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## Gas Fueled Machinery System

Q: I am one of them who is expecting that the gas fuel engine will become the solution for NOx and SOx for example emission control area. SOx is probably ok using natural gas but NOx has a big issue for the two-stroke engine so I have a question to Mr. Bryndum. Is there a possibility that the gas fuel engine can achieve NOx Tier III without the SCR or EGR or other equipment?

A: It's correct that making engine and 5 % pilot fuel then you will reduce NOx by 30 %. And we do not see the possibility to bring this further down. That is, shall we say, a sacrifice for the much higher fuel efficiency of the combustion. But running on natural gas and MGO as a pilot fuel, you'll have eliminated the SOx and we will be able to have the very simple EGR system ready at that time for the Tier III on the ME-GI engine. Today the EGR system for the heavy fuel burning engine is a little more complicated to the SOx emissions and exhaust gas. However, if you eliminate that, then we can easily fit EGR system after that, shall we say, together with the ME-GI.

Q: Thank you very much for your very informative presentations. As an engine manufacture and different gas engine concepts that are quite interesting in the presentation today, both MAN and Rolls Royce presented different gas engine concepts. One is high pressure gas injection dual fuel engine, and the other is low pressure pre-mixed spark ignition engine. Now I think there is one more gas engine concept. That is low pressure pre-mixed dual fuel engine. So I'd like to know why or how do you see the strong point of these gas engine concepts and I'd like to know also the weak point or some challenging target of your gas engine. Mr. Bryndum and Mr. Bjorkeli

A1: Maybe I can start little bit from what we see from the spark ignited engine. We see the benefit of that being this simplicity of having only one fuel and of course pay well to use the low pressure. Of course, on the negative side I will look through all the time on that was principle is the methane slip. But nobody extremely good time of engine we have managed to get the last 2g methane slip as well. So that is the negative side is methane slip. The positive side is the simplicity, low pressure and of course very low NOx emission. Was that ok?

A2: It's correct that you can also have the auto process dual fuel instead of spark ignited. For the two stroke engines we have full fuel flexibility. That means you can run with the same efficiency all three modes. This you can also do with the four-stroke dual fuel engine but again the other disadvantages of, shall we say, methane slip and lower efficiency. It's there and of course it could have taken into consideration and also this forum taken up as presentation in this forum. But I think that ship designers and ship operators they will have to decide whether they need dual fuel flexibility or not. In Northern part of Europe, we see the LNG supply net being build out rather than quickly, and therefore, shall we say the local traffic in that area could be on spark ignited one fuel design.

Q: My question is related to the previous question to Mr Bjorkeli. So personally I prefer the pure gas engine spark ignited rather than the dual fuel, because I think that dual fuel has some problems from the combustion point of view. But more people seem to prefer dual fuel from the fuel redundancy point of view at present. From this point, which application, which feed do you expect for the spark ignited in the marine application of course I mean tag boat or feed or something like that?

A: What we see here of course the primary target, we start with the ferries, which have very limited the area operated have a lot of protocol, going back to tug boats and ferries. Because of no limitation and to end very quickly to pick up load that's about the advantage. We also see in local traffic but also we have been together our friend at Oshima developed 100 max built carrier. Also we own the engine. If you have enough fuel capacity and endurance, I will see any limitation today or using that was designed for endurance of 17000 nautical miles if I don't remember it wrong. But ferry, tug boats and official supply vessels like primary target source, also a little bit related to engine size of what we are producing today.

Q: I'd like to ask Rolls Royce, I want to know two items. What methane number can your engine use? And the next question is if different kind of methane mixed, is it possible to burn your engine?

A: Our engine can take as today methane number goes to 17. That means that we can meet the most of the all over the places, if you have meet gas quality or gas from different sources. We have experienced once on the ferries you saw the picture there, did we gas supplier have to stop his liquefaction plant and he took it cargo from Spain with

gas to Africa. Then of all, different methane number, then we need to adjust a little bit timing, this almost like you filing different octane number of your car, so that was a little bit adjusting, that is very simple just to adjust the timing little bit because the methane number was different. But don't mind the number 17, we have no problem.

Q: In that connection, I have one question. In case of Ocean going worldwide when bunkering the seventeen methane number, and somewhere it bunkers one hundred methane numbers, and you said you had no problem, you can control your engine, but how this engage is necessary to have some kind of fuel standard for LNG.

