BSEE BOLT FAILURE FORUM (AUGUST 29, 2016)

[00:00:50]

Good morning...and we're back! Hello, okay, I said I'd like to start on time and I'm a minute late. Which means we're still technically about 19 minutes ahead of schedule, according to the agenda?

[00:01:34]

So, welcome back and thanks for taking your seats. I've got to tell you, as compared to when I've M.C.'d other events, this was really fast, like amazingly so. The International Regulators Forum, we were walking around and I felt like I needed sticks to poke people and get people to their seats, so thanks for that. So, there have been a couple of questions. I'm going to do a little bit of book keeping, and then we are going to get into our second panel. So, we will conclude probably a little bit early unless people have a lot of questions, so that's good news since we are going right through your lunch hour. Please hang in there, and hopefully if you do get hungry, just pop downstairs for a snack and then come back up. Questions have arisen about whether or not this is live webcast. Well, it is not live webcast right now, but it will be available. I can't exactly say how long, maybe a couple of weeks it will take us because part of what we like to do is, as you can see, is we like to be accessible to everyone and so this will be up on our website with a transcript or with subtitles within...I'm looking in the back...two weeks he says. So, what we'll do is, we will push out a notice through our website and perhaps to the broader community of people who attended today to let you all know that it is available for viewing on our website. So, one other thing that is kind of a reminder is, we've been using the term "bolts" pretty loosely here, so just to remind everybody, in case somebody came a little bit later, when we say "bolts" we mean fasteners, we mean connectors, studs, the whole collective of things, so you may hear people say these things interchangeably, but the word "bolts" actually is kind of ambiguous in how we are using that. So, I'm Allyson Anderson. Is that up here? Yes, it is. Ok. I am the Associate Director at BSEE, and I will be moderating this panel. You don't get the benefit of bio, and, frankly, you don't need it because I think I know about eighty percent of the people in the room, so welcome back. So, now with the rest of our panel, what we are going to be talking about is looking at maybe what the gaps are, and what's next as we framed it in the agenda. And so, the panelist that you have here have, if you notice there's a pretty diverse group of people, but since you don't have the benefits of their full bios, I'm going to kind of give you a look ahead. Many of you know Erik Milito, I'm going to go from Erik on down, Trent Fleece, and then we have Jack McHale, Jim Lancaster, and then Haimei Zheng. So, just to briefly introduce each person, and then we'll let people come up and do their presentations in order, and I'll just sit in the audience since that's full.

[00:04:12]

So, Erik Milito and Trent are sort of a team for representing API and Industry today and so I think Erik is going to be doing the presentation but, for those of you who don't have the good fortune of knowing Erik, he's the API group director for the Upstream and Industry

Operations and he's been at API for quite some time, but what I find most interesting about Erik is that prior to joining API he had a deeper rich career with the US Army - if it's okay that I mention that - and I thought that was one of the more awesome parts of what you have done in your life. Also, he has been an attorney in our solicitor's office, in the way back machine at DOI, and so he is familiar to many people here. Trent Fleece is - I would like to say - the guru of BOPs on this panel, in particular so he's coming from BP and he's been their team lead for BOP operations I think for a little bit of time now, but he's work there for about 18 years. And, he is a licensed professional electrical engineer. Okay, so that is your first set of speakers this morning.

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Next we will have Jack McHale. Now, Jack is a part, hopefully, of our interagency team. And he's representing the NRC, and we invited Jack today because the NRC has had a really interesting set of issues with bolts and some of their nuclear facilities and, while they are of a different type of bolt and used in a different type of way, what we can learn from the interagencies is about how they have looked at addressing the problem and many of the topics that Candi brought up in her presentation earlier are things that they considered in their analysis of their bolt issues. And so Jack is very very accomplished in his field and he has also some great experience in the US Navy and he was working in the submarine office there. I think you were submarine officer, right? In the Navy? But, throughout all of his time in the NRC, he has had a variety of roles that he may speak to you about when we get to him.

[00:06:18]

Dr. James Lancaster is the Director of National Materials and Manufacturing Boards. There is his relevance here - he brings some of the metallurgical and background to our discussion today and he would be someone who would normally speak about what we are doing with the National Academy but we've been asked to not give too much there until the contract is awarded. So, he is going to speak more generally about how the National Academy tackles issues such as this one that we are discussing today. And, notably, he has a PhD in Physics and he is a lawyer, which is a dangerous combination.

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So, the last panelist that we have is Haimei Zheng and she came to us from Lawrence Berekley Lab and she is part of a project, that I believe we are working between BSEE and LB&L, and is going to speak to that today. She is adjunct faculty at the University California at Berekley and, suffice it to say, she is very accomplished in her field. She is - the one thing that I am pulling out here - is that she won the LB&L Directors Award for Exceptional Scientific Achievement and her background area is in a lot of material science and metallurgy as well so, she will be speaking a little bit about what they are going to be doing in concert with BSEE. And so, I'll turn it over to Erik to get started, but the general format here is that they will have their presentation for 10 to 15 minutes and, hopefully, at the end we will get back together and people will have questions, so let's have some questions ready and hopefully we can make this a little bit more of a lively discussion. So with that, I

turn it over to you.

[00:08:04]

[New speaker: Erik Milito]: Thank you Allyson, I'd like to thank Director Salerno and Assistant Secretary, Janice Schneider, for inviting API to come and participate in this very important event. We, as the industry, really look at safety as a core value and we want to make sure that it is clear that we are also here to collaborate in these efforts and we appreciate the collaboration to date and we look forward to continued collaboration. I think, in order to help set the stage and to help communicate how API is involved with this, it's important to have some background on API. I am going to take you back, a little bit far, to 1919 when API was originally formed. We started after World War I as a standards-developing organization. We realized that due to the war efforts there was a lack of consistency in the industry when it came to the standards and the materials that were used in the oil fields, and we were developed as a standards developing organization. Now, looking forward to today, we have 685 standards and we have 7,000 volunteers around the world working on these documents. These are the experts in their fields and we follow a process that is accredited by the American National Standards Institute and it requires that there is a balance of participants in the development of a standard. That there is a consensus, that there's due process and we do bring together a lot of these parties that we hear about today - the equipment manufacturers, the drilling contractors, the operators, academia, and BSEE representatives. It's important that we have the government involved in this process because these documents really are the foundation of system reliability, system integrity, and a total system of safety. Now, if you think about these documents, they are utilized around the world. They're the most cited standards globally and the US off shore over 100 of our documents are incorporated by reference into the regulations. So, we see it as a true effort of collaborations because the regulators are able to take our documents and make them a requirement by putting them into the regulations. We also have, and in order to describe the type of documents we have, some of you know a lot about this, a lot of the industry people in here, but I think it's important to lay this out, we have a standard. It's called a specification. That's one of the key documents you hear about a lot today. A specification is a document that governs the design, manufacturing and testing of oil field materials and equipment. So, we have a lot of documents like that in the offshore and in exploration and production as a whole. We have well over 200 documents in our portfolio that relate to exploration and production. Then, we have recommended practices, which govern how a company operates, how a company drills a well, how a company fractures and stimulates an on shore shale well. Lots of documents are recommended practices. Then, we have a standard that's called a standard. A standard takes a combination of a specification and a recommended practice, sometimes elevates it by creating terms in there that make it more prescriptive or more mandatory - the way you look at a document. Then, we have bulletins that are guidance documents but we have this whole suite of documents that we continually develop and we have a requirement for us to relook at these documents every five years and to revise them so that we are keeping up with the times. Lots of committees - the committee that we have in place is the committee on standardization of oil field equipment and materials. Lots of subcommittees that report to that committee, so we have subcommittees on materials, quality, subsea equipment,

BOPs. Lots of different sub committees working day-to-day and they're are volunteers in this industry are coming forward to make all of this happen.

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This is all important in the context of what we are talking about today because we have bolting specifications and we have BOP standards and we have flange documents and valve documents. All relate and work together to enhance the overall system's safety. In addition to that - what complements all of this - is the API monogram program. So, we have a specification Q1, which is a quality management system document for manufacturers. And, a manufacturer of equipment - a manufacturer of a bolt - is in the position to be able to come to API, go through an audit and certification program, so that they receive the monogram and they can put it on their product and it shows that they have gone through the audits and the requirements necessary to demonstrate that they can manufacture that equipment under the quality assurance and quality control guidelines of the API Q1 standard. So, that's a very neat complement. If you think about the comments that we heard today from Dr. McNutt - she talked about what are the requirements and what are the standards and how can we certify against those? So, we have a system in place that we look to and that we rely on to have a specification have the design requirements, the materials requirements and we have a certification program in place as well. So, that's the backdrop that I like to give to you before I get into the overall presentation on what we've been doing as API and what we've been doing as an industry. And, it's not just API - it's API working with the broader industry to make sure that we are communicating our work on the bolt issue. Not just here in the US, but the work we do, I believe, is going to have an impact globally. We've heard a lot about how we need to make sure that we are not focusing on just in the Gulf of Mexico; and we represent global companies who operate around the world and they take this information and disseminate it around their operations around the world. We believe that we have a holistic approach we are taking to proactively address this bolt issue.

