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Erik Svedberg, PhD Senior Program Officer, National Materials and Manufacturing Board The National Academies of Sciences, Engineering, and Medicine 500 Fifth St NW, K973 Washington, DC 20001

Via email

Dear Mr. Svedberg:

The National Academies has posted a prepublication copy of a report entitled "High-Performance Bolting Technology for Offshore Oil and Natural Gas Operations." The American Petroleum Institute (API) has reviewed the report and provides the following technical corrections for consideration.

The API is a national trade association that represents more than 625 members involved in all aspects of the oil and natural gas industry, including exploring for and developing oil and natural gas resources in the Outer Continental Shelf. Safety is a core value of the oil and natural gas industry. As part of API and Industry's commitment to improving training, operating procedures, technology and industry standards, we have formed a multi-segment workgroup to address issues related to subsea bolts and fasteners. These experts have reviewed the prepublication report and provide the attached detailed information.

API appreciates the opportunity to work with the National Academies to continue to advance safe offshore operations. We look forward to the corrected final report. If you have any questions, please contact me by phone at (202)682-8439, or by e-mail at hopkinsh@api.org.

Sincerely,

Holly A. Hopkins

cc: Scott Angelle, Director, BSEE Doug Morris, Chief, Office of Offshore Regulatory Programs, BSEE Lars Herbst, GOM Regional Director, BSEE

Attachment

API Technical Corrections to the NA Prepublication Copy of High-Performance Bolting Technology for Offshore Oil and Natural Gas Operations"

Page S-3: "Further, there are important environmental factors that directly influence the rate of degradation of fastener materials, such as ocean water salinity and chemistry, the presence of hydrogen from cathodic protection systems or natural sources, and the presence of hydrogen sulfide (H2S) or carbon dioxide (CO2)."

COMMENT: It should be clarified that H_2S is not likely to be present in significant concentrations in the seawater environments where subsea BOPs are operated. It is more likely that H_2S or CO_2 , sourced from geologic formations, will be encountered inside of the BOP.

Page 1-5: Figure 1.3 - The desired weak point is above the LMRP, not at the top of the riser. A weak point at the top, could result in a dropped riser.

Page 1-5: "Qualitatively, to a first order, the risk associated with a pressure boundary connector failure is proportional to its distance from the well head. The most important fasteners attach the lower marine riser to the wellhead; those next in importance lie in the lower marine riser and hold together the components such as the blind shear ram necessary for critical functions in well control, and ultimately blowout prevention. While those fasteners in the upper marine riser are important in well control, their failure would not endanger the ability to prevent the well from causing a major environmental disaster. However, failure of upper marine riser connectors could result in drilling fluid or hydrocarbon release, or force reliance on vastly more expensive means of well control, e.g. use of the blind shear rams."

COMMENT: Should replace "lower marine riser" with "BOP."

All of the fasteners, from those used in the wellhead connector at the bottom of the BOP stack to the highest ram in use are of equal importance in maintaining well control capabilities. Fully functional wellhead connector fasteners have no utility in well control if the ram fasteners fail.

It is incorrect to say that if an "upper marine riser" fastener fails, that "failure would not endanger the ability to prevent the well from causing a major environmental disaster." Fastener failure leading to riser failure creates a reduction in hydrostatic head within the wellbore that can lead to a loss of "primary" well control. As a mitigation to this risk, in the case of riser failure, the BOP is designed to automatically close and seal, preventing an environmental release from the well.

Blind shear rams are not a "vastly more expensive" means of well control. Their use is simply part of the appropriate well control response following a riser failure. The recovery from a riser failure is expensive, but there is no cost consideration in the operation of the blind shear rams.

Page 2-26: Subsea BOPs are not sent to shore every 5 years. The report should be re-worded: "BOPs are either sent to shore every 5 years for recertification or they are part of a Continuous Certification Program (CCP) in which the BOP Stack is inspected, maintained, tested, and certified by the OEM onboard the vessel/rig on a set frequency/schedule, thus eliminating the need to send it to shore every 5 years for recertification."

Page I-14: The LMRP is disconnected from the lower BOP stack to protect the structural integrity of both the riser system and the well.

Accidental discovery

Page 25/200:

"What record we have is clearly the result of fortuitous circumstances in which the bolt failures **were discovered accidently, or when they failed not under pressure early, before a major loss of well control event occurred.**" [emphasis added]

Page 17:

"However, this small number provides little comfort, or basis for analysis, given the "censored data" problem produced by lack of an industry wide program to inspect for bolts that are progressing to failure, or have failed completely and are merely being held in position by gravity. Sobering accounts, such as the failed studs on the Seadrill's West Capricorn (WC) **that were only discovered (and thus reported) because an engineer put his hand on one**, illustrated the compelling need for an industry wide continuous connector monitoring problem so that such failures can be discovered in progress, and not by accident." [emphasis added]

COMMENT: Without context, the emphasized text sounds as though, there was a chance the BOP would have been deployed with this failure.

The connector with the failed bolts had just been retrieved from its first deployment, that is, these were new bolts that had just been installed (and therefore torque checked before deployment) and deployed for one well. On its first retrieval, during the maintenance program, the failure was discovered...at this stage in the maintenance program it was by chance, however the pressure testing of the equipment had not yet been completed so, it stands there were processes in place that would have revealed the failure before the next deployment.