A: Yes, that has been discussed, I think it's necessary to have some standards, but I'm not expert and I hope that we look like…. but of course you need to have some kind of standards on the way too much, because it's the methane that you like to pay for. I believe the guy who pays for it wants to know what kind of energy content they're paying for. So fuel standard is needed but I don't have the correct answer.

Q: Same as the question from Dr. Yasueda and Dr. Ito, the merit and demerit of the dual fuel and mono fuel four-stroke circle engines. The case of shortage of gas fuel, of course, dual fuel can switch to the diesel fuel, but it's not only that. For example, it's for a marine gas engine not on the ground. So the specialty of the marine use is the fluctuation of the load from the propeller side in the rough sea. In this case of the dual fuel, we can change to the diesel mode quickly. However, in the mono fuel case, you must avoid knocking. So how is your opinion in such a case? Mono fuel has absolutely no problem for such a rough sea or not?

A: We don't have any problem as I say one of the merits by the all engines. It starts you can pick up load very quickly, as quickly as diesel engine. So there's no difference today that we run the engine on the load relation as traditional engine running on diesel. We have seen from zero to 200 % in 20 seconds. So the vessel so far in operation we have not experienced any problem to pick up the load relation.

Q: The reason why I have asked you is that I saw the platform supply vessel in Norway that has DF engine. Then, the area for the vessel was very rough. So such a case if the censor catches the small knocking, then automatically the engine changes to the diesel mode. This is impossible for the case of the mono fuel, I think.

A: I don't want to comment too much of this, previously because our competitor from Wartsilla is not here. However, I think that the only reason for dual fuel on those applications was that stop oil and give too short charter for the owner to go and to build a pure gas engine. Otherwise, this lesson should be pure gas. Because as you agree that if you have any fluctuation or any knocking, you will have to run on back to diesel immediately. But for two, what I showed is running DPD mode pure gas. Because of the no knocking problem on the spark ignite engine that we expect, so it can control the amount of gas and with the variable turbo charger. We see that is one of the big advantages. There is no need and no problem for variable load.

Q: Today your presentation is concerning the two-cycle gas fuel engine. You selected 300 bar injection of gas. But 300 bar is really high pressure. You presented and explained lower output. You reduce the injection pressure down to about 150 bar. The combination of 300 bar and 150 bar is today's your piece of your presentation. But I think if you reduce this 300 bar down to 200 bar or 100 bar, it's very simple for application of gas processing side. In this sense, could you reduce this 300 bar? If I change my question, why did you select 300 bar for your application? This is maybe some principle in diesel cylindrical, up and down, the inside pressure or strange cylindrical and so on. Your low pressure design is 500 bar or 600 bar. But why did you select 300 bar suddenly? Could you explain about the background such case?

A: We are talking about diesel engine. That means you need to inject fuel at the higher pressure than you have in the cylinder when you have compressed there. Even when you have achieved maximum pressure in the cylinder, still you need to inject the fuel. That means you need higher pressure than inside the cylinder. The maximum pressure in our engine today is around 180 bar or 190 bar. That is a maximum. At that time, you need more pressure to inject. If you say 300 bar and then it's 320 bar more pressure you have to inject the gas into the cylinder. That is to shoot the gas enough long into the cylinder. To make a good flame, you need this overpressure of 120 bar. At lower load, you don't have so high maximum pressure. Then you can also reduce the injection pressure. Remember that fuel we inject with 800 bar and nobody is afraid of 800 bar liquid fuel. That is no problem. We do not see 300 bar as problem from technology or from safety.

Q: As you said pumping compress work for gas facing is the 5 % of the total power from the engine, but the case of the liquid, pumping is only less than 1 %, I think. I'd like to ask you that FGSS (fuel gas supply system) would be very expensive. I'd like to just ask

you the lifetime of the FGSS system, how do you suppose the dock to the dock is possible or not?

A: As I said our target is to have lifetime good enough for dock to dock 2.5 years to 22.5 years. It's about the 16000 hours, that's the target standards. Now we are developing a system conceivable in the FGSS. It should be… should have lifetime more than 16000 hours. So now we are in the middle, that's about 8000 been achievable in our system. The present system can achieve that, so in the near future the 16000 hours or more would be achievable. That's what we are doing in the test site. We'd like to contribute to have such aspect to have leniently pumping system because other ship is on in the ocean without help from the shore, so the ship stock on the ocean by having long lifetime is possible.

