Deposition Testimony of:

Ruben Schulkes

Date: November 12, 2012

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Page 8:22 to 9:07

00008:22 Could you please state your full
23 name for the record?
24 A. Ruben, R-u-b-e-n, Manuel, second
25 name is Manuel, third name is Sylvester, fourth
00009:01 name is -- Christian name is Maria, and final --
02 surname is Schulkes, S-c-h-u-l-k-e-s.
03 Q. Thank you.
04 And what is your current work
05 address?
06 A. My work address is Research
07 Center of -- of Statoil in Porsgrunn, Norway.

Page 9:11 to 9:14

00009:11 Q. Can you -- would you mind -- could
12 you spell that out, please?
13 A. Research Center of Statoil in
14 Porsgrunn.

Page 9:18 to 9:24

00009:18 Q. Thank you.
19 And is Statoil your current
20 employer?
21 A. It is.
22 Q. And are you employed by anyone else
23 currently?
24 A. No, I'm not.

Page 11:16 to 12:02

00011:16 Q. So, Dr. Schulkes, what it means to
17 be a Rule 30(b)(6) representative is that you're
18 responsible for knowledge not only in your
19 personal capacity but also the knowledge of other
20 employees at Statoil who have personal knowledge
21 of the topics that we're going to discuss today.
22 Does that make sense?
23 A. Okay. That's understood.
24 Q. Okay. And you do understand that
25 you're also giving testimony in your personal
00012:01 capacity today as well, correct?
02 A. Yes.

Page 14:13 to 15:04

00014:13 Q. Okay. All right. If we could
14 please turn to Tab 1 in the binder. And that
15 should be marked as Exhibit 11000.
16 A. Yes, looking at it.
17 Q. I'm sorry, Dr. Schulkes.

Have you seen or reviewed a copy of this document before today?
A. Yes, I have.
Q. Okay. And you've been designated to testify as to all the topics in this notice?
A. Yes, I am.
Q. Okay.
A. I have been.
Q. And -- and have you read each of these topics in this notice of Statoil before today?
A. Yes.

Page 15:15 to 15:25

Q. Do you know how electronic and hard copy documents were collected in response to these three requests?
A. In all cases they were handled by our contact person in Houston Natalie Eades.
Q. I'm sorry, Dr. Schulkes. It -- it was coordinated by someone in Houston?
A. Yes, Natalie Eades.
Q. Oh, okay. And who is Natalie Eades?
A. She's a lawyer in our Houston office.

Page 16:08 to 16:18

Q. Okay. So how were -- how did she coordinate the electronic collection, if you know?
A. When we first received notes from the United States court of this case, we collected all our relevant e-mails in a team site. These e-mails were then collected by Natalie and made available to I assume it was the BP attorneys. And further requests we have received we've tried to answer or give documents as much as we --

Page 17:15 to 20:08

Q. So if I could just rephrase what I think I heard you say, Ms. Eades collect -- all -- different people from Statoil would have posted their electronic documents to a particular site, and then Ms. Eades went and retrieved those documents from that site; does that sound right?
A. Uh-huh, that -- that is correct.
Q. Okay. And -- and what about the -- the hard copy documents? Do you know how those were collected?
A. There were only very few hard copy

documents in the cases that were available or they were there, they were scanned and then delivered to -- sent via e-mail to Ms. -- Ms. Eades.

Q. Okay. So you -- you personally moved electronic -- your own electronic documents or documents that you received from other people to this on -- on-line repository for Ms. Eades to collect?

A. That's right.

Q. Okay. What about Dr. Selmer-Olsen? Did he do that as well?

A. No. Mr. Selmer-Olsen -- Selmer-Olsen, he's not a Statoil employee. He works at a different company, and he's not delivered any documents relating to this case.

Q. Okay. And how about Dr. Schuller?

A. Schuller has been a very central player here, and he has delivered all the e-mails which are related to this case to me, which I then have moved to this -- the team site.

Q. Okay. So he sent the electronic -- is it just e-mails or did he also send you electronic documents?

A. It was e-mails and -- and basically all -- all the files related to this -- this particular case.

Q. Okay. Now, if I understand correctly, he -- he was using two different e-mail addresses during the time period that we're going to be discussing today. Do you know if he sent you e-mails from both e-mail addresses?

A. I am not sure. It may be the case. But he -- he is -- in fact, Dr. Schuller is not a Statoil employee either. He's a consultant working for us. He works at the university and is a consultant at Statoil for one day a week.

And whenever I requested information on this -- on this topic, he tried to respond as quickly as possible. And given that he is four days a week not in our Statoil office, he may have sent us information from his university address.

Q. Why did you ask Dr. Schuller to assist with this project if he's not a Statoil employee?

A. Because Dr. Schuller is the guy who about ten years ago developed the choke model which was being used here, and he is very central in -- in relation to performing this type of calculation.

Q. And if I understand, you said he -- he performs consulting for Statoil?

A. That's right.

Q. And that's on a one-day-a-week

basis?
A. That's right.

Page 20:12 to 20:21

Do you know if Mr. Ramberg provided documents to Ms. Eades?
A. Mr. Ramberg was only involved in this case during the nondisclosure agreements -- or negotiations. So he -- he -- I don't think -- I'm not quite sure if he did supply Ms. Eades with documents. I think we had the documents we need. The only relevant document which Mr. Ramberg was engaged in was the nondisclosure agreement which we had with Lawrence Livermore.

Page 22:04 to 22:12

Q. Okay. What about -- I'm not sure if it's Dr. or Mr., it's Gyllensten, G-y-l-l-e-n-s-t-e-n?
A. Yes. Mr. -- if you pronounce it Norway, we would be saying "Yuel-en-sten." But he has done background calculations for us, and the results of these calculations are contained in the files which are supplied to Ms. Eades.

Page 23:20 to 23:25

Q. Okay. Dr. Schulkes, did anyone at the Lawrence Livermore lab, whether it was Mr. Miller or anybody else, advise you or anyone at Statoil to retain and not destroy any documents that you created in connection with your work?

Page 24:05 to 24:07

A. Yes. As far as I'm aware, this -- there was no request by Wayne Miller to -- for us to retain all the documents.

Page 24:09 to 24:16

Q. Do you know if anyone at Statoil -- in light of the fact that no one had asked you not to destroy documents and that you needed to retain them, do you know if anyone at Statoil did, in fact, destroy or delete any documents? And that would include e-mails.
A. I don't think any relevant e-mails were deleted. There was one instance which I

Page 25:09 to 27:25

00025:09 Q. Okay. And then -- so that would
10 mean, then, that Statoil has provided the parties
11 with all of the documents, all the unique
12 documents that were created by Statoil in its
13 work in connection with Lawrence Livermore?
14 A. That's -- that's my impression, yes.
15 Q. Okay. Dr. Schulkes, can you
16 describe what you did to prepare to testify
17 today?
18 A. I was assuming that I would travel
19 to the US in the beginning of October. And since
20 basically early August, I have had weekly
21 meetings with Mr. Schuller to go through the work
22 he has done in order to make sure that I
23 understood as much as possible the details of
24 what he has done.
25 Q. Okay. So you've had weekly meetings
00026:01 with Dr. Schuller since October; is that what you
02 said?
03 A. No, since early -- early August.
04 Q. Early August. Okay. Thank you.
05 A. Yeah.
06 Q. And how long would these meetings
07 last for?
08 A. Varying. I've had full-day
09 meetings, I've made -- I've had meetings lasting
10 half an hour, an hour.
11 Q. And was anyone else present at these
12 meetings you had with Dr. Schuller?
13 A. No.
14 Q. And if I understand your testimony,
15 you met with him to discuss the calculations that
16 he performed?
17 A. I met with him to discuss both the
18 timeline in which things had been done, the
19 calculation -- the calculations that had been
20 performed, tried to understand as much as
21 possible the results that were achieved and these
22 details.
23 Q. And did you speak with anyone else
24 in preparation for your testimony today?
25 A. Well, I spoke to Natalie Eades and I
00027:01 spoke to -- we had some telephone meetings with
02 Alan Weigel, but that's --
03 Q. Sure. Other than counsel.
04 A. -- about it.
05 Q. Yeah, my apologies. I should have
06 said other than counsel. Okay.
07 A. No, no -- not in any -- not in any
08 detail, other than informing my superiors that
09 this was a case which was coming up, but that's
10 it.

Q. Were there any individuals that you wanted to speak with but you were unable to speak with in order to prepare today?
A. No.
Q. Okay. So you didn't speak with -- is it Mr. or Dr. Selmer-Olsen?
A. He's -- he is a -- it's Dr. Selmer-Olsen.
Q. Okay.
A. But, no, I did not speak with him.
Q. Okay. And in order to prepare to testify today, did you communicate in writing with anyone other than counsel?
A. I will have had e-mail contact with Dr. Schuller on this issue.

Page 30:08 to 30:23

Q. Did you review any documents to prepare for your deposition today?
A. Yes, I did. I -- as I indicated earlier, in the last few months I have gone through the e-mail correspondence between Schuller and Wayne Miller from Lawrence Livermore. I have been reading up on the papers that were published some ten years ago on these choke models. Yeah, I've been trying to make myself familiar with the -- with the run -- the documentation.
Q. So the documents that you reviewed would be documents that were prepared by either Dr. Schuller or e-mails that Dr. Schuller may have received from Mr. Miller?
A. That's right.