We don't deny that the failure was quite advanced a high potential of more severe consequences while deployed, but the tone of the above text implies this would not have been discovered if a person didn't put their hand on the nut.

Page 27 Service Life

"...Given the low margin between the currently inaccurate bolt preloading methods and operational loads, it is highly likely there have been instances of plastic deformation in Gulf of Mexico deepwater drilling operations"

COMMENT: This statement is speculative and where it's not based on data, (as the report does identify that inspection could not detect such,) advise the wording is revised to state:

"Given the low margin between the currently inaccurate bolt preloading methods and operational loads, it is highly likely there have been instances of there is a potential for plastic deformation of bolts in Gulf of Mexico deepwater drilling operations"

Torqueing as a pre-load measurement method

COMMENT: The report repeatedly stresses that the number of failures have been small in comparison the number of fasteners in service and that even smaller than that sub group are fasteners (or reports of fasteners) that have failed from over/under tension (ductile failures).

While we recognize that there are more precise methods of applying and measuring pre-load that torqueing, this report doesn't appear to present data to support there would be a measurable reduction in risk by applying different methods.

To improve on bolt tension application and measurement we need to look at flange designs, most designs in operation do not have space for tensioning systems, however elongation measurement is an option we can explore for BSL3 type connections.

It would be best if the OEMs weighed in on the subject of flange loading to discuss how much load variance is accounted for in the designs knowing that a 10-30% variance in tension can occur when using torque as a method to apply and measure pre-load.

Data

"number provides little comfort, or basis for analysis, given the "censored data" problem produced by lack of..." [emphasis added]

COMMENT: It is not clear why the author considers data they've been provided as "censored"? To clarify, data provided to NAS was not filtered.

Figures I.1, I.10, & I.11



COMMENT: Slip joint is located below the upper ball / flex joint. Move or remove slip joint label, or include a new figure like this:



Upper Section Marine Riser System.

Page I-4 – "It is possible that currents could cause VIV (Velocity Induced Vibrations) which might cause fatigue. Fairings (see Figure I.4) may be installed on risers to prevent VIV."

COMMENT: substitute Velocity with Vortex:

".... could cause VIV (Vortex Induced Vibrations) which "

Page I-8: "The tensioners also pull enough to pull up on the BOP at the sea floor. For example, the rig tensioners may keep a 2.5 million pound pull on the riser, 1.2 million pounds will represent the weight of the risers and 1.0 million pounds will be tension pull on the wellhead connector (through the BOP).⁴ This tension will increase bolt tension over and above their preload."

COMMENT: Possible, but not a common occurrence. The riser is usually tensioned to have only 50 to 100 kips tension at the top of the LMRP, depending on mud weight. Riser flange bolts are preloaded above the tension rating of the riser string. For example, a 3.5 million pound rated riser might have its' flange bolts pre-tensioned to 4 million pounds.

Page I-12: "BSEE requires that BOPs be tested every 14 days. Part of a BOP test is the pressure test program. BOP's are tested at a low pressure (several hundred psi) and at high pressure (to 1.5 times the rated pressure of the BOP. For example, 15,000-rated BOPs are tested to 22,500 psi."

COMMENT: This is incorrect. Proof test is a shell test done during manufacture and after remanufacturing that requires welding, heat treatment or machining. Subsea pressure tests are Maximum Anticipated Surface Pressure (MASP), or rated working pressure.

Page I-17:

"Fatigue Analysis

It is interesting that fatigue analysis has been the least-accepted design effort by industry. Perhaps this is because there was a perception that the higher frequency load cycles due to rig heave resulted in relatively low stress levels. These higher frequency, lower-load conditions were:

• Tension load cycles due to rig heave which were partially offset by the riser tensioning system."

COMMENT: Heave is not an issue for fatigue if tension compensators are working properly. Main damage comes from wave motion and rig lateral motion.

NOTE: References to API 16R should be removed. Requirements from API 16R were incorporated into the latest revision of API 16F, which was published in November of 2017.

Page 2-23, third sentence:

"The only assessment of mechanical properties in the final heat-treated parts is hardness."

COMMENT: This is an incorrect statement. API 20E and 20F do not repeat mechanical testing that is already required by the ASTM specifications that are required in these specifications. The report needs to be corrected with the following information:

ASTM Bolting Specification Testing Requirements after final heat treatment

(For ASTM product specifications referenced in API 20E and 20F)

Supplement tests

| | | (required when cited by purchaser) |
|------|---|-------------------------------------|
| A193 | Machined tensile. Full size tensile as applicable | High temperature, stress relaxation |

| | Hardness (sample or 100% as applicable by grade) Macroetch | Stress rupture, grain size Magnetic particle inspection |
|------|---|---|
| A194 | Hardness (sample or 100% as applicable by grade) Proof-load (cross-section hardness as applicable) Macroetch, Elevated temperature test | Grain size Charpy impact |
| A320 | Machined tensile. Full size tensile as applicable to Include: yield strength, ultimate strength, Reduction of area, and elongation | Charpy impact on austenitic steel |
| | Hardness (sample or 100% as applicable by grade) Macroetch, Charpy impact on alloy steel | Lateral expansion from Charpy |
| A453 | Machined tensile Hardness (sample) Stress rupture (as applicable by class) | |
| A540 | Machined tensile Hardness (sample) Charpy impact | Product analysis, macroetch Ultrasonic, Magnetic particle Elevated temperature Fracture transition temperature |