Q: My concern about the ME-GI engine, first one is about the maintenance. I suppose that the maintenance cost will increase in certain level compared to diesel engine because there are several sensitive components like a gas injector. The gas injector has the dry contact on the seat without oil fuel compared with diesel engine and also other additional sensitive components. How long do you expect the maintenance cost is very roughly compared to diesel engine? Second question is about the lowest operating engine load for the gas mode. Last one is lube oil. I supposed that we need two kinds of lube oil for the gas and diesel mode. Do you expect that we can use the only one kind of lube oil for ME-GI engine of course in the future?

A: Yes, regarding maintenance cost and time between overall, our target is of course to have the same time between overall as for the heavy fuel burning engine. In such a case, if we see today the lowest overall time is for the fuel which is around 16000 hours for heavy fuel burning engines, we also want that for the gas injection bulbs. But of course you'll have the double number of fuel bulbs now. So for that part of cost it will be double. Then we have the components in the gas control block. There, we do not see that there are some major elements for short overall. There would be the electronic bulbs and developed seat in the window valve, but I would expect overall time and 3 reconditioning times up to 13000 hours. There are more components that will also be electronic controllers, so the maintenance cost will increase. Then we should add that today on the two-stroke engine there is very attractive load. From that point of view, we do not see any optional for ME-GI. Regarding load we have demonstrated now several time on our research engine and also on the engine running it now. We have to set this

at 15 % load. I know some ships today. They operated continue below 15 % to 10 % load due to the market situation over capacity. Many vessels go slow steaming down to 10 %. If slow steaming and lower power diesel is the future, and then of course the MGI of the vessel will be specified. The MGI will be low for the certain type of the vessel and then again the percentage of its points will move up for those vessels, so they will not overrate 10 % or 15 %. It should be noticed that when you go below 15 % load, then the engine automatically go and gas stop. That means the gas still ready to be injected as soon as you go above 15 % load again. You could imagine the situation when you have to pick up the pilot, and then you have to go to get slow while he enters and then immediately after you want to increase above 15 % load. That is no problem. You can continue on gas. But the 15 % load I think that the figure we keep will be quite steady long time in the future. Regarding cylinder lube oil, we are sure you need two types of cylinder lube oil if the alternative is heavy fuel burning and gas burning. Then for the heavy fuel with the sulfur, you need the usual TBN 17. And for the gas, we will recommend to all specified a TBN 20. It is maybe not fully developed in the market, but it will come enough supply as fuel lube oil today.

Q: What happened to the gas if ME-GI engine has to shift over from LNG to heavy fuel oil? What happened to the gas that is already pressurized? That's the test be released from the full lines and this was done manually or automatically?

A: That is why we have the two non-gas burning modes. One is gas stop, they had the gas stays in the system ready to resume the gas injection. The other mode is gas shut down. This is what you get if you have the severe failure in the gas system. The gas shut down means that the system is purged and filled with nitrogen. Of course when you approach harbor, you always make gas shut down and empty to the system and entering the harbor on the gas oil or diesel oil.

Q : But if you just switch over from LNG to heavy fuel oil, already pressurized gas can remain in the accumulator.

A: But if you shift from gas to heavy fuel, then the gas is in the system and it starts to be consumed and the gas system continues to work.

Q: Regarding the Bergen Rolls Royce medium speed gas engine, your engine has the good performance for the load fluctuation and gas property. You know that keep such

good performance, what's the mean effect the pressure of your engine.

A: I don't have the data with me. Sorry.

## LNG Fueled Ship Design

Q: As for LNG fuelled container ship, how much does it cost compared with general container ship using heavy fuel oil?

A: Sorry but it's our confidential. The pay period for marine gas oil is 6 years and for heavy fuel oil and scrubber is about 3.5 years.