Page 31:03 to 31:11

Q. Okay. So we've discussed meetings that you had with Dr. Schuller and we've discussed documents primarily, I think, created by Dr. Schuller and e-mails from Mr. Miller that you undertook to prepare today. Is there anything else that you did in order to prepare to testify today that we haven't already discussed?
A. No. I believe that what I've said is what I've done to prepare for this case.

Page 31:22 to 32:13

What is your current position at Statoil?
A. I'm -- within research and development, I'm the manager of the sector called Offshore Heavy Oil.

Q. What does that mean to -- to be the manager of the section called Offshore Heavy Oil?
A. Well, within this -- it's not a section, so it's what we call a sector, and then within the sector, I have three departments that work on various aspects of off -- offshore heavy oil production and processing.
Q. Offshore production and processing?
A. Yeah.
Q. And are -- so you're familiar in -- in your current job with calculating flow through pipes?

Page 32:16 to 32:17

A. Well, not so much my current job but more my previous job.

Page 32:19 to 34:18

Q. What was your job in July and August 2010?
A. I was a department leader for a department called multiphase flow transport.
Q. Multiphase flow -- what was the last word?
A. Transport.
Q. Transport?
A. Uh-huh. Yes.
Q. And is that flow of a multiphase fluid through piping?
A. That's right.
Q. And is it exclusively piping or does it flow through other vehicles?
A. It's -- it's mostly piping, but it's -- it is dealing with transport issues in -- in -- in -- in pipes and -- and valves as well.
Q. And is that different from flow assurance?
A. It's a part of flow assurance. Flow assurance is a wider -- wider area.
Q. Were you involved in developing the Hydro model?
A. Not in -- in -- in person. I was -- at the time the Hydro model was developed, I was also department leader for the department in which the work was ongoing, and as such I had responsibility for the work that was being done.
Q. Okay. So you were managing individuals at the company -- was it Statoil at the time or was it a different --
A. No, that's -- that -- that's why it's called Hydro model, because it's -- at that time the work was being carried out in a -- in a Norweigian company called the Norsk Hydro, which

was later merged with Statoil.
Q. Okay. So -- but -- so a different company than -- than where you work today, but you were managing employees who were involved in creating the model?
A. That's right.
Q. Have you in your work at either the -- the former company or the -- or Statoil currently, have you ever prepared calculations using the Hydro model?
A. I had done so, yes.
Q. Okay. And in what capacity did you use the Hydro model?
A. Let me think. So I'm, I would say, troubling to recall this. It's a long time ago.

Page 34:20 to 35:22

When -- when you were using Hydro, was that something that you routinely did in your job or was it more sporadic?
A. No, it was a sporadic thing.
Q. Did -- did you ever use OLGA in your professional career?
A. Yes.
Q. Do you use OLGA today?
A. No, I don't.
Q. Do you manage employees who use OLGA?
A. Yes, I do.
Q. Do you manage contractors who use OLGA?
A. Yes, I do.
Q. What about Fluent? Are you familiar with Fluent?
A. Yes, I am.
Q. Do you use Fluent?
A. Not anymore. I used to use it.
Q. Okay. And do you manage employees and contractors who use Fluent?
A. Yes, I do.
Q. Is Dr. Schuller familiar with OLGA, to your knowledge?
A. He is.
Q. How often would you say he uses OLGA, if you know?

Page 36:02 to 36:02

A. He -- he uses it regularly.

Page 36:04 to 36:10

Q. Regularly -- regularly in his work

for you or regularly generally in his work?
A. No, regularly in his consulting work for Statoil.
Q. And -- and what about Fluent? Does he use Fluent regularly in his consulting work for Statoil?

Page 36:13 to 36:13

A. No, never.

Page 36:15 to 38:15

Q. Did Dr. Schuller -- to your knowledge, Dr. Schuller has not used Fluent in -- in work for Statoil?
A. As I'm aware -- as far as I'm aware, he has not done so, yes.
Q. And -- and what about in connection with the work for the Lawrence Livermore project? Would that -- would you still say no -- no to that answer, that he hasn't used Fluent?
A. Yes, that's right.
Q. Dr. Schulkes, could you just briefly, if it's possible, describe your educational background?
A. I did a -- a bachelor and a master degree in applied mathematics and physics in New Zealand. After that I did a Ph.D. in applied mathematics, fluid mechanics in -- in Delft, University of Delft, the Netherlands.
After that I spent four years in the United Kingdom, two years in Cambridge, and two years at the University of Norwich, working on various fluid mechanical problems.
And in 1995 I started a career in industrial research, first in Norsk Hydro and afterwards in -- from 2007 in Statoil.
Q. Okay. In your -- your post-doctoral studies, you -- you described it as fluid mechanical problems. Did I get that correctly?
A. That's right. That's correct.
Q. But did that include multiphase hydrocarbon flow?
A. Not hydrocarbon. It was motion of -- of bottles and drops, so it was a multiphase flow topic, but it was not hydrocarbon.
Q. And in your educational background, did you ever study multiphase flow of hydrocarbons?
A. No, I did not.
Q. In your professional career, do you have experience in multiphase flow of hydrocarbons?

A. Yes, I do. And for a period of ten years, I was industrial professor at University of Oslo where I was teaching multiphase flow to students.
Q. And that included hydrocarbons?
A. Well, I mean, there -- there's no essential difference between hydrocarbons and -- and nonhydrocarbons as far as the -- the -- the mathematical description is concerned.

Page 38:24 to 40:01

Q. And this should be marked Exhibit 11005; is that correct, Dr. Schulkes?
A. That's right.
Q. Okay. This is an e-mail at the top printed by Ms. Eades. The e-mail is from Dr. Selmer-Olsen dated July 16th to miller99@llnl.gov. You're copied as well as Dr. Schuller. The subject is "help with the Hydro model"?
A. Uh-huh.
Q. Is the miller99, is that Mr. Wayne Miller?
A. Yes. I assume so, yes.
Q. Okay. I'd like to turn to the -- the second page of this document, please. And you'll see an e-mail from Wayne Miller on the 16th of July to Dr. Selmer-Olsen, same subject, help with the Hydro model, and Dr. -- or Mr. Miller writes: "Thank you for talking with me about running the HYDRO model for two-phase flow through a choke valve."
Did I read that correctly?
A. Yes.
Q. Do you know why Mr. Miller called Dr. Olsen -- Selmer-Olsen to discuss the Hydro model?
A. Well, at that point I did not, but later on it became clear.

Page 40:15 to 40:16

Q. Okay. But you now -- you now know why Mr. Miller contacted Dr. Selmer-Olsen?

Page 40:19 to 40:19

A. That's right.

Page 40:21 to 41:03

Q. Okay. And why did -- why did he

contact Dr. Selmer-Olsen?
A. As far as I understand, it was -- Lawrence Livermore was performing choke calculations on the Macondo well, and Selmer-Olsen was contacted to -- with -- to get help in relation to run these choke calculations for the well.

Page 41:17 to 43:23

Q. And then Dr. Selmer-Olsen contacted you and Dr. Schuller after he spoke with Mr. Miller?
A. Yes, he did.
Q. And -- and how did he --
A. He -- he --
Q. I'm sorry. Please finish your answer.
A. I think he may have contacted Dr. Schuller first.
Q. Okay. Do you know what Dr. Selmer-Olsen and Dr. Schuller discussed?
A. No, I don't.
Q. At any point did Dr. Selmer-Olsen contact you?
A. No, I've not spoken with Selmer-Olsen.
Q. Even -- even on -- in July 6th -- mid-July, you didn't speak directly with Dr. Selmer-Olsen?
A. No, I did not.
Q. Okay. Did you speak with Dr. Schuller about his conversation with Dr. Selmer-Olsen?
A. Dr. Schuller, he informed me that he had been contacted with -- by Selmer-Olsen. And from that point on, I've had regular discussions and contact with Dr. Schuller on this topic.
Q. Okay. I'd like to focus now on the first page of the document in the e-mail from Dr. Selmer-Olsen to Mr. Wayne Miller. And Dr. Selmer-Olsen wrote: "Dear Wayne Miller: Since we spoke earlier today, I have been in contact with Statoil (Dr. Schulkes and Dr. Schuller) regarding running the so-called HYDRO code on the choke flow in the current Gulf oil spill. Statoil is the owner of the HYDRO code after merger with Norsk Hydro.
"Statoil says yes to assist you and run some cases using the HYDRO code. A contact should be made between you and Dr. Ruben Schulkes in order to move things forward. I expect Dr. Schuller (and possibly myself) will be involved afterwards."
Did I read that correctly?

A. That's right.
Q. Okay. So that -- that last sentence, Dr. Selmer-Olsen wrote that he expected he'd be involved afterwards. Was he, in fact, involved in this project?
A. From my understanding, all of the work has been done by Dr. Schuller, but it may have been the case that there has been contact with -- between Dr. Schuller and Selmer-Olsen to discuss some results, but I'm not aware of the discussions that have been between those two people.

