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Stability of Jack-ups
Top Ten Questions From Industry to Class

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Abstract

Even with the advanced design capabilities evident among designers and builders of jack-up rigs, there is a number of questions on matters of stability that return with notable frequency. This paper will ask and answer the ten most frequent questions submitted to one Class Society on the matter of stability of jack-ups.

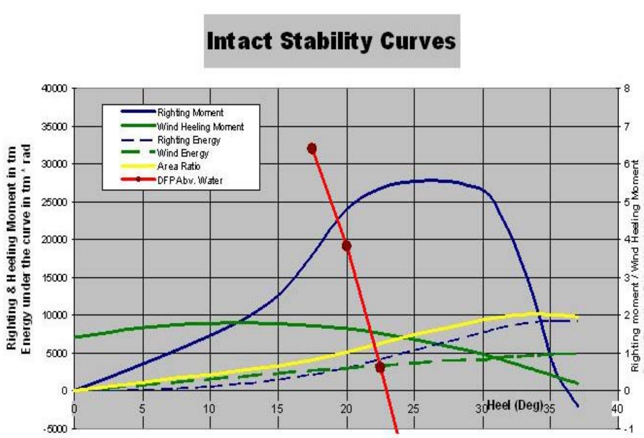
Keywords: *Offshore, Stability*

Introduction

The current worldwide fleet of mobile offshore drilling units (MODUs) consists of 49 drillships and barges, 220 submersibles and semisubmersibles, and 435 jack-ups. Given that many rigs have been built to one of a few standard designs, one might infer that a small number of stability analyses resolve this matter for the entire population of MODUs. The reality is very different: most rigs have their stability evaluated several times in their service life and the number of stability approvals by class societies is on the order of several thousand, each with its unique features. The first set of MODU Rules were published by ABS in 1968 and unlike Rules for conventional vessels, they included stability requirements. The record of stability calculations is documented in the formal files of the classing society, but the ongoing dialog with industry is mostly held in the form of “experience” in the minds of the Naval Architects.

TOP TEN

After decades of the cooperative work between class and industry, the questions of why, when, who, and why on matters related to afloat stability have enriched our experience. Below, the authors ask and answer the ten most recurring questions.



1. **Why are the approved allowable vertical center of gravity (AVCG) values lower than those submitted for approval?**

   Stability analyses require extensive

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* The views expressed in this paper are those of the authors and do not necessarily reflect those ABS

computer calculations. Regardless of how detailed is the documentation submitted for approval, it remains necessary to verify the results through independent analysis. If the independent calculations by the class society results are more conservative than those submitted, the lower AVCG will be approved. In most cases, the reason for discrepancy is identified.

In the case of jack-ups, the height of the center of gravity varies within a narrow range for a given position of the legs. This often allows for the selection of a reasonably conservative AVCG that is below the allowable that would be obtained through strict application of the Rules. Such a conservative approach simplifies the work by the designer and class society and, in most instances, such values are approved.

2. Why are the submitted wind overturning moments calculated for stability not acceptable to class?

Frequently, designer calculations are in conflict with the applicable class Rules for one or more of the following reasons:

- Methodology used to determine the center of lateral resistance of the below the waterline hull, spud cans and legs (including disregard for the effect of legs below the hull baseline).
- Combining standards for the determination of the shape coefficient of legs; for example, SNAME 5-5A combined with Cs=0.5 from the Rules.
- Failure to take account of piping and fittings on legs such as ladders, raw water piping, anodes, etc.
- Failure to take account of racks, spoilers, and other attachments that disrupt the air flow.
- Assuming the overturning moment to be constant regardless of heel and/or direction, or as decaying with the cosine of the heel as is the general assumption for ship shaped structures.

3. Why are the submitted damage stability calculations not approved?

The critical direction of stability for a given set of conditions (extent of damage, draft, etc) is the one that results in the lowest allowable VCG. To reduce the need for a lengthy set of calculations, some software will select the wind direction based on speculative criteria; this may not always be the governing azimuth. Because the critical direction is a function of exposure to wind, stability characteristics of the hull, position and height of the downflooding points and performance criteria, the only way to identify the critical condition is to test multiple directions of wind and identify the true critical direction. Even when all cautions are taken, the angles tested by the class society and the designer may be different. In such cases, the results may be different and the most conservative will normally prevail.

The allowable VCG determined for the range of stability criteria, is a special case as the approach to this evaluation is different for each software, developer and user.

This same answer applies to intact stability calculations.