Q: 1. About IHI-SPB tank, it has been approved by ABS, ClassNK, and Germanischer Lloyd you said. And you said type B LNG tank is required 3D fine mesh FEM analysis, fatigue analysis, crack propagation analysis and so on. So I want to know that the method to get AIP from different class is same or not by the difference of classification.
2. IHI-SEB tank needs safe supporting system, for example, bearing seat, anti-pitching and rolling anchor and so on. I'd like to know if IHI-SPB tank can fit to hull form including these self-supporting systems.

A: 1. At first, about difference between class, there is almost no difference.
2. Support fits to high form, but according to high form, supporting system will change for efficiency.

Q: You mentioned something about the economic analysis on the future fuel bunkering and pay back changing to gas fuel. As I said in my presentation, a carbon factor of natural gas was methane would be 2.75. This is based on the fuel ton or mass, and then the other information I'd like to confirm is that specific consumption of the methane or natural gas would be 130 g/kWh or less, I think. Usually, the heavy fuel diesel engine is about 160 g/kWh. That means by carbon factor the EDI reduction would be about 10 %, and also the gas takes about 20 % because of this high fuel efficiency. if you change to heavy fuel to natural gas fuel. That's automatically nearly 30 % and EDI reduction that we pass in the future and EDI reduction in 2025, that's why in the calculation. Secondly, fuel price that is year 2020. As I said, it's a carbon contents should be less than 0.5 %. All the fuel have to be de-sulfured or we should use distilled fuel like diesel oil. Then other estimation by the economical side about the bunker price at 2020 would be higher

jump up. Not in a gradually increasing of the price but the estimation would be more than 1000 dollars per tons of fuel. In that case, that is a second incentive to change fuel to gas I think. I'd like to have your comment on that point.

A: Regarding CAPEX and OPEX analysis, there are some debates in the market how to make comparison. Why we are applied the LNG fuel ship; the first one is that most all of the people say LNG price is lower than HFO (heavy fuel oil). That's right. Some Japan cases are unique and different case, but the most other area, LNG price is lower than HFO price. In case of ECA, the lots of pure fuel must be used instead of HFO and its price is higher than HFO. I remember about 1000 per ton compared to HFO is 700 per ton. So if you operate vessel in the ECA, payback period is shorter and shorter. Just think about the ECA, for instance, North Sea, we just pass through the North Sea one or two days. When I approached the port, even though you have the LNG fuel ship, you had to change to the fuel oil but not the LNG because the port administration recommended changing the fuel oil not use the LNG for the safety aspect. That's why in general operation ships I don't think many times to visit ECA and very long days operate vessel in the ECA. Very small portion of the voyage, the rules of fuel oil can be applied, and it doesn't make much effect to this CAPEX and OPEX calculation, but we don't know exactly how the tendency changes to fuel oil market. After 5 years, HFO will suddenly change and dramatically increase, then all the constants will be changed. Therefore, this CAPEX and OPEX must be reanalyzed.

Q: From 1st January 2022, the sulfur content of the fuel should be 0.5 % or less globally, not only in the ECA. In ECA case, its reduction is 0.1 %. But you recommend from the oil refinery or oil major that the price of the sulfur content 0.1 % or 0.5 % is not so different because we need desulfurization or distillation anyway.

A: Regarding sulfur contents, nowadays, from 4.5 % down to 3.5 %. I heard it's very difficult for refinery plants to change their process to remove sulfur contents so you need a huge amount of the extra to change their production system. In other case, if the market matches demands, the refinery operator will change their production system. We drilled well in the subsea or other area and produced crude oil. This crude oil must be in the refinery process, and finally HFO remains. HFO is the only one area target. That is the shipping transportation. This HFO cannot be used in the land, in truck, in car, in factory or in your neighbor side. Nobody wants this kind of bad oil in your around. So remaining HFO must be used in the shipping transportation. I think HFO price will

not dramatically increase because there's no chance to find the consumer except shipping and transportation. This is the one of the view point.

Q: But as I said it's already decided that sulfur contents the year after 2020 shall be less than 0.5 % is global. Even the high heavy fuel consumption or market is not about the finding in the ship but SED already decided.

A: Yes, it's already decided 0.5 %. The refinery plants try to find final consumer for their heavy fuel oil, but the shipping company is looking for the 0.5 % heavy fuel oil but not 1 % or 2 %. They have to have the kind of plant to produce 0.5 % sulfur heavy fuel oil. There are the two ways viewpoints; one is that the 0.5 % is very severe conditions so the price goes up to make this kind of oil. The other is that there's no way to sell the remaining heavy fuel oil without considering the shipping transportation consumer in the shipping company, so they have to make a 0.5 % heavy fuel oil with some profit price.