Page 44:06 to 46:08

I just want to make sure I understand. To the extent that Dr. Selmer-Olsen was involved at all, if -- if he was involved --
A. Yeah.
Q. -- it would have been communications that he had directly with Dr. Schuller about Dr. Schuller's work for Mr. Miller and Lawrence Livermore; is that correct?
A. That's right, that's right.
Q. Okay. And -- and in your preparation for testimony today, you didn't talk with Dr. Schuller about any conversations that he may have had with Dr. Selmer-Olsen?
A. No. I -- I -- what I -- what I recall is that there have been con -- Dr. Schuller has mentioned that there have been conversations between him and -- and Selmer-Olsen on this topic, but I don't know the nature of the conversations. I don't know how often they've been in contact.
Q. Okay. Now, you stated earlier today that Dr. Selmer-Olsen is not a Statoil employee, correct?
A. That's right.
Q. Okay. Why would he have been involved at all in this project beyond making the initial contact for Mr. Miller?
A. The situation is that Dr. Selmer-Olsen, he took his Ph.D. on developing choke models. And when we about ten years ago started to work with multiphase -- multiphase flow-through chokes, it was natural for us to build further on models that existed, and for us it was natural to use the most advanced model which was currently -- which was available at that time, and it was the model which Selmer-Olsen had developed.
So in the further development of the model, there has been -- there have been scientific discussions with Selmer-Olsen and

Reidar Schuller, Dr. Schuller, to understand the physics which is involved in modeling these complex systems.

So Selmer-Olsen, he is basically the father of this choke model, which in -- in -- about ten years ago we sort of took on board and further developed. So that's been natural for us to have discussions with Selmer-Olsen, because he -- he is a knowledgeable person on this topic.

Q. Okay. So Dr. Schuller would have been consulting with Dr. Selmer-Olsen given the complexities of this particular flow problem?

A. Well, I mean, again, it's --

Page 46:11 to 46:15

A. -- speculation because I don't know the extent to which there has been contact, but, I mean, I know there has been contact and the -- the contact would have been related to understanding the physics in this problem.

Page 46:17 to 48:07

Q. Okay. Thank you, Dr. Schulkes.

Let's now turn to Tab 7, please. Okay. And at the top this is printed by Ms. Eades. It's an e-mail from a Dr. Selmer-Olsen on the 17th to you and -- and Dr. Schuller. I'm actually interested in the -- the e-mail right below that. And my apologies. This is Exhibit 11006. Is that the exhibit number that you have in front of you, Dr. Schulkes?

A. Yeah, that's right --

Q. Okay.

A. -- that's right.

Q. So the -- the e-mail that -- that I want to focus on is from yourself, so it's immediately the next e-mail down on the 17th to Dr. Selmer-Olsen, miller99, which we've established was Mr. Wayne Miller, and Dr. Schuller. And you wrote: "Dear Wayne and Stale." I -- I apologize if I'm totally butchering that. "I have spoken to Reidar - he is able to start on the work at once. If the total amount of work does not exceed one week we do not need a contract. If the complexity or amount of the work is" much -- "is such that more time is required, we will have to establish some sort of contract.

"Based on my conversation with Stale I understand that the work from our side will consist of the following:

"- based on input from LLNL perform

calculations with the Hydro choke model to compute flow rates in the BP GoM well.
"Results will be delivered in the form of curves (based on choke model calculations) and explanation of the curves."
Did I read that correctly?
A. That's right.
Q. Does that accurately describe your understanding of the work that the United States Government asked Statoil to perform?

Page 48:10 to 48:11

A. Can you ask your question again? What was it you asked?

Page 48:13 to 49:05

Q. The -- let me direct you specifically to the -- the sentence. It begins with: "Based on my conversation with Stale I understand that the work from our side will consist of the following:
"- based on input from LLNL perform calculations with the Hydro choke model to compute flow rates in the BP GoM well.
"Results will be" -- "Results will be delivered in the form of curves (based on choke model calculations) and explanation of the curves."
And -- and what I asked you, Dr. Schulkes, is whether that accurately describes your understanding of the work that the -- the United States representative, Mr. Wayne Miller of Lawrence Livermore, asked Statoil to perform?

Page 49:08 to 49:12

A. Well, basically what I -- what I'm writing here is that I -- I'm trying to clarify what is wanted. I'm actually trying to phrase the question, which is where -- where the aim is to get a clear understanding what is required.

Page 49:14 to 49:17

Q. Okay. And -- and -- and today, is it -- what you wrote here, does that accurately depict your understanding of the work that Mr. Miller asked Statoil to perform?

Page 49:20 to 49:20

00049:20 A. I -- I think so, yes.

Page 49:22 to 50:02

00049:22 Q. At any time after this e-mail, did
23 Mr. Miller ever tell you that he or anyone that
24 he was working with at Lawrence Livermore or
25 generally at other national labs that they wanted
00050:01 to change the scope of the work that you describe
02 in this document?

Page 50:05 to 50:05

00050:05 A. I'm not aware of that.

Page 50:07 to 50:10

00050:07 Q. And at any time after this e-mail,
08 did Statoil decide to change the scope of work
09 without the input of Mr. Miller or anyone from a
10 national lab?

Page 50:13 to 50:16

00050:13 A. We -- we did not modify the scope of
14 the work. We -- we've basically delivered to
15 Lawrence Livermore Laboratory what we thought
16 they wanted to have.

Page 50:21 to 51:22

00050:21 Q. Now, you performed this work free of
22 charge; is that correct?
23 A. That is correct.
24 Q. Okay. Is it usual for Statoil to
25 perform short-term work free of charge?
00051:01 A. No, it's not.
02 Q. Okay. So why did you do it in this
03 particular instance?
04 A. We -- on -- on a topic like this
05 where you have a relatively short limited amount
06 of work, then quickly the amount of time and
07 money spent on getting the contract in place
08 is -- exceeds the value of the job which is done.
09 Q. Okay. Let's turn to Tab 9, please.
10 And that should be Exhibit 11008.
11 A. That's right.
12 Q. Okay. This is an e-mail from
13 Mr. Wayne Miller to Dr. Schuller. You're copied
14 on it, as is Dr. Selmer-Olsen. The subject,
15 "Help with the HYDRO model." Are you familiar
16 with this e-mail?

A. I am.
Q. Okay. Mr. Miller wrote: "At the moment there is a concern that we have some agreement that the information we send you, and your results, remain confidential."
Do you see where I'm reading from?

Page 52:01 to 52:02

A. Yeah, I see what you're reading, yes.

Page 52:04 to 52:13

Q. Okay. He goes on to write: "Is it possible that we can create a non-disclosure agreement or something similar with Statoil?" I'm "sorry about the need for this. This work is sensitive for political and business reasons."
Did I read that correctly?
A. Right.
Q. Did it surprise you that Mr. Miller referred to this work as sensitive for political reasons?

Page 52:16 to 52:16

A. No, it doesn't surprise me.

Page 53:09 to 56:10

So Doctor -- or, I'm sorry.
Mr. Miller wrote, "This work is sensitive for political and business reasons." And I asked you if you were surprised that he referred to this work as sensitive for political reasons. You said that you were not surprised by that, and I wanted to understand why you were not surprised that Mr. Miller thought this work was sensitive for political reasons.
A. It was obvious that the -- the spill in the Gulf of Mexico was of such a magnitude that it's influencing the business.
Q. Did Mr. Miller ever say to you what he meant by that phrase, "sensitive for political reasons"?
A. No -- no, he did not.
Q. And can I just clarify, Dr. Schulkes, I think that you provided us a reason why you thought it was sensitive for business reasons, that it -- I don't have the transcript. Where is that? It was influencing the business. It was obvious that the spill in

the Gulf of Mexico was of such a magnitude that it would influence the business.
But I'm not sure if you explained why you weren't surprised that it was sensitive for political reasons?
A. Well, I can't -- I cannot answer I have a good reason for answering why I knew it was sense -- sensitive for political reasons. The business implication was very clear. The political reason is -- at that stage wasn't clear.
Q. Okay. So if -- if we could just go back for a moment. You had testified earlier that you were not surprised, and I just lost you from the screen. You had testified earlier that you were not surprised that Mr. Miller had indicated that the work was sensitive for political reasons.
Do -- do you now feel that maybe you don't know why he said that, that it was
00055:01 sensitive for political reasons and maybe you're not -- you are surprised that he said that?
A. With my current knowledge, I would not be surprised if -- I'm not surprised. But at that time, I probably wasn't aware of the political dimension in this -- in this case.
Q. And what are the political dimensions that you're referring to?
A. From my understanding of the business, any major spill like this will influence the possibility of companies to operate in new areas, and then there is -- was a -- a business side to that and a political side to that.
Q. Okay. Thank you. Let's turn to Tab 10, please. And that should be marked Exhibit 11009. Do you have that?
A. That's right.
Q. Okay. Excellent. This is an e-mail from Mr. Wayne Miller to Arthur C. Ratzel and Bob Ferencz. And the subject is, you know, "Fwd: FW: Help with the HYDRO model." And there are -- would appear to be three attachments. Do you see that?
A. I see that.
00056:01 Q. Have you seen this top e-mail before today?
A. Not before today.
Q. Okay. Mr. Miller wrote in that second paragraph, "LLNL is drafting an NDA today for them to consider, for keeping the flow results confidential."
The reference to to them to consider, do you have any idea if he's referring to Statoil?