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So, what we are going to do is give you an overview and share with you the work that we've been doing. The second bullet I think is important because we have two work streams, that you see at the bottom, we have the multi-segment task group that was organized shortly after the release of the August 2014 QC-FIT Report, and then we have a working group that we put together after that safety alert earlier this year. But the significance there is that we brought together operators, rig contractors, and the equipment manufacturers to work collaboratively together and to have all that expertise there. Many of them are in this room and these are people that I think BSEE, National Labs, anyone involved in this can rely upon, because they are out there day-to-day. It is their job to enhance safety. It's their job day-to- day to focus on that core value of safety. And that's who we rely on at API is the experts. We've also been collaboratively engaged with BSEE, shortly after that QC Fit report came out. We asked for a presentation on it and we'll get into that in a little bit. And then we're committed to that moving forward with all the stakeholders in the room.

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Now this is a busy flow chart - it's a busy timeline and I'd like to point out that API has worked on bolts actually started well before that - well before this timeline even starts - and I'll talk about that when we talk about the specifications that we have specific to bolts. The QC Fit report came out in August of 2014. When it came out we talked to BSEE and said well, can you present to us on it? We have semi-annual standards committee meetings, and we had a presentation from BSEE on that - I believe in the December standards meeting. That was the first time we had the opportunity to hear about this concern and the significance of this issue from the regulator. Shortly after that, we put together the multi-segment task group, which had at least a couple dozen experts participating in that group. And, they were looking at this from the standpoint of: 1 - identifying the potential failure mechanisms related to bolts and the equipment associated with bolts; 2 - identify the contributing factors around those failure mechanisms; 3 - is to then look and identify the mitigations in place, the API standards, the ASTM standards, the regulations, the equipment, what processes and what standards and protocols do we rely on currently, at that point, that mitigate against the potential risks we've been talking about here today. Finally, to make recommendations that fill in the gaps and to enhance and improve the overall system of mitigating against those risks. They looked at the same factors that we heard Dr. Hudson talk about. We are looking at materials, design, stress, external environments, and we'll get into that as well. So, by the end of the year, we've had dozens of meetings, bi-monthly meetings of the multi-segment task group, and then we provided a report with 20 recommendations related to various aspects of API standards, as well as those conflicts that might be out there between the ASTM document and the API documents - what type of research do we need to do? Do we need to look at the design factors? The material factors? So, we then put to work all of these standards sub-committees on materials on block preventers, on subsea equipment, on quality, and they're now implementing the recommendations. So, this is really the focus on the API technical programs - our standards our quality programs - making sure that we have that feedback loop of continuous improvement, to make sure that we are addressing and enhancing everything related to bolts.

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March - the safety alert comes out with recommendations into it. Trent has been sharing that work group of 50-plus experts, developing the ways and the path forward, to operationalize ways to enhance operations. The meetings that occurred there with BSEE in March and in June and we provided a letter in July that laid out our path forward. We received a positive response from BSEE in that, based upon what we know now, we really believe we have a holistic approach in place to address all of the factors and make sure that we are operating in a way that mitigates the risk as great as possible. As we move forward, we obviously want to make sure that we continue that collaboration that we need between industry and the government and, as we move forward this year, continue the workshops between the technical representatives; folks like Trent and a lot of people in this room and the BSEE technical folks here in Washington and in regions on the district level is going to be key to make sure that we do this in the fit for purpose, practical and overall safe way.

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So, we've focused on four areas: research, we have standards committees that are implementing the research on things like hydrogen embrittlement and corrosion resistant alloys. Our standards, I'm going to talk specifically about those in a sec, but we are going to continue to look at those, review them, revise them, and consider the changes that need to be across the board because they all inter-relate and they normatively reference each other. So you've got the BOP standards, the Flange standards, the quality management systems standards. They all relate in an overall system that we rely upon and we're looking at all of those. The quality assurance, quality control -- that is the Q1 monogram program that we have. We continue to look at that to see if there are areas that we need to address when we go out and do audits and we certify manufacturers. Are there gaps that we are looking at? And then we have a feedback loop there as well that takes the information from those audits, from those certifications, that's able to go back into the standard setting committees, and we have a committee that oversees the monogram certification program. That feedback loop plugs all of that information back there as well. And then, as I've mentioned, we've proactively put together the work groups to address both the long term technical program development and enhancements that need to occur, as well as what we need to do to operationalize the work out in the field.

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So the specifications - and this is where I mention that the work actually began prior to the QC Fit report in August on that timeline that I showed you - but specification 20E is a specification specific to bolting. It's the alloy and carbon steel bolting for use in the petroleum and natural gas industry specification and it hits on all the issues we've been talking about when it comes to materials. So, that came out in 2012. After that committee finished this document, that committee went to work on 20F, which is the specification on corrosion resistant bolting for use in the petroleum and natural gas industries. So, well before we were aware of the significance of the bolting failures, as BSEE has raised them, we had committees that were proactively developing specifications for the bolts used in offshore and subsea operations. Allyson mentioned, what we were talking about here, well the documents actually define what a bolt is for the purposes of these standards. You can see that it includes all thread studs, tap-end studs, double-ended studs, headed bolts, cap screws, screws, and nuts. It's a large population of fasteners and connectors that are used in the offshore we are talking about. And the topics covered by these specifications are diverse, and are intended to make sure that we have materials in place that will withstand the operations and the conditions that we see in the deep waters of the Gulf of Mexico.

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Now, when you look at it from the factors standpoint, - which factors are we looking at? Dr. Hudson referenced the circles that Trent developed, but we look at it from a material resistance standpoint, a stress standpoint, and a subsea environment standpoint to make sure that we are covering really all of the bases as we address this issue. And we have some

examples up there. Material resistance - do we have the materials in place so that we are mitigating against the risks and the potential failures. We believe that we have these standards and these specifications in place with 20E and 20F that are designed to make sure we have those types of materials in place. On the stress side, the design of your offshore system that you have in place, your blowout preventer system, as well as the way you apply and put in place the bolts, the torqueing that we've heard a lot about in a subsea environment. Are we looking at what factors the external environment presents that could impact those bolts that are in place and are we investigating and minimizing the consequences that can occur and create environmental cracking? Which is what we don't want to see at all and so we look at things like hydrogen sources. So, this is the way that the multi-segment task force has looked at this and the working group to make sure that we are really covering all facets of operations, materials, design, external environment to have that full system of safety that is the ultimate objective.

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And here is our overall summary of the actions that we have taken. We have engaged the experts, we've developed the multi-segment task group report with the recommendations for the standards and the technical programs - and not just for API but for organizations like ASTM, so that we have the consistency we need. And then we've established the work group to provide the recommended path forward. And those recommendations include something as simple as defining critical bolting. What bolts are we talking about that we really need to make sure that we are addressing? And, we've defined that as bolting that the failure of which could result in loss of containment of wellbore fluids into our environment. So, that's the focus of our recommendations. And then, we have the standards in place. They're relatively new - 2012 and 2015. We have increased adoption of those specifications. We have upgrading of bolting as the BOPs are being maintained and swapped out. We've heard a lot about some of the OEMs doing a recall, so we see the exchange of bolts to the 20E / 20F types of specified bolts. Enhanced quality assurance and quality control. Now that these documents are out, the original equipment manufacturers can go through the API monogram program to get that certification to show that they're designing and manufacturing their bolts according to API spec. Updated make-up procedures with additional engineering rigor and oversight - looking at things like torque and other aspects of operations. Looking at the bolts storing spot checks - when you're pulling the BOP - during those phases of operations. Elimination of electroplated zinc coatings - that goes back to the original February multi-segment task force, task group recommendations, that was one of their recommendations and we're carrying through with that. Enhanced failure reporting. One thing that's happening globally is that the International Oil and Gas Producer's Association has a joint industry project in place where they are collecting BOP reliability data so we have that going on as we speak along with the additional reporting requirements that are now in the Well Control Rule. So, we view this as a holistic approach moving forward that addresses all of those elements that we've talked about and this nicely complements technical work that is on-going.

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One thing that I would like to talk about quickly here, is that we heard Dr. McNutt also talk about how Admiral Rickman came up with the robust safety system for submarines. Well back in 2011, the industry actually created the Center for Offshore Safety, which we believe is a robust system for offshore operations. The Center for Offshore Safety has a focus on Safety and Environmental Management Systems and they look at things like management of change, hazards identification, mitigating against those risks posed by hazards, so we have a barrier in place through a SEMS program and now we have the regulator, BSEE, requiring that, requiring audits against that, and requiring companies to go out and demonstrate that they not only have the SEMS in place but that it meets the associated rigor that is needed to have safe operations. I point that out because we often talk about something like bolts but, we as an industry like to look at that as part of an overall system of safety and that is what is incorporated through safety in an environmental management system that are promoted through the center for offshore safety as well as the BSEE regulations. And we have our own Charlie Williams which, I don't know - maybe he is a modern day Admiral Rickman - but he's doing good work there in helping to promote a culture of safety. What we're trying to do is to make sure that we have that total system reliability, system integrity, and total system of safety through all of the efforts that we're doing. And that we have an industry here that stands committed to effectively addressing this whole issue through research, standards and technical programs, quality assurance and quality control, and continued collaboration with BSEE and all the folks in this room. So, thank you and I look forward to any questions that you might have.