Comments: May I comment for the discussion between you? It's true that from 2020 maybe 2025 but surely the sulfur global change will be duty. Of course you are true also that shipmaster has the holy duty to ban the high sulfur heavy fuel. Then one way is to use the scrubber, exhaust the scrubber. In next session, K-LINE presenter will show you the case of pay back a year, payback time as a function of the price between the heavy fueled oil and natural gas in details, so please expect that he will show you such a comparison.

Q: The trial to ship-to-ship in Hokkaido has been carried out but still it took about 14 hours from large ship to small ship. So how can we make time shorter, quicker and how is the most important point to make it more quickly?

A: In Hokkaido Tomakomai we carried out ship-to-ship. About the loading rate, at first our crew experienced slower loading rate. But from time to time, the, so called before loading and after loading operational time became shorter. Basically the transfer rate was about 1000 m3/hour for one line. In that case, it's only one line but our designer's ship used to maybe two lines, so it is 2000m3/hour. Our calculation for bunkering time is usually 3 hours for 6000 m3 tank. In addition, preparation time before and after loading operation is about 1 hour each, so I think the total is 5 hours.

Q: So 5 hours during the container loading barge can charge the natural gas all.

A: Yes.

Q: About your provision system concept. In other presentation, all both main engine and auxiliaries are DFO gas engines. But in your concept, it seems to me that you keep diesel engine as a generator. Are there any special reasons to keep diesel engine?

A: Of course, we think gas or dual fuel diesel generator can be used. But this concept is simply for our small scale LNG carriers, so this cost is very low, and that generator is only fuel but instead of change to gas engine or dual fuel diesel generator in use.

Q: So the reason is just a cost?

A: Yes.

Q: I'm interested in DSME LNG fuel VLCC and LNG fuel container ship of IHI. Then I'd like to ask you the following questions. First question is how many LNG fuel tank and VLCC and container ship. Can you keep the collision distance with by five from outer shell easily? I think this rule is very severe for general merchant ship if there are two tanks on the ship especially. Second question is how to determine the capacity of the boiler.

A1: At first, number of tanks. In SPB tank, one tank is one tank but divided into two tanks by centerline bulkhead. Capacity of dual-fuel boiler is decided by natural boiled gas consumptions.

A2: In case of number of tanks, it depends on the cruising range. For example, the Suezmax case recently we calculated considering 16000 nautical mile, we decide the tank capacity 4200 m3. Considering this capacity we decide the number of the tank, but at least 2. More than 2.
Moderator: Regarding a minimum distance of tank from ship's hull, discussion is ongoing and at IM and BLG and we have to wait for the finalization.

Q: About a bunkering ship, you said you apply type C tank, and also said equipment for

tank pressure adjustment like gas combustion unit any fractions. You may have in the accordance with their requirements of the LNG fuel ship. But I think a bunkering ship should be prepared for any cases. That should be type A or B with the fractions or gas combustion. Do you have any study about that to select the type C as your bunkering ship compared to other type of the container system.

A: We are sorry but carried out study to another tank type only tank type C for bunkering ship. But huge vessel for LNG fuel ship, I will study tank type A or B will start from now.

Q: Do you think type C will be the best solution at moment? Or you can find better in type A or B?

A: Tank type C is the best solution for a small ship but special equipment reduced the capacity. For large ship almost all equipment is additionally used for liquefaction plants, and the gas combustion unit is bigger and so on.

Q: I'd like to ask LNG bunkering ship of Kawasaki Heavy Industries. I'd like to know how to transfer the system. In this, your presentation is only for the owner's specification, but I'd like to know your idea for the pressure or some transfer pump, so please explain this matter. And then I'd like to…very difficult to the conclusion, but I'd like to know the percentage of the ship cost compared to the traditional your LNG carrier about this matter?

A: One question is how to transfer. Transfer is normally same as LNG ship by a normal pump not using a pressurized one. It is used for LNG pump and divided two tanks to LNG supply base. Next question is cost. Cost is very difficult for this ship. We don't carry out explanation for ship. I'm sorry.