Page 56:19 to 56:20

00056:19 A. I mean, it's very natural to assume
20 that there's a -- this "them" refers to Statoil.

Page 57:06 to 57:17

00057:06 Q. Okay. And Doctor -- or Mr. Miller
07 says that -- that they're -- that LLNL is
08 drafting an NDA today for them to consider for
09 keeping the flow results confidential.
10 Now, Statoil did enter into an NDA,
11 a nondisclosure agreement, with Lawrence
12 Livermore, correct?
13 A. That's right.
14 Q. And was it your understanding that
15 the reason to enter into this nondisclosure
16 agreement was to keep the results of your work
17 confidential?

Page 57:20 to 57:22

00057:20 A. It was my understanding that any
21 information which we received from Lawrence
22 Livermore Laboratory would be (inaudible) --

Page 58:02 to 58:09

00058:02 A. Would be kept within Statoil.
03 Q. Within Statoil.
04 And that would include the results
05 of your work for Livermore?
06 A. That's right, that's right.
07 Q. Do you know -- do you know why you
08 were asked to not disclose the results of your
09 work?

Page 58:12 to 58:18

00058:12 A. That would be pure speculation, but,
13 I mean, given the -- the size of the spill, it
14 was clear that this is -- this is something which
15 could be used by many parties in a -- in a way
16 which was not -- not beneficial to -- to BP or
17 any -- anybody involved in this case. So --
18 we -- I assume that's the case.

Page 63:18 to 64:22

00063:18 Q. Great. So we were talking about the
19 Hydro model a little bit earlier today. I want
20 to talk about it a little bit more right now.

Can you describe why the Hydro model was originally developed?
A. As I -- as I indicated before, the Hydro model was based on the model which had been developed as part of the Ph.D. thesis of Selmer-Olsen. The use of chokes in oil industry is -- is -- is widespread. We use chokes in many -- chokes and valves in many, many different parts of our operations. And having access to accurate choke models is -- is important for our company and many other oil companies.
So we, about ten years ago, decided to use -- we've got a large-scale experimental facility in which we can perform detailed experiments with hydrocarbons under high pressure, and we decided to run the experiments there to test the accuracy of available choke models at that particular time.
We discovered that there was quite a large uncertainty associated with these existing choke models, and then we started developing -- further developing the -- the -- the model which Selmer-Olsen had developed in his Ph.D. thesis.
Q. When you referred to a choke model as accurate or -- or needing accuracy with the choke model, what are -- what specifically are you referring to?

Page 64:25 to 66:16

A. The -- what was important from -- from our point of view is being able to -- given the pressure difference over a choke being able --
THE REPORTER:
Given the what? Stop, stop. I'm sorry. Given the pressure difference?
THE WITNESS:
Give the pressure difference over a choke over a valve, what is the flow going through the valve.
EXAMINATION BY MS. SALTZBART:
Q. And so this model allows you to predict the rate at which a fluid is -- is -- is cross -- going across the valve?
A. That's right.
Q. And about -- you said about ten years ago. What -- can you actually -- can you -- when you were testifying earlier, you -- you were describing something that happened about ten years ago. Was that validating these models?
A. What -- what we are doing is we -- we are using choke valves in -- in our operations where we have many wells coming into a processing facility. We want to be able to control

production in such a way that we basically get most of the oil out of the fields given the limitations of the processing facility.

And in order to achieve that particular goal, we have to be able to control the production from each and every well we are producing from. And -- and controlling oil production happens by means of chokes or valves.

So there is -- there is a clear link between good models for valves and allowing accurate -- anyway or accurate allocation of your production from various -- various wells.

Q. Would you say that the -- the application of Hydro to the -- the Macondo well, is that similar to what you described as having many wells feeding into a -- a processing facility?

Page 66:19 to 66:24

A. Well, it's not similar. And in this case you just got one stream and one valve, so it's -- the -- the objective is anyway to say we want to be able to compute what goes through the valve given the pressure difference over the valve.

Page 67:01 to 70:05

Q. Can you describe how the Hydro model works?

A. I can. Basically I have to go back a little bit. Choke models are -- usually are built up by assuming that you can treat the fluids through a choke as a -- as a frictionless fluid, as a frictionless motion. And if that is the case, then you have exact expression for how much -- if -- if that is the case and if you have only one fluid available, just only -- only gas or only liquids, then you can compute it with relatively large accuracy what goes through the choke valve.

If you have frictional effects or if you have turbulence effects, these are what are called losses in a valve. Then it becomes difficult to do -- actually do exact calculations, and then we rely on experiments to actually give us results on -- for choke valves to be able to predict how much goes through a choke given a -- a pressure difference over the choke.

It is relatively -- still relatively easy if you have a single phase flow, if you have only gas or only liquids. Things become very, very complicated if you multiphase flows through

a choke. And the reason why it becomes very difficult is related to the fact that the -- the gas and liquids do not move with the same velocity through the choke, the -- the liquids being much heavier than the gas is -- is lagging behind the gas.

So what happens just before a choke is that you get a very rapid acceleration of the -- the gas and the liquids moving into the choke, but because the liquid is heavier, it takes longer to accelerate and you get what is called a slip, a relative velocity between the gas and the liquid.

And this slip effect means that it becomes quite difficult to accurately predict the mass flow rate through a choke given the pressure difference over a choke.

So many experiments have been done in order to take into account this particular slip effect, and there are what is called correlations. These are basically experiments that have been done, and people list -- try to -- try to modify the choke model to give better predictions when you take into account these -- these -- these slip effects.

00069:01

You can do these -- this type of modeling by still not really going into the details of what happens in a choke. And what is different from -- with respect to the -- where -- where the Hydro model is different from other models is that we use what is called a control volume method. And a control volume method means that you -- you have different volumes which make up the choke, and in each volume what you do is you use a mechanistic -- a mechanistic understanding of -- of these flows. You try to ensure that you have mass balance, momentum balance, and energy balance in each control volume.

And that is where the -- the Hydro choke model is different from most of the conventional choke models, where we actually try to put as much physics into the model as we can in order to make it both more accurate and also it allows us to use the model on -- on situations in which you don't have any experimental data.

So if you -- if you apply the model to a new system, then having a model which is based on physical reasoning, that's got a larger chance of -- of predicting accurately.

00070:01

Q. And -- and that applies both to the long version and the -- and the short version of the model?

A. In principle it does, yes.

Page 70:09 to 72:11

00070:09 Q. And the slip effects, you -- I think
10 you described that -- that you've seen -- you see
11 slip before the choke. Am I -- am I remembering
12 that correctly?
13 A. Well, what -- what is -- basically
14 before the choke, the slip effects are more
15 significant because you get -- before the -- you
16 enter the choke, just as you enter the choke, you
17 get a large acceleration of the gas and the
18 liquids. And because the liquids part of the
19 droplets are heavier than the gas, they -- they
20 lag behind. They are not accelerated as quickly
21 into the choke as you would assume if there was
22 no -- no slip.
23 Q. And is that because the choke is a
24 smaller -- is -- generally tends to be a smaller
25 diameter than the pipe upstream and downstream of
00071:01 it?
02 A. Yeah. That's right. The -- any
03 choke represents a flow restriction.
04 Q. Okay. In this particular instance,
05 though, the upstream and downstream pipe was
06 actually smaller than the choke valve; isn't that
07 correct?
08 A. Well, I mean, that is yes and no. I
09 mean, upstream -- in the Macondo case -- you're
10 referring to the Macondo case?
11 Q. Yes, my apologies. Yes,
12 specifically --
13 A. That's okay.
14 Q. -- the choke line of --
15 A. Uh-huh.
16 Q. -- of the capping stack that was
17 installed on the Macondo well.
18 A. Yeah. Well, what is -- in that
19 particular case, we had a 3-inch pipe upstream
20 and a 3-inch pipe downstream. And the choke
21 point, when it's fully open, had an equivalent
22 flow area of 4-inch. What that basically means
23 that after the choke has reached an opening
24 which -- where the equivalent flow area is equal
25 to 3-inch, then opening the choke even further
00072:01 doesn't have any effect.
02 Q. So the acceleration we were
03 discussing earlier and -- and where the -- the
04 slip between the two phases is most significant
05 is in the situation where the piping downstream
06 and upstream of the choke valve is larger than
07 the choke itself. And -- and in this particular
08 application, it was only until the choke was at
09 the same size as the piping that's surrounded it
10 where the -- the validity of -- of the model
11 would work as it was originally designed?

Page 72:14 to 73:12

00072:14 A. I don't think the model has been
15 applied outside its -- its range of validity. We
16 have looked in detail at -- at what happens when
17 the choke -- the Macondo choke is opened and try
18 to understand what -- what happens if it's opened
19 more than where -- when the choke gets a flow
20 area which is larger than the pipe both upstream
21 and downstream the choke.
22 But, of course, things do not -- I
23 mean, you have -- you have a -- you have a pipe
24 which is a given diameter. You put a flow
25 restriction in the pipe, because the cage choke
00073:01 is a flow restriction whatever you do.
02 And if you then design the choke
03 such that the flow area through the choke is
04 lighter than the pipe cross-section, it doesn't
05 mean that you have less restriction. I mean, you
06 still have an -- an object in the pipe there
07 which is restricting the flow. So you cannot
08 assume that because the -- the -- the -- the flow
09 area in the choke is larger than the -- the
10 cross-section of the pipe that the flow -- that
11 you're -- you do not have a restriction anymore.
12 I mean, there's still a restriction there.