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[New Speaker: Jack McHale]: Okay, good morning, my name is Jack McHale with the Nuclear Regulatory Commission, and again I thank BSEE for the invitation to come and speak about an issue that we've been dealing with. Now, this will be the part of the program that is now for something completely different, because when I heard three-inch diameter, 16 inch bolts, I'm talking about a bunch of little bolts that are about the size of my pinky; but I'll go ahead and show you that. Most of the presentation here is really just kind of some pictures of where these things are installed to give some context to the application, but also I think that they are things that we've heard discussed this morning as far as quality control, in-service inspection, the regimen as far as installation procedures and all of that. The nuclear industry certainly deals with a lot of those issues so, hopefully there will be some parallels for that. So again, these bolts that I'm going to talk about - the baffle former bolts - are something that are subject of industry aging management programs. Again, they're in a nuclear reactor, and they have the unique feature and the service environment is probably - except for one thing - very mild compared to what we've been hearing about. It's in very pure water, the external - you know the pressure temperature environment on these bolts is maybe they're in a 2,200 PSI vessel and it's about 600 degrees Fahrenheit in there. The plates that they are holding in place have about a 30, three zero, not any zeros after that, pounds per square inch differential pressure across it, so loads are fairly, you know, mild. But, they're being bombarded by neutron radiation from the reactor core through their whole life. So, as this effluence accumulates over the first forty years of reactor license time, leads to embrittlement and issues. So, again because of that, these bolts were actually flagged as an aging management primary inspection

component. In other words, knowing that this phenomenon with radiation-induced embrittlement was going on, these bolts were planned to be inspected sometime around the 40-year lifetime in the reactor. There's a couple of things that you may hear - there's 40 years of - 40 calendar years is a standard initial licensing period for a reactor, but the inspection of these bolts is actually based on a 25 to 35 effective full power years of operations. So, in other words, if the reactor is at 100 percent power for one year that's one effective full power years, so about 32 effective full power years tends to be around 40 calendar years with the outages for refueling and other things. So, again, just to contrast those two little scales there.

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So, the reason this got our attention is that, again although this mechanism was known and there was actually some experience back in Europe back in the late 1980's that showed that some of the bolts were subject to failure, we had two reactor units this year during their refueling outages, that discovered a lot larger than the expected number of bolts that were failed. Again, these refueling outages take place about once every 18 to 24 months, and again the fuel is removed from the reactor vessel, and I'll show you a picture of that. And during that, they discovered more degradation of these bolts than had been found. Although it wasn't a substantial safety concern, it certainly got the NRC's and the industry's attention.

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So, what are we talking about as far as these bolts? Again, the baffle-former assembly bolts hold together a baffle assembly, and the core where the fuel sits in a pressurized water reactor is in this purple area here and it's surrounded by a baffle assembly. And really all that baffle does is direct the cooling flow up through the fuel. So, here's an inlet nozzle that fuel comes in, comes down, outside and around this core barrel and then comes up through the bottom and these baffles more or less direct it up through the fuel, goes out the outlet nozzle and goes off to make steam to run turbines. So because of this configuration here, it really comes down to fitting square pegs in a round hole. The reactor vessel is a big barrel and the fuel assemblies are square pegs and I have a picture to show you later, so this baffle assembly conforms the square pegs to fit in the barrel. And the way this is constructed here is shown pretty well on this side, these red plates here, the baffle plates, and there are eight levels of these former plates, where you can see coming up the side here, eight steps, and the bolts we're talking about are here at the face of the plates that actually bolt those baffle plates to the former plates. And again, directs the coolant up through the core. And, the other thing is, that it really tightly packs everything in there, so if there was a seismic event, you know everything pretty much is restrained. And, also if you were to have an external coolant pipe break, that could put some jet forces in the flow out, the break would put some differential pressures across those, the core, and you would want that all to be restrained. So that's what these assemblies do.

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Ok, I'll move onto another picture. Now this is just another picture of what the bolts actually look like and how they're set in there. Again, this is just an arc of that barrel and this step thing here is one of the former plates, and the baffle plates is just bolted to the face - the edge of that former plate with these bolts, and those are the baffle former bolts. There about - depending on the reactor design - there are somewhere between about 728 and 1,088 of those baffle former bolts in a pressurized water reactor. And, because of that large number of bolts, you can actually tolerate a fair number of failures done. There's analysis that manufacturers have done, you can have perhaps 30 to 50 percent of those bolts that have failures and not impact the overall structural integrity. But that kind of assumes a uniform distribution of the failures, so if you have clustering, in other words, if they start to fail in one area, that becomes a little more problematic as far as the structure, to the point that you may have one of those plates detach, which would you know, potentially then impact the fuel assemblies that are next to that, and that's something that you would want to avoid.

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So again, just to show you the construction, these bolts are just hex head bolts. And there are some variety in the designs of these. This one has got an internal hex on it, and it has a locking bar, just tack-welded across it, so that it's restrained. And again, theses bolts are about 5/8 of an inch in diameter, about 2-inches long, they are stainless steel, they are type 304, 316 or 347 stainless steel, and the 347 bolts have been the ones that have been the most problematic in the recent experience.

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Again, here's a picture of - this is not a real reactor, because there's a ladder down there in the corner - this is a mock up at one of the vendor's facilities, but again you can see the fuel assemblies and there are all of these little square spots on the bottom. There'll be a fuel assembly sitting in each one of those. So again, we're fitting the square pegs in the round hole. And again, the baffle plates are these plates here and all of these little rows that you see are the heads of the baffle former bolts. So, what did they see when a couple of our utilities went in for inspections? Again, during the refueling outage, the fuels removed from the vessel so it exposes the sides of the plates and, in some cases like on the left here, you can see the head of the bolt's missing. So, the whole locking bar that I showed had broken of and the bolt head was actually missing. And then, in other cases, one of the tack welds might be broken. It's a little tough to see and you can see that head of the bolt is no longer flushed with the plate. It starts to protrude. So again, it shows that something has happened to the bolt - so some visual indications were the first indication of a problem with these. Another thing to mention is that the bolts are actually inspected for the aging management program. There's a requirement to do a 100% inspection of the bolts and it uses an ultra-sonic method, so there's a probe that's developed to fit over that hex head and locking bar and each of the bolts gets a signal sent down it and comes back with an indication and the ultrasonic method is a go / no go type of check. Any indication is treated as a cracked bolt - a through-cracked bolt - even though the crack may just be a small fraction of the way through. And in fact, in the plants that did come up with a larger than expected fraction of

bolts that were broken - most of them were - I don't know in the order of 60 to 70 percent, were still in tact, so they had to be torqued to be removed. But again it shows that there was a start of some type of cracking going on there. The other thing that the industry does, is if there's for some reason there is a bolt that is unable to be inspected because you can't get the probe around the locking bar or something, they count it in the failed population. So it's a very conservative method but again it - and one of the things that I'm going to talk about a little later is - there's some thought about trying to refine the technique to size cracks, so that we are not over predicting failures.

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So in the past, the experience has been that the plants that have done these inspections have found less than 10 percent of the bolts cracked. Some plants found at, you know, zero out of 800 in some bolts cracked, or one or two bolts out of a thousand. So again, very low failure rate. And then, what was the new discovery this year is that a couple of the plants had about 25 percent of the bolts with indications. So with 25 percent potentially degraded, this is definitely an outlier.

[00:41:02]

So, what type of cracking is there? It has been known that the mechanism for this is a radiation-assisted stress corrosion cracking and the bolt failures have occurred at the transition between – my pointer is not working - but you can see it at the head of the shank region. The new bolts that are being installed have an improved transition there. This one actually is not too bad because you can see it's got the curved contour. Some of the bolts are very stepped, it's like a notch almost between the head and the shank, which is obviously a stress riser so the replacement bolts are more with that fileted head. And also the 316 stainless steel is what is being used as a replacement bolts and that allows for a little additional pre-loading, which could be a factor in the failures in the other cases. In other words, when the pre-load was lost on the 347 bolts then you get thermal and flow induced fatigue type things creeping in there and probably contributing to the failures. Again, even though there were some more significant numbers of cracking in these bolts, we did not determine that this was a significant safety issue and it's really because of the inherent margin. Like I said there where you know in the 700 to over 1,000 range of bolts in each one of these assemblies and - also you really - to the accident or condition that would cause these bolts to be challenged would be again a severe earthquake beyond almost the design basis of the plant or also a large loss of coolant accident, which basically is a large attached pipe to the reactor breaking off and causing some jetting forces. Again, there is very low probability of those initiating events happening so, again, not a significant safety challenge but certainly the unexpected nature of the number called into question. Are we looking for the right things and are we on top of this issue?