Q: About bunkering ship, regarding your selection of main engine to be the dual-fuel engine, so wondering what operation or module you intend to run that vessel, and what's the reason for selecting dual-fuel engine on such a vessel? Why you have selected DF main engine? I generally asked about why selecting a diesel generator for the main engine. What's the reason for selecting dual fuel engine?

A: Main engine dual-fuel diesel electric is a very famous type of vessel for this size, but

gas engine in usual. This is an elder ship, it is important for a redundancy we think, but we selected dual-fuel engine and shaft generator for an emergency case. So we selected DF engine.

Comments

1) As we discussed about the standardization of the connection of the gas fuel from bunkering point to ship. In future if gas fuel ships increase, we need the same system such a connection available at every port in the world. That's just information we will start that work.
2) Maybe if Japan decides to apply the ECA, this design should be changed from DF engine to gas mono fuel engine probably.

## LNG Fuel Supply

Q: Just as an additional comment to Mr. Ikeda's presentation regarding the extra crew. As of today we had an experience in Norway where there was no need for any extra crew. It was just a kind of extra training for the engineers which so far the owner and Rolls Royce together are taking care of by themselves. So like the ferry you saw is still operating with 5 or 6 crews in total. We also see that although having no fuel treatment system and very little maintenance on those ships, they're managing quite well.

A: Thank you for your comment. I hope so, but as you know we have the LNG fleet. The gas handling team in our crew organization is required for such LNG fleet. On the other hand, for a non-gas carrier ship, we don't have such a special team. I understand any requirements would be under discussion of IGF, but as a ship operator, maybe we should have some extra crew as a gas handling team for this kind of LNG fuel ship at this moment.

Q: As I agree, it is uncertain, but I personally believe that we can manage without it, so there will be some cost to save there also for K-LINE side.

A: No Asian can do.

Q: You here on page 15 indicated the payback period corresponding to the bunker price. I'm a little bit puzzled that in case of difference of the price, difference minus 60 dollars/mt. In this case, LNG fuel is a little bit higher than the conventional heavy fuel,

right?

A: I have to explain more details about this figure. As I explained, the market price of LNG in the case of North America, Europe and Japan, only Japan indicated liquefied natural gas price. As you pointed out the reason of minus figure, it's a comparison based on the metric ton. So there are different caloric values. So if we convert to mmbtu or something like that we can have a plus figure.

Q: Do you know if the United States is interested in exporting LNG as ship fuel in the future?

A: I don't know. I don't have a right answer. Perhaps the United States is interested in fuel supply.

Q: When we discussed such an expectation of the LNG fuel vessel to be deployed and then be separated. There are still many subjects to be resolved at this moment. We don't know when LNG fuel vessel will be the majority of the marine fuels. But at this moment, Mr. Blikom indicated the technology is already almost completed. There are still two items. One is the legislation problem; the other is availability of the LNG. From this point of view, one target for the legislation point of view and next key indication when such LNG fuel vessel will be spread. It's one IGF code when it will be completely established. Maybe Mr. Yoshida knows the situation well. At this moment, I'd like to ask Mr. Blikom, if you have any feeling when the port legislation in ECA area, especially European area will be completed. You have no practical information, but I'd like to know just your feeling.

A: It's really simple I think. It doesn't need to be finalized because most of these countries, they adopted a risk-based approach, so anything that's not covered by the rules or legislation directly can be treated with risk analysis. And that's exactly what all these ports will do for the LNG bunkering. When I set up something new, I set up the bunkering station or barge or whatever it may be. If they require risk analysis to be done, that risk analysis will include assets, quantified risks, consequences, mitigation measures, and recommendations to operational procedures. I think in terms of doing the operations as a ship owner or a supplier of fuels, everything is in place already.

There's no reason to use legislation as argument not to do it. When there will be at the final stand or an accepted way to do it, I think at the earliest 2015. But it doesn't really mean much in that area of the world.

Q: Just one more question. In case of the risk assessment, we applied some more than the typical vessels. But frequent use of the bunkering operation, we need to develop standardized procedures. As you mentioned, standard procedure is very difficult to cover all bunkering operations such as a big vessel, small vessel, everything. So from this point of view, we need some very common use standard, and the legislation maybe included such an area in the port of North Europe. So I'd like to know if risk assessment is a subject to the legislation in North Europe or not?