Page 73:14 to 73:18

00073:14 Q. I -- I understand that. Let me --
15 let me ask you this, Dr. Schulkes. Was Hydro
16 originally designed for geometry where the
17 upstream and downstream piping is smaller than
18 the diameter of the choke?

Page 73:25 to 74:12

00073:25 A. We did not perform tests on the
00074:01 system where the choke and the equivalent flow
02 area which is larger than the up- and downstream
03 diameters of the pipe or cross-section flow area
04 of the pipe.
05 EXAMINATION BY MS. SALTZBART:
06 Q. And your application of the Hydro
07 model for the choke line of the capping stack
08 that was installed on the Macondo well, would
09 that be, to your knowledge, the first application
10 of the model to a geometry where the upstream and
11 downstream pipe is smaller than the diameter of
12 the choke valve?

Page 74:15 to 75:09

00074:15 A. I've got -- I've got no idea. The
16 Hydro model has been used by many other
17 companies. And they may have used it there or
18 not. I don't know.
19 EXAMINATION BY MS. SALTZBART:
20 Q. In terms of gathering experimental
21 data to calibrate the -- the model or maybe
22 validate the model, are you aware of any
23 instances in which the geometry where the
24 downstream and upstream piping was smaller than
25 the choke valve were used in experiments?
00075:01 A. No, not aware of that.
02 Q. In a system where the -- the
03 diameter of the choke valve is larger than the
04 piping upstream and downstream of it, would it be
05 fair to say that the Hydro model is still valid
06 up to the diameter of -- of the pipe, so -- so to
07 the extent that the choke is open to 60 percent,
08 which would equate to the 3-inch pipe, would the
09 application of the Hydro mod -- model be valid?

Page 75:12 to 76:13

00075:12 A. I'm -- I'm having difficulty with
13 the way you phrased the question, because, I
14 mean, even though the -- this particular choke
15 valve in the Macondo well consisted of different
16 holes, and the holes had a half-inch and
17 one-half-inch opening.
18 So in any case each of those holes
19 had a cross-section -- cross-sectional area which
20 was less than the cross-sectional flow area of
21 the pipes, both upstream and downstream. But if
22 you add the collective areas of these holes, then
23 you get a collective area which is larger than
24 the cross-section of the flow -- of the pipe.
25 So I mean, there -- there is -- I
00076:01 think we -- I mean, it may be semantics or not,
02 but there is -- there is a restriction in the
03 pipe, regardless of how you look at it, how large
04 the opening is. And this restriction has
05 openings which are significantly smaller than the
06 cross-section of the pipe, both upstream and
07 downstream this -- this choke. But -- but if you
08 add the collective area of these holes, then you
09 get a -- a cross-sectional area which is larger.
10 But as I understand these choking
11 flows, is I don't -- cannot see any reason why
12 the Hydro choke model cannot be applied to a
13 system like that.

Page 76:15 to 76:21

00076:15 Q. And -- and the system like that
16 being a system where the upstream and downstream

pipe are smaller than -- if I refer to it as the effective diameter, would that -- would that be an appropriate --
A. Or the -- yeah, the -- the effective flow area, yes.

Page 76:24 to 78:12

00076:24 Q. Just so I'm clear, so you're saying that, you know, there would not be a reason why
00077:01 you could not apply the -- the Hydro choke model, whether long or short, to a geometry where the downstream and upstream piping is smaller than the effective cross-sectional flow area of the choke valve?
A. I cannot see that there's a -- a -- a significant limitation of the model there. But -- but what we're seeing is if you have the -- like any of these models, I mean, these are -- these are very complicated systems and you have to think about, what -- what -- what does it mean if you have a fully open choke? Do you really have a cross -- a flow area which is larger -- larger than the cross-section of the pipe?
It may be -- of course, you -- I mean, what -- if you look at the geometry of this particular choke, the -- the size of the holes -- combined size of the holes is larger than the cross-section of the pipe. But the fluid has to flow into these holes, and then you get a restriction upstream the holes, which is actually starting to break the fluid, because you have to -- I mean, the -- the choke valve is placed in a pipe and the holes are in a section which is
00078:01 concentric with the center of the pipe. But the fluid has to flow past -- past the -- the body of the choke into the holes.
So that you cannot -- we cannot pretend that by making many holes in this choke that suddenly the flow area disappears. I mean, it's -- it is still an obstruct -- obstruction in the pipe.
Q. So there's still frictional losses from flow --
A. Oh, yeah, this is -- this is -- yeah.

Page 79:05 to 79:11

00079:05 Q. So there -- the question was, so there would still be frictional losses from flow through the choke?
A. Yes. And the answer is yes.
MR. WEIGEL:

Yes.
A. Very much so.

Page 79:13 to 80:15

Q. When we first started talking about the Hydro model, you were talking about uncertainties associated with existing choke models and -- and that was a reason why there was work to improve the accuracy of the -- maybe this was ten years ago or ten plus years ago. Am I recalling that testimony correctly?
A. That -- that's right.
Q. Okay.
A. That's correct.
Q. And -- and is it your view that today that the Hydro model has fairly high accuracy in predicting flow through a choke valve?
A. That's our opinion, yes.
Q. Okay.
A. At least -- at least for systems which are similar to where -- or to which the model has been -- although -- on which the choke model has been developed, which means light crude hydrocarbon systems.
Q. Right. And what about similar geometries, since we were talking earlier that -- that you had not actually tested the model in a geometry where the upstream and downstream piping were smaller than the effective cross-sectional flow area of the valve?
A. That's right.

Page 80:19 to 80:21

Q. So would the uncert -- could -- would the uncertainty be somewhat different from the geometries that you have tested?

Page 80:24 to 80:24

A. It might be, it might be.

Page 81:16 to 81:20

Q. So I said, so you wouldn't know because you hadn't tested the type of geometry that was utilized at the choke line of the capping stack that was installed at the Macondo well?

Page 81:23 to 81:23

00081:23 A. That's correct.

Page 81:25 to 82:15

00081:25 Q. Okay. Dr. Schulkes, what kind of
00082:01 inputs do you need to run the choke model?
02 And -- and let me just say that if there are
03 different inputs for the choke as -- I'm sorry,
04 for the short version as compared to the long
05 version, if you could identify what those
06 different inputs might be.
07 A. Just to say that for the particular
08 calculations we have done for the Macondo well,
09 we've only used the short version of the model.
10 Typically, what we require to run the choke
11 models is upstream and downstream diameter of the
12 pipe, the effective flow area in the -- in the
13 choke. We need -- often -- typically, we -- we
14 are given the upstream and downstream pressure,
15 and we need fluid properties.

Page 82:23 to 85:02

00082:23 Q. And what type of fluid properties do
24 you typically need?
25 A. For these hydrocarbon systems, what
00083:01 we typically get is what is called a PVTsim file.
02 And the PVT file is a file -- or is -- is
03 basically a characterization of the fluid which
04 is -- which is flowing and it's -- it basically
05 tells us how much liquid and how much gas is
06 available at a given pressure and a given
07 temperature.
08 Q. Do you ever use any other commercial
09 modeling packages besides PVTsim?
10 A. Well, we -- we have an internal
11 package which we use, but PVTsim is -- is the --
12 is the main package which we -- which we use.
13 Q. And can you describe what the -- the
14 differences are between -- I understand you
15 testified that -- just previously that you only
16 used the short version of the model. But could
17 you describe to me what the differences are
18 between the short and the long versions?
19 A. Well, the long model, as its -- as
20 its sort of name suggests is a choke which has
21 got a -- got volume. You can -- for example, the
22 simplest choke is a -- is an orifice plate. It's
23 just a plate with a hole in it. And an orifice
24 plate does not have a volume. But a choke which
25 has a definite volume like a cage choke, which is
00084:01 similar to the one which is used in the -- in --
02 in the Macondo well, that -- that is a choke
03 which has a volume. Where the choke has a given

volume, then the internal frictional losses in the choke may be significant.
Q. Okay. And -- and you indicated that the -- the choke where -- we have here is -- is a cage-type choke; is that correct?
A. That's right, that's right.
Q. And -- and which model, then, did you say would be appropriate for the cage-type choke?
A. Well, I mean, there is -- there is no sort of -- sort of clear answer on that. You -- you have cage chokes that have a significant internal loss, you have cage chokes without a significant contribution of the internal loss. And our assessment of the cage choke which we -- we're doing calculations on for the Macondo well was that this was a cage geometry without significant internal loss, and that's why we chose to apply the short model.
Q. Did you document that finding or that -- those conclusions anywhere?
A. I -- I can't -- we -- we probably did, but I -- I don't know the details of this -- this documentation.

Page 85:09 to 86:09

Q. It should be marked Exhibit 1102, and it's --
A. That's right.
Q. Okay.
-- a paper titled "Evaluation of Multiphase Flow Rate Models for Chokes Under Subcritical Oil/Gas/Water Flow Conditions"?
A. Uh-huh.
Q. And it appears that Dr. Schuller is one of the principal authors; is that correct?
A. That's correct.
Q. Okay. And -- and Dr. Selmer-Olsen is also an author of this paper; is that correct?
A. That is correct.
Q. Okay. Now, I know we -- we've discussed Dr. Schuller earlier, so you -- you do know him personally; is that right?
A. That's correct.
Q. Do you also know Dr. Selmer-Olsen personally?
A. I do.
Q. Okay. Do you hold them both in high regard professionally speaking?
A. I do.
Q. And you would -- you would respect their professional judgments and opinions?