[00:43:37]

So, what the industry has done and what the NRC has done - immediate corrective actions for the plants that discovered this obviously were to replace bolts and in some cases the plant would also choose to not only replace the bolts that had failed, but take an additional

population of bolts and replace them in a pattern that would avoid this clustering phenomenon that I mentioned. And it's really based on projected future degradation, so in short you're putting some margin in against that happening. The other thing the industry was very prompt in putting together a baffle former bolt focus group to look at several aspects with this. First, the inspection regime that we're using - the techniques, also to help with the procurement of bolts, and also the tooling for all of this because one thing that I did not mention earlier, one of the challenges with this is the inspection of the bolts and any kind of replacement of the bolts is done under water because the reactor components, although the fuel is removed, all the reactor components are highly, you know, have been highly irradiated, so there is a significant dose field from it so the water is a shielding. So developing tools and probes and cameras that can do this work somewhat remotely is part of the challenge with this. Other things that have happened is, again, the focus group met with the NRC in a public meeting last month to talk about the progress on these issues. The original equipment manufacturer issued, as I heard mentioned earlier, bulletin or safety letters. There's a nuclear safety advisory letter that the manufacturer put out that talked about this. Also, we've identified a subset of plants that have, that are most susceptible, to this problem and it really has to do with, again, the bolt material and also the flow configuration in the reactors. So, certain reactors are the ones that are the outliers that are the 25 percent of failure, as opposed to the one or two percent failures that we have seen. Those plants are identified and they've committed to do an inspection at the next opportunity - when their next refueling outage comes - there will be an inspection and also with that they've done evaluations to show they're acceptable for operation until they reach their next shut down date. And those shut downs will be occurring over the next year, starting this fall and into the fall of 2017. Again, the industry has been working closely with the NRC on this. Also the plants that did find failures have sent bolts off for metallurgical analysis, and that will take a while to have that completed. Again, dealing with very highly radioactive components there, so it's sent to the hot cell facility and that work will be done. Again, there is some interim guidance for inspections that have come out that talk about moving up the inspections for the most susceptible plants to the next opportunity, the NRC will likely endorse that inspection guidance through a staff safety assessment, which is a typical process we would use for endorsing some of the industry programs. So, again, there will be some communication - generically from the regulator. It's already occurred to some degree from the industry and we'll be working through the process of looking at our guidance that's out there - the regulatory guidance for aging management programs and instituting a change where we see they're necessary based on the new operating experience. With that I will wrap up and look for questions later. Thank you.

[00:48:28]

[New Speaker: Dr. James Lancaster]: Thank you for inviting me BSEE. I'm going to not talk about the activity that we've been discussing with BSEE on some of these topics that we are focused on today. But I am going to give a little bit of background about the academies, what we do, who we are, and, with the expectation that many of you will hopefully be engaged in the project that we are going to undertake, and we look forward to working with you on that. We are a long standing organization here in D.C. We formed in 1863

under President Lincoln. We are a congressionally-chartered organization, and our directive was to provide input into the government so that it could make knowledgeable decisions in public policy. So that has been our focus for the last 150 years. We actually not only focus on government policy, we also provide input to the public in the goals of improving public understanding in science and technology and we also promote those that actually engage in research - so that is our three cores.

[00:49:56]

As I mentioned, it started out as a National Academy of Sciences, we have expanded in the last 150 years. In the 1960's, the National Academy of Engineering was formed and then last year we formed a new academy - the National Academy of Medicine, which used to be known as the Institute of Medicine - it is now a full academy. So those are our three member organizations. That last organization there - our form of NRC, The National Research Council - is actually the organization that does most of our projects. So it's the ones that produce the reports and does some of the other activities, with one notable exception, and I'll get to that in a second because it's actually important here. But, in terms of our projects, and I'll be talking about some of them also, these three academies are actually our go-tos for many of the folks that we are looking for, for experts to help us address those projects that we are involved in. We draw from the academies, but we actually draw outside the academies. Most of our projects have maybe a third to a half of their members from the academies and then the remaining groups, the sources of experts, are either folks that are suggested by academy members, or staff, or some of the boards that provide their expertise in drawing, putting together our groups. The one exception that I mentioned earlier, that isn't in the National Research Council, that does do some of these projects is NAE Program Office and they do many of the other activities, and of course their focus is on engineering and they do a lot of education and on-line activities. The Research Council has seven program units, as I mentioned earlier, I'm with the National Materials and Manufacturing board. I serve under the Division of Engineering and Physical Sciences and so these are our resources - the boards, the academies - for putting together the groups that do the studies. One of the things that I do want to stress is that we are not an appropriation - we don't get our funds through appropriations. We're 501c3, so all of our funding comes either from individual projects - we do have some institutional funding and we also get some foundational funding. So that is essentially how we do our work.

[00:52:50]

I am going to briefly talk a little bit about these two organizations and the two that are engaged in the discussions with BSEE are the NAE Program Office and the NMMB and I'm going to give you just a little bit of background about them and then I'll talk about some of the activities that we engage in. Here is the mission statement for NAE. It's two components - one is the focus on the engineering profession and they do a lot of activity that focuses on the engineering profession. The other aspect of it is drawing from the engineers that form the body of the NAE and provide that expertise and insights to projects that we undertake. Their council is some esteemed engineers and other folks - Marsha McNutt is actually involved in that. These provide oversights to the activities that NAE is involved in and also

provide long-term supervision and support for those projects.

[00:53:57]

This is the board that I work for, the National Materials and Manufacturing Board - this is actually a fairly recent board. We used to have a separate board for materials and a separate board for manufacturing and, I think as this forum reflects, those two are very interconnected often. And so we combine those two boards and there is the current set of board members. They provide a lot of the expertise that we draw from in putting together studies, supervising studies, and stewarding studies. And, for the most part, we're both the NAE and program office and NMMB draw from both academia and business. The NAE is - their 2,200 members or so about half are in the business world. We are a little more academic-based, but these are a number of people that are involved in manufacturing at all levels and also materials at all levels.

[00:55:08]

Now I'm going to switch from who we are and talk about what we do. I have listed here, grouped here three types of activities. If you have been engaged with the academies you're probably most familiar with the consensus studies that is at the top. Those are ad hoc studies, meaning that we put together a committee for the express purpose of dealing with, address, an issue, and I'll get into a little more detail later. And they actually come up with a series of consensus recommendations, a sense of advice or sets of options that they provide to the sponsors and those that would be interested. The other set of activities that are on-going are convening activities. I'll mention workshops in a little more detail later, but we also have meetings of experts and focus sessions. And again these are not consensus building, they are not recommendations, but they are opportunities to gather together experts to address specific issues. And then the boards and the round tables are continuing activities and more resources for our projects than anything. So just a little more detail about the workshops. Typically, this is as you would expect, either a conference or a symposium. It's focused on a particular topic and there are many purposes for doing these activities. One very well could be the workshop in and of itself is what the sponsor wants. They are interested in the gathering, interested in hearing the experts discuss, and some of the results that come out of that are workshop reports or summaries, so these are actually written materials, and I've got a couple of examples that I will give you later that reflect what is going on. Other activities that we use these for are either planning for future studies or as input for consensus studies. So this would be an information gathering activity, multi-day activity that provides an opportunity for those from communities to engage with a committee that is conducting a study and actually discussing the issues with that committee.

[00:57:37]

So these are the consensus studies, and I've put out a couple of bullets that give you a little more information about them. These are actually a lot of times come in from a sponsor where a government agency, it could be state or federal agency, will come in and say we have an issue that we need some advice on. And so we will sit down and discuss with that

sponsor, develop the task that we call a statement of task, or the charge that we will give to the committee. And then we actually put together the volunteers, so we we'll draw from those resources that I mentioned earlier to put together a committee of 15 to 18 folks who have the expertise to address the topics that are set forth in the statement of task. We evaluate very closely for conflicts of interest, so that's a key consideration for us. And then we gather a lot of information and so we'll either gather it through workshops. We take place, we will have four or five meetings of the committee where we'll gather information and we'll go out on site visits. So we do a lot of efforts to gather the information and then once the information is publicly brought in, the deliberation take place in private. And that is one of the key considerations of these activities is that these are actually independent assessments and evaluations that end up producing consensus decisions on the questions that are raised. And then after the committee generates its report, we'll put together a second group of experts, and that group of experts will actually take that report and then independently evaluate it - so they will take the statement of task, will ask themselves, did this committee do its job, and are its findings and recommendation, its advice, is it well founded? And then once that is completed, we will release the full report. So that's kind of, in a nut shell the process that we go through.

[00:59:52]

I've listed here a couple of summaries the NMMB has put together fairly recently - Applying the Material State Awareness to Condition-Based Maintenance and System Life Cycle Management is one that just came out this year. Novel Processes for Advanced Manufacturing - so you see it's materials and manufacturing-based. You'll notice that a lot of these are defense related. We have very close ties to DOD's communities of science and technology programs and so a lot of these activities actually are generated through a standing committee that we have, the Defense Materials, Manufacturing, and Infrastructure Standing Committee. And then finally, I've just listed a couple of recent reports that we've had. Probably the one closest to the current topic is a corrosion study that we came out with in 2009, but we've also done issues dealing with lightweight technology, again dealing with DOD related materials, and then Optics and Photonics. It's a little bit different from this topic, but it actually one of its recommendations was to set up a national initiative and the national photonics initiative came out of this report. Incidentally all of these reports and workshop summaries are available online. Download for free at our National Academy Press - that is nap.edu. And I believe that is the last of mine, so I look forward to your questions.