4. Why is there often disagreements regarding buoyant and non buoyant spud cans?

The simple answer is that buoyant cans are those where the water level in the can does not match the sea level. These cans are likely to be permanently full of water and this amount must be accounted as ballast in the loading condition.

Non buoyant cans have the water level change as the can changes “draft” or immersion, due to communication with the sea. In such cases, the buoyancy of the can is disregarded and the water inside the cans is also ignored in the loading calculation.

The difference between these approaches is minimal and, if comparing the payload at a given draft, both methods should yield close results. The non-buoyant can has the benefit of an AVCG that is independent from the position of the legs. Buoyant cans allow a rig to attain a reduced draft if the ballast is removed so the cans are empty. This is only practical during the increasingly unusual practice of ocean tow.

5. What is the difference between Watertight and Weathertight closures above and below deck?

Doors on watertight bulkheads must be of the same or higher strength as the structure around them. They must also be tested for that pressure to demonstrate the strength and sealing capability. If they are not tested onboard, they must be certified for that service. The Class Rules and typical regulations mention three types of doors:

a. Remotely operated doors

b. Manually closed doors fitted with open/closed indicators (local and centralized in a permanent manned room) which may be open while the unit is afloat.

c. Doors which are to remain closed while the unit is afloat.

The most common practice is the fitting of manually operated doors but the need to install signals is often missed by many designers so that builders have to be reminded of this during construction.

External doors are required to be weathertight. This means that they are capable of preventing passage of water. They are normally tested under a 30 psi hose test and visually checked for leakage. When this is not possible, the surveyor can accept a “chalk” test.

Regardless of doors, the watertight characteristic of these doors is not unidirectional. They must be effective with the water pressure on either side of the door.

The Rules have no specific expectation on the type and number of closing devices. However, it is generally accepted that the single action (aka quick acting) door is the preferred choice since it only requires a turn of the hand wheel to engage all of the dogs. This is important since doors with a single dog engaged are not fully effective against water ingress.

6. Why is Load Line assignment so complicated?

The assignment of Load Line, or freeboard, is both required by the Class Rules and the country of registry. The Convention on Load Lines does not provide much room for alternatives. Additionally, the organizations that assign freeboard tend to be subject to close auditing to verify that the applicable standards are properly applied.

The Load Line certificate is an essential document that allows a unit to operate in waters away from its country of registry. Thus, regardless of the extenuating conditions, jack-up rigs are not allowed to proceed to sea unless the necessary certificate has been issued. This requires the following steps to be completed:

a. Minimum freeboard assigned on the basis of the hull geometry (so-called "tabular" method from the Convention)

b. Approved stability analysis (intact and damage) to set the allowable VCG

c. Approved Operations Manual to provide guidance on loading the unit within the AVCG

d. Approved Lightship characteristics (usually by way of a stability test)

e. Completed onboard survey of the conditions of assignment and the corresponding survey report.

The onboard survey report is carefully reviewed to verify that vents, air pipes, ventilators, hatches and door sills are of an acceptable height. Drainage, hull penetrations, doors, portholes, railings, scuppers must also meet the Load Line regulations. This represents a long list of construction details that is not always clear to the many engineering disciplines that participate in the design of a jack-up rig.

7. Why is it necessary to redo the stability analysis when the "as-built" ventilators and air pipes are different from the design?

A downflooding point is any opening that, if submerged, will lead to the flooding of any space in the hull. Once this occurs, the stability calculations for that condition are terminated and all the relevant criteria must be satisfied. Calculations are made to minimize the possibility of these points being submerged; if the location of an opening changes, the angle of inclination at which that point is submerged changes too.

Ventilation inlet and exhaust openings, chain pipes or hawsers, open hatches, or any other opening that remains unprotected, are a main concern during the intact stability assessment.

External closures that are protected by check valves or weathertight (WeT) closures are a similar concern in the context of damage stability analysis, as they are not effective against a static immersion: they are designed only to withstand an intermittent exposure to water. Changes to tank vents, hatches, WeT doors, etc have a similar effect on damage stability as the unprotected openings have on intact stability.

If the designer defines the "boundaries of weather tight and watertight protection", these boundaries may be used by all engineering disciplines to place any opening at or above the level at which stability was evaluated. This provides flexibility to move openings as necessitated by construction issues, as long as the opening remains within the boundaries.