Page 86:12 to 86:12

00086:12 A. Yes, I would.

Page 86:14 to 87:17

00086:14 Q. All right. I'd like to turn to page
15 178 of this paper, please. And I'd like to draw
16 your attention to the paragraph that starts out
17 with "Conclusions" in bold. Do you see that?
18 It's on the right-hand side in the middle part of
19 the page.
20 A. Okay.
21 Q. And the second sentence in the first
22 paragraph, it reads, "Two different geometries,
23 orifice and cage type, and three different
24 opening areas (2.0, 3.5, and 5.0%) were tested."
25 Did I read that correctly?
00087:01 A. Right.
02 Q. Okay. And then if you go down two
03 paragraphs to the paragraph that starts with
04 "Mass Flow Rate Models," do you see that
05 paragraph?
06 A. Uh-huh.
07 Q. Okay. The --
08 A. Yes.
09 Q. The second sentence in that
10 paragraph reads, "The Hydro models have been
11 shown to predict the mass flow rate with the best
12 accuracy for the new data set used in this model
13 evaluation." Did I read that correctly?
14 A. Right.
15 Q. Do you agree with that statement?
16 Are -- are you familiar with this paper and the
17 conclusion?

Page 87:20 to 87:20

00087:20 A. I am familiar with the paper.

Page 87:22 to 88:09

00087:22 Q. And you agree with that statement?
23 A. Yes, I can agree with that
24 statement.
25 Q. Okay. Turn to the next page,
00088:01 please. On the left-hand column, you'll see the
02 second paragraph begins, "The recommended model
03 approach is the Hydro short model for orifice
04 choke and the Hydro long model for cage-type
05 choke."
06 A. That's right.
07 Q. Okay. I read that correctly.
08 And -- and that -- that's consistent

09 with your testimony earlier today, correct?

Page 88:12 to 88:12

00088:12 A. Uh-huh.

Page 88:14 to 88:21

00088:14 Q. Okay.
15 A. Yes, I do.
16 Q. There doesn't seem to be any
17 discussion here about further looking at what --
18 the cage-type choke to see whether the long model
19 or the short model is appropriate. It seems to
20 kind of clearly state here that the Hydro long
21 model is appropriate for the cage-type choke?

Page 89:03 to 90:07

00089:03 Q. Dr. Schulkes, doesn't this sentence
04 say that the Hydro long model is the appropriate
05 model for the cage-type choke?
06 A. Well, you cannot -- you cannot be as
07 categoric as that. What -- what is the defining
08 parameter for a choke is -- is what is called the
09 CV value. And if you have a -- a CV value which
10 is close to 1.6, then you -- you are more in a
11 short -- in a choke model which is developed for
12 short systems. And from what I understand has
13 been done, is the CV value for the caged -- for
14 the Macondo well choke was assessed, and it was
15 closer to what is -- what is valid for a short
16 choke than for a long choke, and that's why the
17 shorter choke model was being used.
18 Q. And who made this assessment?
19 A. Mr. Schuller.
20 Q. Were you consulted in making this
21 assessment?
22 A. No.
23 Q. And is it your understanding that
24 the information he would have reviewed would be
25 the CV value for the particular cage-type choke?
00090:01 A. This is the information he received
02 from -- from Wayne Miller, from Lawrence
03 Livermore, and his professional assessment would
04 have meant that he chose the short model rather
05 than the long model.
06 Q. Would the long model be valid for
07 this particular type of cage choke?

Page 90:10 to 90:10

00090:10 A. I -- I cannot answer that.

Page 90:12 to 92:08

00090:12 Q. So you didn't run the long model as
13 part of the work for Mr. Miller?
14 A. Some calculations were done with
15 the wrong -- with the long model or the wrong
16 model maybe. So there are some of these Excel
17 files which were given to -- as part of this
18 deposition here. They show that both the long
19 model and the short model have been run. But for
20 the results which were then presented or given to
21 Lawrence Livermore Laboratory, only the short
22 model was used.
23 Q. Now, you're here testifying on
24 behalf of Statoil. Is it your -- is it Statoil's
25 position today that the short model of Hydro is
00091:01 the most appropriate model to apply to the
02 cage-type choke that was used here, the CC40?
03 A. That is our assessment, yes.
04 This -- this particular cage choke, right?
05 Q. Right, the -- the CC40.
06 A. Yeah, that's right.
07 Q. Okay. All right. Let's turn to
08 Tab 41, please. And this is marked
09 Exhibit 11039.
10 Have you seen this document before?
11 A. No, I have not.
12 Q. Okay. This is an e-mail from
13 Mr. Wayne Miller to some of his colleagues, and
14 in particular to Stewart Griffiths, Arthur C.
15 Ratzel, Ronald C. Dykhuizen, Curtt N. Ammerman,
16 and a P. Derik Wapman are copied, and it's dated
17 July 13th at 2010 at -- at 10:34 p.m., and the
18 subject is "multiphase choke models." Do you see
19 that?
20 A. I see that.
21 Q. Okay. July 13th, that's before
22 Mr. Miller contacted Dr. Selmer-Olsen, correct?
23 A. That's right.
24 Q. Okay. I'd like to direct your
25 attention to the very last sentence in this first
00092:01 e-mail on the page. It reads: "The more complex
02 models Perkins, Hydro, etc., would require
03 significant software time to implement and may
04 not be worth it from the error measurements."
05 Did I read that correctly?
06 A. That's right.
07 Q. Do you know what error measurements
08 Mr. Miller is referring to here?

Page 92:11 to 92:11

00092:11 A. No, I do not.

Page 92:13 to 93:04

00092:13 Q. Did Mr. Miller discuss with you any
14 concerns he had about error measurements
15 associated with the Hydro model?
16 A. No, he did not.
17 Q. Are you aware if Mr. Miller
18 discussed concerns about error measurements with
19 the Hydro model with Dr. Schuller?
20 A. As far as I'm aware, he did not.
21 Q. Okay. And what about
22 Dr. Selmer-Olsen? Are you aware of whether
23 Mr. Miller mentioned a concern about error
24 measurements to -- with the Hydro model to
25 Dr. Selmer-Olsen?
00093:01 A. No, I do not.
02 Q. Are there error measurements
03 associated with the Hydro model that -- that
04 you're aware of?

Page 93:07 to 93:09

00093:07 A. Well, the error measurements are
08 clearly stated in the paper we were looking at
09 earlier.

Page 93:11 to 95:18

00093:11 Q. I'm sorry. So you said the error
12 measurements are discussed in the 2003 paper that
13 we were discussing earlier?
14 A. That's right.
15 Q. And are you aware of what those
16 error measurements are?
17 A. If I look at the paper, yes, there
18 is -- they are clearly stated there.
19 Q. And that -- we're --
20 MS. SALTZBART:
21 For the court reporter, we're going
22 to Exhibit 1102.
23 A. If you look at page 180, the
24 Figure 11 is an assessment of the error of the
25 different models.
00094:01 EXAMINATION BY MS. SALTZBART:
02 Q. And I see it says, "Hydro modified
03 slip and Hydro original slip."
04 Can you explain the difference
05 between those two?
06 A. Yes, I can. I explained earlier
07 that the gas and the liquids does not move --
08 THE REPORTER:
09 I'm sorry?
10 A. -- with the same velocity --
11 THE REPORTER:
12 I'm sorry. I didn't hear the

beginning.
MS. SALTZBART:
"I explained earlier."
THE REPORTER:
About the? Something --
MS. SALTZBART:
About the gas --
THE REPORTER:
-- about the liquids. There was a cough.
A. I explained earlier that the gas and the liquids do not move with the same velocity through a choke. And this -- this is a very complex physical process, and quite a few people have tried to describe the slip between the gas and the liquids in -- in the choke.
There are -- if you look at Figure 5 on page 176, there are listed five different slip correlations which have been used. And it was found that by using the Chisolm correlation, which is the curve denoted by the little circles, perform best, but at what is called a low gas quality, that is a system with a lot of liquid in it. It was found that the Chisolm correlation did not work well.
And based on the experiments which we did, we modified the slip correlation. We took -- basically took the Chisolm correlation and slightly modified the Chisolm correlation in the area where you have low gas quality. That means large liquid fractions.

Page 95:21 to 96:03

A. So which you -- when you look at the Figure 11 where it says, "Hydro modified slip," then that is the model in which a slip correlation has been used which is designated as new model in Figure 5.
Q. And do you have to make a judgment about the appropriate slip correlation to apply in any particular application of the Hydro model?

Page 96:06 to 96:09

A. Basically what is the case that we only used the new model, which is described in this paper when we apply the Hydro model. We don't use any of the other slip correlations.

Page 96:11 to 96:24

Q. Even in -- in fields that have a significant amount of gas as compared to the

liquid phase?
A. Well, what I said before, if you -- if you have a system where the amount of gas is significant compared to the liquid phase, then you can use a Chisolm correlation because it gives exactly the same result as the new Hydro correlation.
Q. Okay. So the -- the new correlation applies to fields that are both significantly liquid as well as fields that are significantly gas dominated?
A. That's right, that's right.