[01:01:34]

[Haimei Zheng]: Good morning, my name is Haimei Zheng. I am a staff scientist in Materials Science division at Lawrence Berkley National Lab. I am also an adjunct professor in material science engineering at UC Berkley. I will speak with you about the project with BSEE, subsea bolt performance and critical equipment drill through fastener study. I would like to thank you for the opportunity to speak at this very important event. In this talk I will introduce you to our project, starting with the motivation and the research goals in this project and our current progress and future work. This morning you have heard a lot of

talks, we know there is very important to study the bolt failure issues and there is a need for an independent assessment of this critical drill through equipment fasteners in offshore oil and gas operations. And this assessment includes identifying the fastener systems currently in use, including both offshore and onshore, domestic and globally, and evaluating design, manufacture, installation, performance, maintenance, and inspection processes. Then we hope to identify the similarities and differences in the industrial standard and regulations. So in the LBL projects, there are two interconnecting components: the first is to review the industrial standard and do the gap analyses; and the second part is materials, the lab experiment, to study materials corrosion under a subsea environment.

[01:04:21]

So the industrial standards, we know that there are a lot of materials. So far we have looked into over 220 material items. Listed here are the materials, the standards, you can see the API, ASTM, ISO, military standards. These are examples we have been looking through. We are continually looking into more, adding more into this list. (And so somehow [there is a technical difficulty with] the materials section, would you like to use my computer, I am sorry about it.)

[01:05:56]

[New Speaker - Moderator Allyson]: Ok, I do not have an aspiring career into standup comedy, so I am not going to tell you any funny jokes, but while she is getting ready I thought that I would reiterate a couple of points, rather than breaking. Doug thought that we could use a break, but I feel like we could lose you forever if you break, okay, so hang with us while we switch this out. So, just to remind folks that the panel that is selected here has to do with - if you haven't picked up the themes - I am just going to put it on a white board here and basically spell it out. Is that we have people from the industry, that we have been obviously Erik set the tone and explained that we have trying to engage with the industry for quite some time, and a lot of the people in the room have been a part of that activity, and hopefully Trent I'll have a couple of questions for you when we get to the Q&A piece of this - to talk about how that's working within the committee structure. So I think that's really important, and thanks to Erik for presenting that. As we move down, with Jack, you know he is going to be a part of interagency working group on this issue which has a catchy name IBAT, ok we really try with acronyms, and sometimes we swing and miss there, but with the IBAT what we will be doing is getting together and have some symposiums. See, a couple of you got my joke, come on now, Elaina gets my humor. So we'll be having a meeting and Brian will close and talk to you more about that and what we hope to accomplish with that. And then Jim, you did an excellent job of skirting the issue about what we are actually doing, and he kind of laid out the structure that we are going to be taking, so you can read between the lines and infer what we are going to be doing with them. And then with Haimei, it looks like you are ready now, so I will leave you with this idea that sometimes people think that there are too many cooks in the kitchen, and we disagree. Every one of these different groups brings a unique perspective from other industries, or different scientific approaches that we can throw at this problem. It is a really

big problem, which is why we are here to tackle it today. Here you go Haimei , I'm going to pull your mic down, make sure that we can hear you, okay?

[01:07:56]

[New Speaker: Haimei Zheng]: Thank you. Sorry about it, now the slides are back. So we have been looking into these standards, trying to identify and compare the different critical attributes for subsea bolts, including materials specifications such as hardness, yield strength, ultimate tensile strength, elongation. We also looked into procurement, including heat treatment, coating, shear stress, fatigue life, threading, corrosion treatment, installation, quality analysis control, in-service inspection, and human factors. So a lot of materials, a lot of parameters to compare. These just some examples of the findings. For example, the hydrogen embrittlement for hardness threshold we identified some of the inconsistences among different standards. For example, the NACE MRO 175 ISO 15156 has most strict regulations specific to sour service environments. It has the maximum allowed hardness in 22 HRC. While the other parameters, the other standards, gave different numbers. For example, the Industrial Fasteners Institute says "The susceptible fastener products have specified hardness above 39 HRC". The NORSOK have the different number, and listed are different standards have different numbers. Just examples. I won't read through the lines. You see the API 16F says the maximum hardness with primary load-carrying components shall not exceed 35 HRC. So we have identified a number of differences in this standard. And they are listed more. The heat treatment, for example, this NACE 175 says all parent materials must undergo heat treatment, while the different standard ASTMF 1941/F says baking is not mandatory for fasteners with specified maximum hardness 39 HRC and below. So this is just examples, and we list many of these things we have found. This more, the ASTMB633 we also found, surprisingly, there are limited number of standards address the sour service environment. So far we have this NACE 175 ISO 15156 specified petroleum natural gas industries materials for use in H2S containing environment in oil and gas production. They are listed of the identification of the sour water containing at least 0.05 psi of H_2S. There's items saying how to avoid this sourfied corrosion and improve the resistance materials. Including the nitrating and listed these different materials. So this just some examples of what we found. I would not be able to go through all of the details, however so far we have been working on a draft, continually putting more of the findings in this document. We would have BSEE to review this document before open to public.

[01:13:19]

And the second part of our study is material corrosion. We know this subsea environment we needed to consider the high pressure and the corrosive environment including the chlorine ions and sour condition, CO_2, H_2S. And we know that there are a lot of studies on total pressure, oxygen partial pressure, and temperature. All of these different parameters influence the corrosion of the materials; I gave you a few examples. The total pressure has significant impact on the materials' corrosion rate. For example, increasing the pressure on different stainless steel - different materials - has different responses to the pressure. Here is the impedance measurement the current response profile you can see is different with

different materials. I would not go through the details, and here you can have more detailed information here. In general, a lot of materials - for example the X60 pipeline steel material - increase the pressure will introduce a higher corrosion rate. Another very important factor is the oxygen concentration. With increases in the oxygen concentration in water, in the environment, the corrosion rate will increase. I gave two examples here on the left is Ion as you see, the corrosion rate, measured by the rate of weight loss as a function of the oxygen concentration, we can see the oxygen concentrated increases introduce significant increase of the corrosion rate. On the right side, again you see the trend on the low carbon steel, the oxygen concentration increase introduces the corrosion rate increase and this is measured by the average penetration depths of centimeters per year.

[01:16:05]

Another parameter is the temperature. The temperature increases the corrosion rates. Here the left shows the pitting potential increases with the temperature increase and the right side shows the steel at different temperature and you can see the corrosion rate measured differently. So for our study, and we looked into the skill down bolts at different conditions and looking into the impact of the total pressure, oxygen partial pressure and temperature. Here is the chart of our planned study. We looked into the bolts with different coating materials at different conditions. So this second part of the study will form the second part of this report that will be published. So this work, we worked closely with Argyle National Lab and I have group members assisting me for this project. Thank you for your attention.

[01:17:28]

[Moderator Allyson]: Okay so, so by my count, it's 12:20 and I did promise that since we are running ahead of schedule we wouldn't take, we wouldn't be here until 1:15. So I definitely have some questions and some follow up. (Thank you, there is going to be some sort of horrible trip hazard. I'm not so sure footed here.) So I definitely have some follow up questions, but what I would like to do is to open it up to the audience first to see if anybody has any questions right now that they wanted to ask any one of the panelist. If not then I'll get into some questions and then if people feel comfortable you can jump in. This is a very timid audience. There is a question here.

[01:18:28]

[New Speaker: Audience Member]: This is just a brief comment, maybe the gentleman from the Nuclear Regulatory Commission could maybe compare the types of code standards and regulations that, let's say nuclear business would use, say ASME code standard versus some of these other standards that are being shown today.

[01:18:48]

[New Speaker – Jack McHale]: Okay thank you, I'll take a crack at that. For the pressure retaining components in nuclear application is the American Society of Mechanical Engineer's ASME code and there is a Section 11 which is for nuclear in-service inspections,

so that kind governs the majority of it, again there's construction codes under ASME as well and then there are some reliance on certain ASTM standards as well for certain things. One thing that is interesting again with this bolting issue, and obviously there is bolting that's in pressure systems, so there, that's kind of handled separately. These internal components because they are not pressure-bound really, with the outside. Again, a lot of that is covered by industry standards. Actually the aging management program that I mentioned came out of the Electric Power Research Institute (EPRI) was the sponsor. There was a materials reliability program, the MRP, that the nuclear utilities all participate in, so this MRP organization actually developed the aging management inspection regime that covers bolts and a lot of other materials that are not necessarily pressure bound, where that would come under ASME. The NRC endorses those MRP, the industry-type standards, usually through a safety evaluation type of thing. And then the ASME code, which again governs the in-service inspection and construction. Those are actually incorporated by reference in our regulations. So it kind of works a little differently depending on which component and application that you are looking at. So hopefully that answers the question.