A: No, that's not directly covered in the legislation, I think. That would be convenient for the ship owners and the designers. And I think I the ISO standard in the draft format by the end of this year will serve that purpose very well, even it's not finalized, then at least that's an indication of the equipment in common should be.
Mr. Yoshida comment: I'll discuss a little bit on this issue about the fuel gas. And I've decided to first develop the fuel gas. IGF code is dealing with the ship side. There was discussion on IMO whatever the standard or legislation at the port, and then the conclusion was as I remember this quite depends on each country and nation which governs ports. So the safety at the port is not handled by IMO, but it is handled by each nation. The legislation of handling of the gas fuel is left to each nation. He said that we need the international standards, so I hope ISO may provide some basis of this, some guidance, or whatever. At least we need the very common mechanical connection methods or handling methods as a worldwide basis. That may help the shipping side and shipping industry. But your ship goes to Norway, comes to Japan or US whatever. Then we need one single adapter system to receive the natural gas fuel on board ship. Otherwise, you need to have a different mechanism when receiving like a different plug worldwide. This is a nightmare, I think. ISO may help us great but at least fundamentally safety issue at each port is left to the each nation. I hope Japan may establish such a thing in the future.

Q: As a naval architect I have a keen question about contents of IGF code. I know as a follower, DNV is a leader in the recent 10 years or more, establishing contents of guidelines and IGF code also. Today, I have a question to Mr. Blikom. I have a question about the location of fuel storage tank. Key issue. Very big issue. This is a nightmare.

The LNG fuel storage tank can be located just below the accommodation block or deck. I know in Norway, a very small ship is between 200m3 and 500m3 size engine fuel storage tank capacity. But today's discussion in your presentation, everybody is saying more than 5000m3 to 9000m3 applications for large VLCC or large size container ship. In this case, if some catastrophic explosion occurs under the accommodation block, all of the crew will die suddenly. Based on this analysis, yes it's ok. But, before taking this consideration, this analysis, we have to say something about how to arrange it a little safer from the point of view of arrangement naval architect. Not analysis, just point of view of making arrangement of some new ships for LNG fuel ships. Just below accommodation block is not suitable if you take more than 5000m3 or larger LNG fuel storage tank. So could you advise how to coordinate worldwide recommendation of this issue? As a leader, I expect DNV to have such information about how to establish some kind of sense of arrangement of fuel storage tank below the accommodation. Yes or no. But as a southern USCG, it's not decided yet. As you know case by case. If IGF code is established, everybody will follow this content of IGF, that's a little bit dangerous way of thinking. How can we stop this dangerous way of thinking for every country and every naval architect: people like me? Below accommodation block is ok even for large size fuel storage tank? About 10000m3 storage tank can be stored or located? How about this -- my comment.

A: Just first need to point out at the time that I'm not our foremost expert on the technical side of the rules and I'm also not our representative of the IGF committee. But I can tell you we're confident about the current status of the IGF code, so we're happy with the way it's dealt with now, and we do not have any problems with having fuel tank underneath the accommodation units. I also can say that we do not experience a lot of discussion on that topic in the IGF committee. They all seem to be very much in agreement is our understanding. But, there have been some other interest groups that have had questions about this. The way I interpret it is more that they haven't understood the logic behind it. They haven't seen the documentation, it hasn't been transparent enough. So we are now doing a job to do the risk analysis on a generic basis. So we demonstrate the risk level for the fuel tanks underneath the accommodation units versus other locations. I can tell you a few findings already from that. There's no difference to the consequence level whether the fuel tank is inside the accommodation unit, in front of it, behind it wherever. The scenarios that you are talking about are disastrous in any case. So what you do when you work with the risk level is not to work so much on the consequence side you can also work on the frequency side. A ruptured

LNG fuel tank is an unacceptable situation. So you work on the frequency, which is not going to happen. So the main thing is the distance from the side of the ship, the collision risk is the risk that has the highest probability of penetrating the LNG tank. So you have to minimize that risk. In my mind, it's also an extremely exaggerated scenario, because it's practically impossible to explode an LNG fuel tank. So the scenarios where you see a fuel tank blowing up the whole ship is extremely difficult to actually do. And in that respect it is not so different from other fuels. You can have diesel fuel gases that can also throw the accommodation units on short. We are now documenting all this I said in a quantified risk analysis and will be submitted to IMO. I do not think it would be available to the public but will be as a decision basis for the IGF committee.

