted Ice-breaker	Ice Class DP3 Flotel
Ocean Hotels		Ocean Hotels Plc.	Davie Yards (Canada)	Newbuilding	Multipurpopse accommodation vessel
Dan Swift		J. Lauritzen Pte. Ltd.	Blohm + Voss Shipyards (Germany)	Converted cable layer	Accommodation and Support Vessel (ASV)
ARV 1		Equinox Offshore	Sembawang (Singapore)	Converted RoRo Ferry	Accommodation Repair Vessel (ARV)
ARV 2		Equinox Offshore	Sembawang (Singapore)	Converted Ferry	Accommodation Repair Vessel (ARV)

Table 2: Offshore flotel ships on order / operation (PART I)

Name	Berths	Station-keeping	SOLAS type	Cost USDm	Delivery
Polycastle	400	DP3	Special Purpose Ship	120	Second quarter of 2012
Edda Fides	600	DP3	Special Purpose Ship	140	First quarter of 2011
Ice Maiden	400	DP3	Passenger Ship	150	Delayed
Ocean Hotels	400	DP2 (DP3 retrofit)	Special Purpose Ship	112.5	Delayed
Dan Swift	291	DP2	Passenger Ship	—	Delivered November 2009
ARV 1	523	DPII	Passenger Ship	35 (only conversion)	Delivered end of 2010
ARV 2	1122	DPII	Passenger Ship	—	Planned for 2011

Table 3: Offshore flotel ships on order / operation (PART II)

5. Damage Stability Criteria in flotel ships

Offshore ships (i.e. flotel ships) industry is one of the greatest developments and activity has occurred in recent times within the naval sector. For this reason, all the movements in the market and the rules governing the technical aspects of it are very important to anticipate the problems that may arise. Recently, the Maritime Safety Committee of IMO (International Maritime Organization) adopted a new Code of Safety for Special Purpose Ships covering most of the vessels in this industry. This new code includes the obligation to perform a probabilistic damage stability study (Pérez, 2011).

Probabilistic concepts address the probability of damage occurring at any location throughout a flotel ship and adopt a more rational criterion of subdivision by considering the likelihood of damage resulting in the flooding of only one compartment, or any number of adjacent compartments, either longitudinally, transversely or vertically. The residual buoyancy and stability of a flotel ship is calculated for each of such damage cases, and either a positive or a zero contribution is associated to each case, depending on, whether or not, the residual buoyancy and stability are considered sufficient.

The establishment of an international maritime law, especially regarding safety in flotel ships, is a long process that is not without difficulties, it requires a lengthy period of research and analysis, consensus and ratification by a sufficient number of countries. Its implementation is not always possible in older flotel ships. The first result is that flotel ships can coexist for years, with two standards widely depending on their seniority or banner, as happens with the well-known case of oil tankers without double hull as the Prestige. However, despite the remarkable technical and legislative effort that are carried out by IMO or the major advances in the safety convention SOLAS (International Convention for the Safety of Life at Sea). Flotel ships are not exempt from these rules and it is necessary to study these. In the offshore field, there is the IMO organization to understand the international level about the safety of such vessels. Traditionally, the flotel ships are taking the rules of IMO exists that do not interfere with other objectives and adapting them to the extent as far as possible.

SOLAS implies safety, but by no means is the same method applicable to all types of vessel. Mainly because many of its rules are unworkable or unrealistic for the flotel ships. The criterion SOLAS begins by defining the extent of damage to consider. These dimensions, based on statistics of failure, are defined as a fault length equal to 3% of the length plus three meters, a penetration of damage equal to B/5 and a height of damage that goes from bottom to top without limit.

It is important to take account the Stockholm Agreement if damage stability studies are going to be done in flotel ships. The Stockholm Agreement was established in the context of resolution of the fourteen SOLAS of the IMO in 1995, and authorized government contractors to enter into such commitments if they believe that the predominant sea conditions and other conditions require specific local stability in a certain sea area. In short, these rules are complementary to the rules SOLAS-90, with the addition of technical specifications to explicitly take into account the risk of accumulation of water on the car deck. The introduction of the Stockholm Agreement is closely associated with three unprecedented stops in the history of damage stability/survivability assessment (Lamas and Pérez, 2011b):

- Water on deck was explicitly taken into account for the first time. This is remarkable in view of the knowledge that 85% of all deaths with ferry accidents relate to car deck flooding.
- The effect of waves, and this is even more remarkable, was explicitly taken into account also for the first time.
- It paved the way to the introduction of performance-based standards for assessing the damage survivability of ships.