[01:21:02]

[Moderator Allyson]: Surely there are other questions - in the back. It would be helpful if you would just say your name and your affiliation.

[01:21:14]

[New Speaker: Ryan Ono (Audience Member)]: Thank you so much for everyone speaking. My name is Ryan Ono with Ocean Conservancy. I have two questions that are a little more scientific in nature, maybe for the two scientists who presented more scientific focused presentation. The first one is: Do any of you know if these bolts or fittings have been tested at a range of pH values or salinities? The reason that I ask is that chemists, such as Dr. Frank Moyer have proposed that ocean acidification could affect the speciation of metal ions in water and that would have biological consequences, but we wonder whether progressively decreasing ocean pH values could affect the structural integrity of the bolts and have just any sort of impact and have some impact on the failure rates of any metal alloys in these underwater structures?

[01:22:31]

[Moderator Allyson]: If anybody from the panel and or Candi wants to jump in and answer that. It is a very good question.

[01:22:43]

[Haimei Zheng]: Yes, this is a very good question. There are some studies, just very brief, some studies pH value indeed impacts the materials properties, but currently there is no conclusion on that. Certainly there are a lot of needs to study, for consistent study, systematic study on this.

[01:23:12]

[Dr. Candi Hudson]: Excellent response Haimei, just to elaborate on what I mentioned earlier, that something that should be explored and possibly future research. JIP, the impact on water salinity with regards to the corrosion degradation rate, the cathartic protection and the material properties. So that is something to explore. I think I may or may not know where you are going. Are you implying microbial induced corrosion, mick, in regards to bio law?

[01:23:44]

[Ryan Ono (Audience Member, who posed initial question) *voice is low, hard to hear*]: No, not necessarily,

[01:23:53]

[Candi]: Ok, well mick is more like a sulfate-reducing type bacteria and they love iron, so, in this instance it may or may not impact. But that is one definitely for further study. At this point, and as Haimei has mentioned there's a little gap in the area, well not little, but it's one for further study.

[01:24:13]

[Moderator Allyson]: Ok, other questions, from anybody? So timid. See I know that normally we get together with a group of, oh excellent, normally we get together with a group of people and everybody talks, so this is very, very different. Go ahead Trent.

[01:24:32]

[New Speaker: Trent]: So we briefly, can I ask a question, I guess would be the first. You said to think about questions, so you know, you mentioned IBAT today. Is anybody from the US Navy involved with that group? Because I mean, as we are sitting here talking today, nuclear although interesting and space although interesting, you know of all the government branches that I can think of right now anyway, the most similar would be the Navy, and I saw US Navy standards come up on one of those slides. And so, you know, have you guys contacted them, or had any conversations?

[01:25:07]

[Moderator Allyson]: Yes, so the group right now, there was an initial invite, and we had an initial call, and Brian was actually going to talk about this a little bit more when he closes, so I won't steal all of his thunder. But to answer your question, we did have someone respond from the Navy and we had numerous others. Now what we're going to be doing right now is going to be firming up that more definitive list going forward, so yes, the bolt action team. So yeah, they actually were part of the mix of invitees. (Trent responded "good.")

[01:25:38]

There is a call over there on the side, or call, hand.

[01:25:45]

[New Speaker: Jenny Mandel, reporter with Energy Wire]: Jenny Mandal, reporter with *Energy Wire. A*re there any indications, either from formal data collection or informal data collection at this point, that this problem is occurring in other countries, off shore drilling industry?

[01:26:01]

[Moderator Allyson]: I don't know if anyone else wants to take that, Candi do you want to take that?

[01:26:06]

[Candi]: We've received some data collection, or data info sharing through IRF, the International Regulators Forum, through ANP and Brazil, so there's still information on-going, and yes we are reaching out.

[01:26:25]

[New Speaker: Jenny Mandal, reporter with energy wire]: Was it yes, we're reaching out, or yes there are indication that (voice is mumbled)

Candi: I'm sorry there's other what?

Jenny Mandal: I said, yes we're reaching out? or Yes there are indications that this is a more widespread problem?

Candi: It's a more widespread problem and we're interested in gathering information and reaching out and so on.

Troy: So Brazil, I know our regional director contacted some of the other countries, and told them about that incident that happened with the connector failure, and like I said in the slide, we had close to 11,000 of those fasteners were recalled by the manufacturer. It did, you know we only had 25 rigs affected in the Gulf of Mexico but there was much larger number of rigs affected worldwide. Brazil did respond back in one of the emails that Lars Herbst, which is our regional director, and they responded back that their largest operator, Petrobras, had reported 56 rigs in that incident were effected by that bolt recall.

[01:27:50]

[Moderator Allyson]: That's in large part a big reason why we tackle this issue, thinking about the scope. The international nature of how rigs and mobile vessels come in and out of US waters does make this something- a bigger concern, so just because we would address it here doesn't mean that rig or some other vessel could go to another country, some part might be replaced using some other kind of bolting and then come back. So that is a

concern, in terms of the international piece. And that's a big part of why we started to talk about it, and as Brian Salerno, who is the chairman of the International Regulators Forum, he has brought it up in some of the meetings and discussions with the rest of the partners in that organization. Ah, any more questions? Question in the back.

[01:28:40]

[Question from the Audience - Lem Hunter]: Hi, Lem Hunter with Vibrant Corporation. Dr. McNutt talked about the safety profile in aviation, which is the industry that I am from. We manage that in two different ways, one or all the types of standards we are talking about here for production of new components and making sure that the initial quality is right. But aviation also has a tremendous amount of on-going periodic inspection. I'm a little bit new to the undersea side of it. What are the current on-going inspection requirements or activities with these bolted assemblies?

Moderator Allyson: Trent, do you want to tackle that?

[01:29:20]

[Trent]: So, it varies. One thing that is worth mentioning, Doug introduced us into subsea Blowout Preventers - they are routinely brought up to the surface for maintenance activities, so there is opportunity to inspect them at that time. So, there are varying inspection methods that different companies utilize, during those periodic maintenance activities when the BOP is on deck. There's a wide variety of inspection methods that are utilized, probably can't get into each one of them specifically. It's a fairly long technical discussion, but the rig contractors do have a preventative maintenance system that inspects the bolts.

[01:30:10]

[Moderator Allyson]: And from BSEE's side, Troy, do you want to comment on our requirement in terms of the BOP testing offshore. I'm putting you on the spot.

Troy: Well, I'm not sure what the process is with the industry, but I know that every five years they're required to inspect that BOP stack. And actually tear it down. I thought that most of that bolts and fasteners and everything were just replaced at that time, yeah, that's what I thought, once they unbolted it a new fastener was put in place but I'm speaking out of turn here. That's what I thought happened, but I'd rather industry answer that question, but I believe that is exactly what happens, those fasteners are replaced about every five years.

[Moderator Allyson]: And we certainly have any number of industry people in the audience if anybody does want to chime in, although that's being brave. Other questions?

[01:31:04]

[New Speaker from the Audience: Pete Bennett, Pacific Drilling]: The five year rule, we will

inspect, but we don't necessarily replace all the bolts. Many are replaced. But the requirement is to inspect them. Sorry, I'm Pete Bennett with Pacific Drilling. Also one point that I would like to mention: I think the, when we refer to the bolt failure and the number affected vessels, it's maybe been misunderstood, perhaps taken a little out of context, this was because of the lack of traceability on the bolts. It wasn't all failures; it was simply that there was inadequate records on the heat treatment that the bolts had gone through with the coating.

[01:31:44]

[Moderator Allyson]: And that's a really good point, I'm sorry, the light is like right where your face is. So on traceability, okay, so that's something that has come up in a lot of various discussions, and I'm interested, that is one of the questions that I actually had, so thanks for taking that up for me. I wanted to pose that to a couple of people on the panel. I wanted to talk to first Jack, when you're looking in terms of your bolts that are being used in the baffles, what is the traceability that you guys have employed with the nuclear industry?

[01:32:16]

[New Speaker - Jack McHale]: Okay, well, I guess in general, this would be a, the nuclear industry uses the safety related label for they call them basic components. Basically it's something that make sure that the reactor maintains the pressure boundary, make sure it can be shut down in accident conditions and keep it cool, you know. So these baffle bolts, and other internals in a reactor would be subject to basically regulatory-mandated quality assurance programs. There would be a pretty rigorous QA program with it that the manufacturers would use, there would be certified material test reports and traceability of materials through the manufacturing process. Also, the NRC has a vendor inspection program that will actually go out on a periodic basis to various manufacturers and vendors. And also in the case of these bolts, when they are being installed at each facility, at each nuclear facility has an inspection oversight, that are actually resident inspectors at the plants and they're backed up by a regional office. So when an activity, such as this bolt replacement comes up, it's a little off normal, the region would inspect the activity, which would include an audit of the paperwork trail to trace the bolts and a verification that the installation was being done appropriate and accordance with the procedures and everything. They also utilize experts from the regional headquarters office to back them up if there is something different. So there is a fairly rigorous process and again I think that it starts with traceability of the material from the source before it ever gets installed in a plant.