Q: I can follow your explanation about the risk analysis or something. Just below the accommodation, in front of the accommodation, after the accommodation, that's some differences from my feeling, not analytical intelligent sense.

A: Perception of the risk is a big thing. We have seen so much about that in the US, and when we speak about ships with LNG in the US, that comes back. It's about 3 things LNG in general. It doesn't really matter where it is. If it's on a truck on the road, if it's in the port, near houses, people have the perception that it's more dangerous than anything else. There are two sides to it. Other substances, other fuels are also dangerous. We use them as fuels because they burn. That's the reason we can use this stuff. On the other hand, it's also good that people are a little bit afraid, because we are talking about gas. It requires different mitigation measure fuels. That we are aware of this and that we are having this discussion is very good because it leads us to making the right mitigation measures and operational procedures. But I can only reinforce that we are doing what we can from the DNV and the standardization point of view that we do this in a safe way, and also keep the door open for new developments and new solutions. I'm very happy about the way we have done that so far and we are confident that this is done in a safe manner.

Q: Natural gas price. Mr. Ikeda explained about the price background, and all other people had already explained natural gas price. But in case of LNG as fuel, for example, nearly half is gas, so liquefaction is needed, and other sources similarly some transportation is needed. Based on that, in case of Norway, the price of gas is 20 dollars. That is tremendously high if we compare with other figures as shown: 3 dollars, 9 dollars, 14 dollars. What about the gap between LNG price and LNG as fuel, if you have

some ideas, because for example small scale liquefaction plant costs a lot, and also transportation by bunkering ship. It costs a ship, so maybe such kind of additional cost will be needed. If you have any idea, please explain.

A1: I have an idea. We have done several studies on this where we have set up concepts for how to do the bunkering, different sizes of ships, and things like this. Once you have the volume at a decent level, then it should be around 3 to 4 dollars markup. So if you get the LNG into a big import terminal for 10 dollars, you can add 4 dollars for handling and small scale distribution before it's onboard on the ship. That's our estimates. The reason why it's 20 dollars in Norway today is that they are basically taking European pipeline gas and liquefying it in small scale plants. So that's gas that's already worth 10 to 12 dollars per MMBtu and then they liquefy it in a not very efficient process because of the small size. So they end up very high cost on the LNG. That's going to be solved, I think. When the volumes go up, they will stop doing small scale liquefaction and using import volumes.

A2: So I don't know the bunkering cost, but generally speaking, I can give you the idea for liquefaction cost and transportation cost from export countries to import countries. Liquefaction cost is around 3 to 4 dollars per MMBtu. Transportation cost from the export countries to import countries, it depends of course. In case of export from the United States, it will be around 3 dollars to Japan.

A3: From ship operator side, Mr. Yuasa's point is very right. We have to consider about the additional cost of liquefaction and transportation cost on a natural gas price. But in my presentation, I indicated we don't have any ideas for the LNG price will be established in a market or cost price. So if we have cost price, Mr. Yuasa said we have to think about the additional cost on the natural gas price. But if market price coming to the some area, we don't care about such extra cost. Anyway, we can say we need certain level of the price gap between LNG and HFO to materialize this ship.

Q: Mr. Mori puts only growth in LNG bunker market high, could you explain little bit more details?

A: Actually, the reason of high in red ink is because this conference is about LNG bunker fuel. Unfortunately, I don't have any concrete data with me today, but according to the researcher, the consumption will be 25 million tons in 2020. Which is equivalent

to around 10 % of total LNG market, and in higher case, it will be 55 million tons which is quite significant figure and give a big influence to LNG market.

Q: Is DNV working on a standard for ship-to-ship bunkering? And could such a standard be covered by ISO standard?

A: Yes, it's covered by ISO. This standard covers both bunkering from ship and trucks and from land.

Q: So this development is in progress ship-to-ship?

A: Ship-to-ship has already been done several times in Northern Europe and also in Japan. There are no really special considerations. The main thing there is to decide on what sort of bunkering equipment to use. It needs to be flexible, robust, and also cheap enough.