8. Why do we have so many conflicts with the execution and results of a Stability Test?

The short answer to this question is that "If something can go wrong; it will." The stability test or inclining experiment is a very important verification of the weight and center of gravity, and sources of error must be minimized so they do not compound with each other and render the results unreliable. The most frequent conflicts are associated with:

a) Cantilever weighing. Cantilever weighing is most important when used as the inclining weight. The expectation is that the accuracy of this measurement is made with a 1 percent tolerance. Most experienced yards have learned that this task requires special expertise. The best work is the one carried out from professionals that work on the basis of "trust but verify." It is not uncommon for some yards and owners to feel that they can emulate the most experienced teams, and subsequently realize that this is a sensitive task.

b) Leg weight takeoff. This issue is a problem only when the stability test is done without using a full complement of legs. When this is the case, weight takeoff is the most frequent method of determining the weight of the remaining rounds of leg to be added. The weight takeoff is accurate in determining the weight of the elements known to the designer. However, pipes, anodes, hoses, steel ladders, aerials, wiring, lights and protective coating are some of the items that may be overlooked.

c) Molded or full hydrostatics. The full hydrostatics should be used as an accurate representation of the hull form and the appendages, and be included in the Operations Manual. This will improve the prediction of draft, and the determination of weight of the rig. This yields an accurate determination of elevated weight, and provides for the reversibility of predicting draft from the calculated weight (and the reverse operation or determining displacement on the basis of draft).

d) "Acceptable" lightship characteristics. The ABS procedure of reviewing stability tests and lightship survey reports includes an independent analysis of the data obtained. The detail and depth of this review is often a function of the confidence built through the starting verification and the criticality of the results. If the submitted results are more conservative than the conclusions of the reviewing process, the ABS review letter will quote the submitted values. While the number may have been deemed conservative, it may be found "acceptable". If the cause for the discrepancy is identified, and the conservatism could affect the capabilities of the unit (often the case on semisubmersibles), the submitter will be alerted to the source of the discrepancy.

e) Inclining with water. Inclining with water is an acceptable practice but very difficult to execute with a high degree of accuracy. Often problems are identified after the completion of the test and repeating the exercise may be required.

9. What equipment and controls need to be installed above the deepest damage waterline?

Any equipment that is needed in case of an emergency, and the access to the locations where this equipment will be operated, must be above the final damage waterline. For jack-ups, this means the main deck level or above. While the following list is not exhaustive, these are the most frequent cases:

- Emergency generator and switchboard
- Batteries and other sources of emergency power
- Remote operation of WT Closures
- Muster stations, and embarkation stations
- Ballast control room (semisubmersibles)
- GA and PA
- Radio room
- Main navigation equipment room, bridge
- Centralized fire monitoring equipment
- Centralized fire control equipment
- Dynamic positioning system controls
- Fire extinguishing system serving various (multiple) locations

10. Are there any requirements regarding the increase in draft on an existing unit?

Compliance with the applicable Rules and Regulations is the short answer. In practice, the list of regulatory expectations depends on the existing and planned equipment on board:

a) The new draft should correspond to a freeboard that meets the geometrical requirements of the International Convention on Load Lines 1966.
b) The scantlings of the unit are suitable for the new draft. On jack-up rigs, this is not a common issue.
c) The jack-up must be capable of elevating in a manner such that the jacking capacity on the heavier loaded leg is not exceeded. For a unit classed under the 1980 (or more recent) ABS MODU Rules, the rig must be able to meet this expectation after the loss of one single component. On conventional rack-and-pinion systems, this means the loss of a pinion (or possibly two pinions, in the case of opposed pinion systems).
d) The unit can be loaded to the maximum afloat variable deck load (VDL), in a realistic way, with minimal trim, to a VCG equal to or lower than the allowable VCG at the new Load Line draft.
e) When jacking from full draft, the resulting elevated condition can meet the storm survival condition without jettisoning equipment or material and without laborious or complicated re-distribution of weights.
f) The load distribution on the legs in the operating condition (with the cantilever loaded to its capacity) and storm survival condition are compatible with the approved leg and spud-can strength.

g) The Operations Manual is updated to reflect the new full draft load.
h) Depending on conditions, a deadweight survey or a stability test may be required.

Conclusions

The Rules, and statutes, that apply to jack-ups are very similar for all Class Societies, Coastal Administrations, and Flag Administrations. The fundamental concepts are well understood by designers and builders. Most of the questions on stability find the answers in the details that are imbedded in the body of the applicable standards. Because such details are not in the main body of the stability standards, their correct application often escapes the attention of the designers.

The solution to this matter is in an improved communication between designer, builder, and the Class Societies. This communication should go beyond the small group that do the stability related work and apply to all disciplines, from the initial design through the construction of the jack-up

References

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ABS Rules for Classing and Building Mobile Offshore Drilling Units, 2008