[01:34:17]

[Moderator Allyson]: Great, now Trent, would you like to speak maybe a little bit about what you guys have discussed in your committee? I think that's an issue that has come up.

[01:34:24]

[Trent]: Yeah, I mean, I think the short answer to that is in API 20, there's three service

levels that are identified, BSL level 1, 2 and 3, 3 being the most rigorous. For BSL Level 3 bolt, there's unique traceability to each bolt. And so, you know historically, the standards have varied. We talked a lot about a lot of the past standards. Historically, there were some standards that allowed batch-type traceability, so you'd understand the material properties for a batch of bolts. Maybe not traceability to each single bolt. Going forward, in our proposal, we have BSL level 3 is the recommendation for critical bolts, and so we would have that individual bolt traceability. It would cover the same sorts of material from the mill through the manufacturing process. All of the key variables would be traceable and trackable.

[01:35:26]

[Moderator Allyson]: Okay, that's great. Another question from the audience? Another question from the panel?

<Panel speaker> Yeah, just for Mr. Lancaster. I'm curious, when you move forward with your potential pending program, is that done through a formal announcement? If there is volunteers or public meetings, how is that announced?

[01:35:50]

[New Speaker - Mr. Lancaster]: Well, once it's approved, we'll make an announcement, the sponsor will make an announcement, and then the information-gathering process for putting together the committee is kind of a, it's a process that we don't go from A to Z, we kind of go in a network and so we'll actually look to organizations, we'll of course to the boards and the academy members, the sponsors, for potential members. And we will have expert areas that we're trying to fill for that committee based on that task, and so that's what we will be looking for is people to fill those expert fields.

[01:36:38]

[Moderator Allyson]: Other questions? So, keeping an eye on time, we are doing pretty well. So I have a couple of things that I thought I would put out for food for thought here. You know as I'm hearing the NRC example and I'm thinking about how you have a bolt there that's very fit for purpose, and they've really looked at all of the different worst case scenarios parameters for how that would operate in a baffle. Okay, so I feel like every part of a nuclear facility is pretty critical because these are very very, if not over engineered systems, because the, while most of the events are low probability they're extraordinarily high consequence activities, as you can see from the example of Fukushima, when one does fail. So now, when you take a look at where we're, what we are looking at, whereas here the NRC has under 50. How many facilities in the US? <There are about 100 operating powerplants. Okay, wow I was way off, okay so about 100. So compare that anyone in the audience know right now how many facilities that we have in the outer continental shelf of the U.S.? Anybody? I'll give you a prize. So we have upwards of 3,000. Alright, so discrete differences of kinds of pieces of infrastructure offshore and on the OCS. So, and those come in and out of waters that count as change, so when you think about that, every one of those is sort of unique like a fingerprint or a snowflake to some regard. There are some

standardizations, but as they come in and out and people move different parts, some of them are older and some of them are younger, we don't have the tighter, sort of maybe quality assurance or control over the broader offshore facility and all of the components. Some of our, the component ratio is very very high. Now when you look at something like a blowout preventer, you'll have a few different kinds of blowout preventers, a few different kinds of connection devises, etc. So now we're narrowing it down, okay, but we still have several different kinds of venders that we are talking about. Now, how many different kinds of venders do you have with the NRC that people can get your bolts from, for instance. <Well actually this is a real short list because then again, if we are speaking just about this baffle bolt> Sure or you can speak more generally how the NRC works. <Okay we'll do the bolts first because that's kind of simple. First off, there are two main types of reactors in the US for power generation. There's the pressurized water reactors, which you know, I talked about today. And there is also boiling water reactor, which is the general electric technology. They don't have these bolts at all, so that drops the number from 100 down to the 60's. Some of the, of the pressurized water, there are actually three manufacturers, Westinghouse, Combustion Engineering, and Babcock and Wilcocks, but now over time, there basically Westinghouse still has their technology and also they've covered the combustion plants, and then there's Areva which deals with the Babcocks and Wilcocks technology and they're also related to the French reactors. So really, you have a very short list of manufacturers, or venders, for this, you know, in the US. So taking the broader look of it, it's really General Electric and Westinghouse, Arriva for the most part is being the original equipment manufacturer reps, so it's a short list.

[01:40:32]

So that was my point, we also have this short list too. So even though we have this broad range of different facilities and different types, as you get into the critical safety components here, we have a pretty short list of actual OEMs that are supplying these. And so, when you keep that in mind you look in the example like the NRC had today, that Jack had, in that they have very tight quality assurance. If we have a small vender community that's working in this space as well, there shouldn't be any reason why we can't have a pretty tight handle on those as well.

So, one of my questions for Trent and Erik in particular is how do you feel that industry in uptake in the application of your standards that you've used and do you think people will readily adopt these? Because, keep in mind these are not mandatory at this point. These are industry standards and they are not in the Code of Federal Regulations.

[01:41:25]

[Trent]: I would say yes and I think when we talk about the population, we have to recognize the difference between production facilities and drilling operations. So you have 3000 production facilities and probably anywhere from 20 to 40 drilling rigs where you actually have a BOP involved. But the industry has taken a very proactive approach to this. We have involved not just API but the other trade associations are aware of it. We're spreading the word, and we appreciate the opportunity to engage with BSEE so that we

understand from you that these steps that we're taking are those types of steps that holistically should effectively address the issue. Now that we're moving down that road, we're going to start to have much more momentum behind the efforts to incorporate 20E and 20F and others because we want to make sure that that's understood as something that the regulator is accepting.

[01:42:30]

[Moderator Allyson] So, in general would you feel that as you've had your discussions within your committee Trent that people have been adhering to the existing standards?

[01:42:43]

[Trent]: Yeah and so, and Erik said it correctly, 20E is a spec, specification. There are API 20E spec bolts being manufactured and being installed in the BOPs operating in the Gulf of Mexico. So, that work has began and as Erik said, as we begin kind of moving down that path, we will be checking with BSEE regularly to update them as progress is made.

[01:43:15]

[Allyson]: Do down the road you know the question has been asked to us over time, in the last couple months about what the impact is. So, so, we've kind of heard from Troy and Candi and others about the global impact of the first bolt recall that had been done. Now, as you are talking about changing the specification, how do you guys propose that as a new specification is put out, that the industries go about replacing bolts?

Because Troy had a nice slide up there where he showed the impact to each one of the facilities and how long it takes. So what is the proposal from API?

[01:43:51]

[Erik]: So that's the process we are going right now and you've seen it through the conversation today where companies have taken proactive steps, original equipment manufacturers have taken steps to do recalls and we are working with the manufacturers, drilling contractors and the operators who were part of that discussion, who are now operationalizing the steps that we've put forward. So it's happening as part of the normal business that this industry does to enhance safety – identify the issue, review the data, identify the steps to take and start taking them. So implementation is occurring, it's going to continue to occur, and it's just through the industry networks that we have and through the conversations that the industry has with the regulator, communicating the significance of the issue.

[01:44:42]

[Allyson]: Do we have any follow up on this thread of discussion so far?
Okay, I have a couple more questions and then we'll close here. Thank you for that answer.

I wanted to shift over to, Haimei very quickly. Thank you for your presentation. I hadn't heard the results of any of that yet so that was pretty exciting for me. And it looks like you are doing really great work. So, I think I am not the only person in the room that wants to know how much longer is your study going to take and then what process, maybe this part's for Joe, what will happen after that research is conveyed back to BSEE? Is it go out for peer review or how is that going to be handled? So if you could just very quickly describe how close you guys are to finishing to the rest of the project?

[01:45:31]

[Haimei]: So this project started January. We'd be into the project for 9 months; it's in the middle of the project. Over another…, we have a total of 21 months, still in the middle of the project. For the procedures after have the report, we've been having the ongoing teleconference weekly, biweekly, have monthly reports going on with BSEE and after we have the report…would we have the review process? And then…

[01:46:22]

[Off camera – Joe Levine, BSEE]: Yeah, I believe the project is scheduled to be completed December 2017, so a year and five months from now. Allyson mentioned Peer Review; BSEE has a process for peer review of select research projects. We look at all the different research that we are currently doing and pick for - independent outside the agency - for peer review on select projects. Within Doug's shop we've only recently implemented this process and we have the first peer review underway, nearly completed. So I couldn't say whether we would peer review this LB&L or not. There is a significant difference. The peer review we currently have is our TAP projects, this is the LB&L is via the ANL DOE interagency agreement. But it's a good idea and we do have a process in place to peer review, yes.

[01:47:45]

[Allyson]: I am not sure everybody realizes that we do utilize peer review here at BSEE so it was a little bit of a shameless promotion there. Thank you

[01:47:50]

[Joe Levine]: It's a good program.

[01:47:54]

[Allyson]: So, so, couple more questions. Anybody else from the audience? There are some. Okay, so I will start with this gentleman and then we'll go back to Lisa in the back.

[01:48.09]

[Satya]: Hi I am Satya, I am with APS. My question is about the testing on the…from the discussion today, it is apparent that most of the failure mechanisms are hydrogen embrittlement-related. So is there any testing associated to understand those mechanisms

at your laboratories, Dr. Zheng?