Page 97:19 to 99:02

Q. Yep. So you're not aware of the error measurements that Mr. Miller was referring to in Exhibit 11039, correct, Dr. Schulkes?
A. That's right, that's correct.
Q. But you did just refer us to error measurements that were described in Exhibit 11002; is that correct?
A. Yeah, that's based on our internal work.
Q. Okay. Are there -- there any other papers that Statoil or -- or someone else have developed that have assessed the -- the accuracy of the Hydro model beyond this 2003 paper that we were discussing?
A. No. We -- we published two papers some ten years ago on this topic and -- well, we -- this particular model has been implemented in other -- other codes and has been applied in a lot of codes and we have not -- but we have not seen these are the assessment of -- of the particular model based on a comparison with data because what is special here is --
THE REPORTER:
Comparison with what?
THE WITNESS:
Comparison with data.
A. The -- the value of such models is -- or the accuracy of such models is to a large extent determined by the quality of experimental data which you have available in order to test these models. And -- and high-quality multiphase flow experimental data is not readily -- readily available. There's very few -- very few such data sets.

Page 99:04 to 101:04

Q. Thank you, Dr. Schulkes.
I'd like to talk now about the -- the different people that were involved at

Statoil or were contractors for Statoil that were performing the work for Mr. Miller at Lawrence Livermore.

So can you describe what your role was for this project?

A. My role in this particular case was basically to assure that work was done in -- in -- in -- in such a way that Statoil could stand behind the work. And I had been -- in initial case, I was involved in the nondisclosure agreement discussions.

And after that I was -- it was basically Reidar Schuller who is the most knowledgeable person on this particular topic. Reidar Schuller was the guy who was doing the actual work.

Q. You're -- you described your role as making sure that Statoil could stand behind the work. What do you mean by that?

A. When we get a request like this, we want to make sure that when we give an answer, that the answer is as good as we can get given the information we have received.

Q. So you were involved in making technical decisions about the work that Dr. Schuller was performing?

A. No, I was not. But I was involved in -- in discussions related to giving extra resources in -- to understand this problem.

THE REPORTER:

Extra what?

THE WITNESS:

Resources.

A. It -- it became clear to us fairly quickly that this is -- it was not just a question about a choke but that it was -- there were fairly large other restrictions in the pipe. And once we found that out, we had to try to understand sort of the -- the complexity in the system.

And at some point we then decided to engage one other person in this project to help us with performing so-called computational fluid dynamics simulations.

EXAMINATION BY MS. SALTZBART:

Q. And who was that person?

A. That person was -- is called Atle Gyllensten.

Page 101:12 to 101:20

Q. Okay. Thank you.

And what specific calculations did Dr. Gyllensten perform?

A. He -- he got a geometry from Reidar

Schuller, which was based on the information we had received from Wayne Miller, and the geometry which he handed over to the Statoil Atle Gyllensten or I'm not quite sure where (inaudible) --

Page 102:19 to 106:07

00102:19 Q. So I apologize, but I think we're going to need you to restate the -- the answer that you were just providing for the work that Dr. Gyllensten was performing. You had explained that he received the geometry from Dr. Schuller and that Dr. Schuller had gotten the geometry from Mr. Miller.
00103:01 A. So if you refer to Tab 18, you will see a handwritten note in -- in Norweigian and --
Q. Okay. Let me stop you there, Dr. Schulkes. This exhibit number is 11017; is that correct?
A. Yes.
Q. Okay. Thank you.
A. In this handwritten note, Dr. Schuller has made a sketch of a flow system which is a simplification of the -- of the flow system which we were asked to look at by Wayne Miller.
In this particular sketch, what you see is basically an input section where it says flow --
THE REPORTER:
A what section?
A. -- and an arrow --
An input section where it says flow and an arrow pointing to the right, and then you have a -- a pipe section, and at the point marked with A, there is what is called a gasket. And after the gasket you have a 3-inch pipe section again. And at the Point B, that's the point where the -- the choke is located. And the
00104:01 downstream from the choke you have, again, a 3-inch pipe section.
When we were asked to perform the choke calculations by Wayne Miller, initially we were in the impression that it was just a choke which was causing flow -- which was the cause of flow restriction. But when we obtained a drawing and we saw that there were quite significant flow restrictions upstream the choke, we wanted to understand the influence of these flow restrictions.
So at some point Reidar Schuller, he asked if he could use Atle Gyllensten --
THE REPORTER:
Use what?

A. -- to --
THE WITNESS:
He asked -- he asked if he could use Atle Gyllensten to perform --
MS. SALTZBART:
A-t-l-e.
THE WITNESS:
-- form calculations --
MS. SALTZBART:
And then G-y-l-l-e-n-s-t-e-n.

00105:01 EXAMINATION BY MS. SALTZBART:
Q. I'm sorry, Dr. Schulkes.
A. -- to perform flow calculations on -- on this geometry to try to understand where the flow restrictions were in the system. And that's where -- what my role was when -- when Dr. Schuller asked to have extra resources to do additional calculations. I was -- given that i own the resources, he asked me if he could use Atle Gyllensten to perform these additional calculations.
Q. Okay. So Dr. Gyllensten was performing the calculations of the upstream features of the choke line, so -- such as the -- the gasket and the -- the 3-inch pipe?
A. Yes.
Q. Okay. And -- and so Dr. Schuller himself did not perform those calculations; is that correct?
A. No, because that is a different type of program. That is a program called Fluent. And Dr. Schuller is not an expert on using Fluent, so he asked another person to perform these calculations.
Q. And did Dr. Gyllensten also perform
00106:01 calculations using OLGA?
A. I don't know. I'm not sure if we did the OLGA calculations. I think it was Reidar -- Dr. Schuller who did those, but I -- I'm not quite sure who did those calculations.
Q. Okay. Whose handwritten notes are these in -- this was Tab 18, Exhibit 11017?

Page 106:12 to 106:13

00106:12 A. It's the handwriting of Dr. Schuller.

Page 106:16 to 108:04

00106:16 So I -- I think you took us to this tab so that you could describe to us the role that Dr. Gyllensten had in -- in performing calculations for the Wayne Miller/Lawrence Livermore project. Is -- is that correct? Is

that why you took us to this tab?
A. No. You -- you asked me what -- what my role was in this -- in this particular project, and I described that I had -- my role was to give the green light to use additional resources to address the -- the question which we had received from Lawrence Livermore. Initially, Dr. Schuller was the only person working on this topic, but when Dr. Schuller found out that the project -- the -- the physics in the problem was more complex than he envisaged before, he asked if he could use additional resources to understand the physics in this particular problem.
Q. Okay. And Dr. Gyllensten is a Statoil employee?
A. He is.
Q. Okay. And you're -- you -- you know that he performed the Fluent calculations; is that correct?
A. Yes, because Dr. Schuller asked me if -- if Gyllensten could perform this task.
Q. Okay. What about Dr. Elseth, E-l-s-e-t-h? What role did he have in -- in the project?
A. None whatsoever.
Q. Okay. And we mentioned Dr. Selmer-Olsen previously. What -- what role did he have in -- in the work?
A. As far as I know, he may have had some discussions with Dr. Schuller to maybe help Dr. Schuller to understand the problem. But as far as I'm aware, Dr. Selmer-Olsen did not do any calculations on this particular problem.

Page 108:18 to 108:25

Q. Okay. And is that marked Exhibit 11014?
A. It is.
Q. Okay. This is a -- an e-mail from Mr. Miller on August 6 to Dr. Schuller, and you're copied and Dr. Selmer-Olsen's copied as well; is that correct?
A. That's right.

Page 109:07 to 113:10

Q. Okay. Is -- is this transmitting the -- the information that Statoil needed in order to begin work on the project?
A. I believe it is.
Q. Okay. Did Statoil begin work on the project on August 6th?
A. I'm not quite sure when

the nondisclosure agreement -- agreement was signed, but we were ready to go after the NDA was -- was signed, and I believe that it was in place on August 6th, but I -- I don't have the details of these dates in my head.

Q. Okay. Well, I think actually if you go down to the bottom of this first page, the -- you'll see the details, the e-mail from Mr. Miller to Dr. Schuller and you're copied, and Mr. Miller --

A. Yeah, okay.

Q. Okay. Okay. So the NDA had been signed, and then on the 6th you received this e-mail -- or you were copied on this e-mail; it was sent to Dr. Schuller. So your -- Statoil's work would have either began on this day or shortly after that?

A. Yeah, it would have -- it would have, yes.

Q. Okay. I'd like to turn the second page of this document, please. And I'd like to direct you to the e-mail that starts towards the bottom half of the second page from Dr. Schuller on July 18th to Mr. Miller. You're copied.

A. Uh-huh.

Q. Okay. Now, Dr. Schuller writes a couple of lines down, "In order to run the model, I will require the following:

"1. Fluid information. We normally obtain this from a PVTSim fluid description. If you can send me a PVTSim-file, I can use this to generate the required input to the choke model. If you do not have a PVTSim-file, we must discuss how I can generate a suitable fluid input file."

Did I read that correctly?