All three steps represent gigantic improvements in the approach to addressing ferry safety but any potential benefits will have to be balanced against any likely costs that might be incurred through the introduction of inappropriate standards. So it will be necessary to study these steps if a flotel ship is considered.

As conclusion, to say that there are certainly some obvious weaknesses in the requirements of the Agreement and this must be borne in mind when assessing flotel ship safety. The Stockholm Agreement was created on the presumption that a vessel designed, or modified, to SOLAS '90 standards ensures survival at sea states with Hs of only 1.5 (m).

All Intact Stability is investigated and calculated according to Resolution A.534 Code of Safety for Special Purpose ships. The subdivision is governed by the factor 0.8. It is performed 1-compartment damage according to SOLAS regulations.

The Damage Stability is ruled by SOLAS Part B Regulation 8:

- The positive residual righting lever shall have a minimum range of 15deg beyond the angle of equilibrium.
- The area under the righting lever curve shall be at least 0.015 meter-radians, measured from the angle of equilibrium to the lesser of:
  –The angle at which progressive flooding occurs.
  –22deg (measured from the upright) in case of one compartment flooding, or 27deg (measured from the upright) in case of simultaneous flooding of two or more adjacent compartments.
- A residual heeling lever is to be obtained within the range of positive stability, taking into account the greatest of the following heeling moments.
  –Crowing of all passengers towards one side.
  –Due to wind pressure as calculated by the formula:
  GZ (in meters)=(heeling moment/displacement)+0.04
  However in no case is the righting lever to be less than 0.1m.
- For the purpose of calculating the heeling moments the following assumptions are made
  –Moments due to crowding of passengers
  a. Four persons per square meter.
  b. A weight of 75kg for each passenger.
  c. Passengers located in such a way that they produce the most adverse heeling moment.
  The moment due to crowding of passengers used in the calculations is: 246.72 [Tm].

–Moments due to Davit-launched survival craft.
In order to calculate the Moment due to fully loaded Davit-launched survival craft it is assumed 106 persons in each craft, total weight of fully loaded craft 13.75 tonnes. This moment is calculated to 318.31 tm.
–Moments due to wind pressure.
a. A wind pressure of 120N/m2 is applied.
b. The lateral area of the ship above the waterline corresponding to the intact condition.
c. The vertical arm is the vertical distance from a point one half of the mean draught corresponding to the intact condition to the center of gravity of the lateral area.

According to SOLAS Part B regulation 8 for the purpose of making damage stability volume and surface permeability the following is relevant:

Occupied by machinery	0.85
Occupied by liquids	0.95
Void spaces	0.95

Table 4: Spaces permeabi lity

According to SOLAS Part B regulation 8 the assumed extent of damages are as follows:

- Side damages:
  –Longitudinal extent: 3m plus 3% of the length of the ship, or 11m, whichever is the lesser.
  –Transverse extent (measured inboard from the ship's side, at right angles to the CL at the level of the deepest load line): a distance of one fifth of the breadth of the ship, as defined in regulation 2.
  –Vertical extent: from the BL upwards without limit.
- Bottom damages:
  –Longitudinal extent: 3m plus 3% of the length of the ship, or 11m, whichever is the lesser.
  –Transverse extent: Symmetrical about CL and without limit.
  –Vertical extent: assumed as SOLAS required height for double bottoms.

6. Conclusions

As the new 2008 SPS Code give provisions to vessels carrying more than 240 persons similar to passenger vessels, it seems that the recommendation of DNV is the better option: this is, to design an Accommodation Ship (Flotel) as *passenger ship* from the very beginning. Reasons:

1. A SPS should already be designed as *passenger ship* in the main parameters of the preliminary design: stability and subdivision.
2. We will avoid future problems with flag authorities.

The other option, to adopt the *MODU Code*, has been chosen in other vessels not being ships:

- *CSS Accomodator,* a DP3 Accommodation Vessel, from *Marine Assets Corporation*, to be delivered in December 2012.
- *SAFECOM 1*, an Accommodation Field Development Vessel from *B + H Offshore*, which has been classified as barge, but that also, complies with MODU code.

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