[01:48:33]

[Haimei]: So, the hydrogen embrittlement that you have seen mostly from the industrial standard review, they are quite a few number of the reports. There is lot of studies on that. We found there are very limited studies on materials corrosion testing under the subsea environment. So we are focusing on corrosion study on those different parameters – pressure, high pressure, corrosive environment, chlorine, different ions, oxygen partial pressure and temperature…impact on the corrosion rates.

[01:49:17]

[Allyson]: So Lisa had a question in the back.

[01:49:22]

[Lisa Sally from API]: Good afternoon. I'm Lisa Sally from API and I actually have a comment and then a question. Just more of a comment and food for thought…just with the study and the research that won't be available until December 2017, if possible, would be helpful to see some of the interim analysis, if there was a willingness to share it in general for us. We'd like to talk about that. I also want to commend BSEE for the foresight to conduct that study and we look forward to engaging as that information is available and for the industry to review and for consideration in our future document. So that's my first comment. My question really centers around an attempt to distinguish between, I'm going to say, forensics and life study and understanding of bolts separately from the operating conditions and the environment of the subsea environment. And so I just generally want to ask the panel and for BSEE in particular, is there a body of work that's been done to understand if you will the forensics of bolts – when they fail? What contributes to that? And the variables associated with that. Has that body of work been isolated thus far?

[01:50:40]

[Allyson]: So I would direct that to either Joe or Doug if either one of you wants to tackle that because some work has been done.

[01:50:56]

[Joe Levine]: Yeah, that's a good question. I am no expert in this area but from what I've seen, we see the forensics on a case by case basis as a failure is reported to BSEE or to a company. They typically do an RCA at a lab, I am not going to name the labs, but there's several in Houston that can do this work. Actually industry, the operators may be privy to more forensic info cause I am not confident that BSEE has all the failure data. So, I don't think there's a body of evidence it's a case by case to my knowledge depending on the

failure. And while I have the mic, just so I can say this with the mic and this to Jack – you said there's like three bolting vendors for nuclear – right?

[01:52:01]

[Jack]: Well, I won't say that; three reactor vendors so they're going to get the bolts from…various sub suppliers, I don't know that number.

[01:52:21]

[Joe Levine]: What I've seen in the subsea BOP offshore oil and gas world, these connectors, it goes from one OEM, and Candi mentioned it in her talk, and then we see second and third and fourth tier OEM subcontracted out for all different aspects of the bolting manufacturing process. So, it's a hard nut to oversee. I wonder is the nuclear bolting manufacturing process set up that way or do you have one OEM that can do the whole thing from soup to nuts or do they have to go out to many other companies?

[01:52:54]

[Jack]: Actually you know, I am not that sure that I…not being close to that process, I don't have a…I don't want to take a guess at it. Again, I know the reactor vendors have their sub suppliers for different components but again how splintered it gets, especially in the bolting area, I really don't want to hazard a guess sorry.

[01:53:25]

[Joe Levine]: Thanks

[01:53:26]

[Moderator]: Certainly, a question we can pose to our interagency group too for more discussion. So as promised I said I wouldn't keep us till the last bit of time although I did see…I think there is one other, a couple of questions in the back. Can we in there for five more minutes? Two more questions and then we'll round up with Brian Salerno.

Yes go ahead.

[01:53:52]

[Tim Foecae from National Institute of Standards and Technology (NIST)]: There is a body of work on fastener quality generated in the late 80s and 90s and onward that was required by the National Fastener Quality Act which is something people should be looking into if they want some background on fastener work in the past.

[01:54:16]

[Unidentified Voice]: And I have to say as a mechanical PE we had to study that month after month after months in school, so yeah there's a lot of data out there on fasteners and what

not. A question on the quality of the fasteners you have had issues reported with. Are they all BSL3s or there's 2s in there as well?

[01:54:38]

[Trent]: So far most of those failures predated the use of bolts that were made to that spec. So I am not aware of any failures with an API 20 BSL level…actually of any three of the levels.

[01:54:52]

[Allyson]: Okay, any other questions? I should say thank you to the gentleman from NIST. NIST is actively a member of our interagency working group as well. Going forward we have invited them to participate so thanks for joining us.

[Inaudible background speaker]: Yeah sure, it's Troy?

[01:55:13]

[Troy Trosclair]: So one of our regs required for any well that is being drilled, we require a 3rd party to come in and say that the BOP stack is fit for purpose. Now, that's a lot on that 3rd party because its everything associated with that BOP stack which includes these fasteners. Now the only time we've looked at fasteners was that first event that happened in 2012 and we actually asked for certificates of compliance with that specification that was given on that particular fastener. And so before we would let that company go back to operation, we looked at those certificates of compliance. I am not saying that we do that right now, we just, we look at that overall BOP – its fit for purpose and we see that, we assume ABS and DMV, Subsea Solutions, whoever it is that 3rd party certification - we assume they've looked at all that specification stuff, its saying its fit for purpose.

It's probably a bad assumption on our part maybe but that's what we're looking at as far as, yeah, it's been certified by somebody and everything on that stack is fit for purpose.

[01:56:22]

[Allyson]: And certainly that'll be another place we'll be discussing going forward as we are working on this topic of bolts. So with that, we have one or two things left and we're going to turn it over to Bryan. If you haven't seen it already, we have bolts – there's debate, bolts or studs? You tell me but bolts over here on the table so you can take a look at that if you've never actually seen the scale that we are talking about. So please go and check those out at the end.

And then the other thing I want to say is that rarely does an event like this happen without a village of people who are very exceptional at their job. So I'd like to thank BSEE's Office of Public Affairs for hosting and putting this event on. When this came up, we identified a need and the team came and delivered a professional event, so thanks to them but first

thanks to our panelists.

Thank you panelists for coming.

{Claps}

And thanks to the Public Affairs Team as well.

Thank you.

And with that I am going to turn it over to Brian Salerno now to close.

[01:57:30]

[Brian Salerno]: Thanks Allyson.

Wow, this has been a phenomenal discussion, great presentations. I too want to add my thanks to all the panelists for really helping to frame the issues and help us map our way forward.

When we started this morning and we had the presentation by Dr. McNutt, she said a lot of really useful things but even just the title of her presentation "Failure Is Not An Option" is one that is particularly germane to this discussion. She made some analogies there that were quiet powerful. The O-ring analogy on the space shuttle Challenger. A simple component but that failure had a catastrophic consequence. Doesn't take much to see how we could face a similar thing if we don't tackle this problem.

Janice Schneider hit on something too that I think is worth calling out. When she was talking about the company CEO that mentioned that they had a number of BOP pulls to replace connectors, really kind of under scored the fact that this information has been…there's awareness at a company level but its been very compartmentalized and part of our challenge is to bring that information out into the open and share it so we have a fuller appreciation of "hey this really is something we have to tackle as an industry" which I think is the overarching theme of why this forum is here , of why we're engaging in this discussion going forward. Think our panels did a great job framing the discussion:

The first panel indicated a number of areas of concern – four in particular: design standard, manufacturing processes, QA/QC, operational procedures, and although many of our different speakers had different ways of framing it, lots of those themes were kind of consistent. Those are the kinds of things that we needed to focus on.

Of course, in our second panel we had a more in-depth discussion on critical knowledge gaps and what might look, what we might be looking towards, as a way forward.

Erik Milito, I think, did a great job just under scoring how…you know this isn't the first

discussion we've had. A lot of work has already been undertaken by the industry, good steps forward. We're really I think quiet pleased with that reaction and again he has a number of focus areas that they've identified such as standards, QA/QC, research which can resonate with some of our first panel discussions.

Jack McHale with the NRC talking about the types of connector issues and the baffles and the reactors, again different issues, I mean offshore we don't have to worry about irradiated systems too much. The QA part of it and how we assess risk I think is very relevant and so we look forward to continuing that discussion with Jack.

Jim Lancaster – we're definitely not done with you. We're really looking for a very robust involvement with the National Academy, with NAE in particular, as we go forward here.

And Dr. Haimei Zheng, the work that you are doing is of great interest to us. The affect of corrosion and your gap analysis, I think, are right in line with the kinds of questions we need to answer.

I think all this really boils down to the fact that we have general awareness that this is a really broad problem. It is very difficult right now to define the scope. I have had a few sidebar discussions about "what's the answer going to be?" and I don't think we know the answer. We can't quite jump to the answer until we fully define the problem, but I think one thing that we all share is that sense of urgency that we've got to get to the answer in fairly short order.

So where we go from here? The I-BAT, our team, we're looking to convene that group September, say second or third week of September; looking to setup maybe an in person group meeting where we can further explore some of the issues raised today and we'll keep the momentum going and we'll keep at it until we get some solutions.

So, with that, again I want to thank all of our panelists, our speakers, and I want to thank everybody from the audience who first of all came and stayed with this program and who asked some very probing and engaging questions. I think that was all very helpful and contributed to I think a very illuminating morning for us.

So with that thank you and look forward to seeing you again soon and please stay engaged on this.

{Claps}

[02:02:50]