A. Right.

Q. Okay.

No. "2. Mass fractions of each phase (gas, oil, water) at the choke inlet. (You state mass ratio 70/30 oil/methane, but is this at the upstream choke position? I expect that a significant amount of gas also flashes from the oil phase as a result of the pressure drop.)"

Did I read that correctly?

A. Yes, you did.

Q. Okay. The third item:

"Choke geometry information: CV-curve (I have received this) and information about the hole sizes in the plug and cage geometry."

Did I read that correctly?

A. You did.

Q. "4: Oil viscosity information."

Did I read that correctly?

A. That's right.

Q. Okay. And then: "5. Your

calculation" may -- "matrix (upstream pressures, upstream temperatures, phase mass fractions at choke inlet, valve openings, downstream pressures...)
"I look forward to receiving more information."
Did I receive -- read that correctly?
A. You did.
Q. Okay. Do you know if Statoil received everything that Dr. Schuller requested in this e-mail that we just read through?
A. He would have done; otherwise, he wouldn't have started the calculations.
Q. Okay. Thank you.
Let's turn to Tab 22, please. Okay. And that should be marked Exhibit 11021.
A. Correct.
Q. Is that -- okay. This is an e-mail -- e-mail from Dr. Schuller to Mr. Miller on August 19th, and you're copied and -- and Dr. Selmer-Olsen's copied. Do you see that?
A. I do see it, yes.
Q. Okay. Dr. Schuller wrote, "Dear Wayne" We've "generated fluid property input for the Hydro choke model, and the model runs fine. The mass flow rate through the choke can readily be calculated for different pressure differences, upstream pressures, valve openings, gas mass fractions, etc.
"However, the problem seems to be more complex than just choke behaviour. The geometry of the piping system with a contraction upstream of the choke and 3" diameter pipes both upstream and downstream the 4" choke may cause situations where the flow rate is controlled by other parameters than only the choke opening.
"We are presently looking into this, but have not yet concluded."
Did I read that correctly?
A. You did.

Page 114:15 to 114:24

Q. Okay. So, again, we're focusing on the second paragraph here that starts with "However," and I want to make sure that I understand what it is that Dr. Schuller is explaining in this paragraph.
Is he saying to Mr. Miller that the geometry of the choke line itself, not -- not the valve, but the geometry of that line is complicating modeling flow through the choke line?

Page 115:02 to 115:06

00115:02 A. What he's saying is that in addition
03 to the choke, which we're asked to look at, there
04 are significant sources of pressure loss in the
05 line and that we have to understand these --
06 these sources of pressure loss.

Page 115:08 to 115:18

00115:08 Q. And -- and that's what he means by
09 "may cause situations where the flow rate is
10 controlled by other parameters than only the
11 choke opening"?
12 A. That's right.
13 Q. Okay. And -- and given that
14 Dr. Schuller has concerns about these other
15 parameters that may be causing situations that --
16 that are controlling the flow rate separate from
17 the valve, what effect did that have on the --
18 the use of the Hydro model for this --

Page 115:22 to 115:22

00115:22 Q. -- particular flow rate calculation?

Page 115:25 to 116:10

00115:25 A. It did not in a way directly have an
00116:01 effect on the Hydro model. It just meant that
02 what -- what we are experiencing here, that in
03 order to answer the question of how much is
04 coming out of the -- out of the line given the
05 pressure difference we are given, it is not only
06 the choke which is contributing to this -- or is
07 determining what's coming out, but there are
08 quite significant other effects which are
09 determining what -- how much gas and liquid is
10 flowing out of the line.

Page 116:12 to 117:06

00116:12 Q. And is the Hydro choke model capable
13 of modeling these other pressure losses in the
14 choke line of the capping stack?
15 A. No, it -- as -- as we understand the
16 problem, we -- we -- we currently we do not have
17 any simulation at all which is able to model the
18 entire system as we were given.
19 Q. Currently Statoil does not; is that
20 correct?
21 A. No. We do not believe the industry
22 has this.

Q. You don't believe that industry has modeling capable of -- well, let me -- let me rephrase that.
You don't believe that there's any models that exist today that are capable of modeling flow through the choke line of the capping stack which included the 3-inch pipe, the gasket, and the choke valve? Am I understanding you correctly?

Page 117:09 to 117:11

A. That's right. The combined effect there is -- is beyond what we feel we can handle with current simulators.

Page 117:13 to 120:12

Q. Let's turn to Tab 28, please. And this is marked Exhibit 11027. This is an e-mail from Dr. Schuller to Mr. Miller on August 25th, and both you and Dr. Selmer-Olsen are copied.
Do you see that?
A. Yes.
Q. Okay. Are you familiar with this e-mail?
A. I am.
Q. Okay. I'm just going to read from the beginning parts of this. It says -- oh, before I do that, I also want to point out the subject is Hydro choke model, and there's an attachment with the file name "flow rate predictions.jpg"; is that correct?
A. That's right.
Q. Okay. "Dear Wayne: I am sorry for the delay in giving you some answers to your questions, but below you will find some results from calculations and some comments to the complexity of the flow problem."
Did I read that correctly?
A. You did.
Q. Okay. He goes on to write: "The information from the choke manufacturer shows that the openings in the choke valve are equivalent to a circular hole of 0.0984 m (approximately 4"). Both the upstream and downstream piping are smaller than this (3" diameter), and there is also a restriction (the gasket) of 2.53" diameter upstream of the choke. The cross-sectional flow area of the upstream restriction is 42% of the maximum choke opening, and the 3" diameter pipes have a cross-sectional area of 60% of the maximum choke opening. Based on this the flow rate must become less sensitive to changes in choke opening when the opening is

larger than approximately 50%."
Did I read that correctly?
A. You did.
Q. Dr. Schulkes, I'd like to focus on the very last sentence in that paragraph. It starts with based on this flow rate -- "Based on this the flow rate." Do you see that sentence?
A. Yes.
Q. What did Dr. Schuller mean in this sentence?
A. We are back to the discussion we had a bit earlier about these -- about the equivalent flow area in the choke when it's fully opened. When the choke is fully opened, it has the -- a flow area which is equivalent to a pipe with a diameter of 4 inches. When the choke is approximately 50 percent open, it has a flow area equal of Y with a diameter of about 3 inches.
So our opinion is that once the choke opening exceeds about 50 percent, it's a bit difficult to be exactly because we really haven't done any sort of detailed calculations yet. But once the flow area of the choke -- once the choke opening exceeds 50 percent, it is our opinion that opening the choke further has a marginal effect on the flow rate through the choke.
Q. So if the -- the 3-inch pipe is both upstream and downstream of the -- the CC40 choke, why would you model this system with the choke valve open larger than 50 percent?
A. Well, we don't. We're -- basically that was what we -- the result which was given to Lawrence Livermore is based on simulations where the choke is only 50 percent open. Because we -- in our opinion it -- it's -- it's meaningless to open it further. It doesn't give less flow restrictions.

Page 120:16 to 120:24

Q. And this appears to be the document that was attached to Dr. Schuller's e-mail on -- on August 25th. Would you agree with that?
A. That's right.
Q. Okay. I -- I just want to make sure I understand, because it looks like you plotted the choke opening on the horizontal from 0 to -- to 100 percent?
A. Yeah.

Page 121:02 to 122:03

Does the 100 percent represent the choke fully open?

A. No. What we have done here is you see that the -- the crosses, they go up until you reach 50 percent choke opening, right, and then you get a kink in the curve and the -- the -- the remaining crosses, they flatten out.

So what is done in these calculations is that we assume that opening the choke beyond 50 percent does not any -- have any effect. So when the choke opening exceeds 50 percent, we keep the choke opening at 50 percent, but in -- in the information received -- we received from Wayne Miller, we got two columns of information: One was the choke opening and one was the pressure upstream -- upstream to choke.

So what we did in our simulations is once the choke opening exceeded 50 percent, we kept the choke opening at 50 percent, but we increased the pressures -- we -- we modified the pressures in relation to the mail which was -- in -- in relation to the values which we received from Wayne Miller.

I would have to find the -- the mail which we received from Wayne Miller in order to explain it more clearly, I think.

Page 122:07 to 123:04

Q. I just -- I just want to make sure because I think I'm still a little confused. Even though this is showing 100 percent open, your -- it's your testimony that the -- the valve when you modeled it wasn't 100 percent open?

A. That's right, because we felt that there was no -- that -- that it's unreasonable to increase the flow area of the choke more than the available cross-sectional flow area of the pipe upstream and downstream to choke.

Q. So what are you representing here with that cross at the 100 percent open?

A. At 100 percent open, what we were representing there is a choke which is -- has the flow area which is equivalent to a 3-inch pipe downstream to choke, but the pressure upstream to choke was given in the -- in an e-mail from Wayne Miller or in the information we received from Wayne Miller.

Q. All right. So effectively what the 100 percent open is representing in this figure is 50 percent open, so it -- so it's equivalent to the 3-inch pipe?

Page 123:07 to 124:06

A. Yeah, because we -- we feel -- our

opinion, and it's very strongly, that you cannot -- you cannot possibly have a opening -- you cannot make a choke which -- which locally increases the pipe diameter.

I mean, basically that's what we say, right, if you -- you have 3-inch upstream, 3-inch downstream, and in between the upstream and the downstream pipe, there is something which suddenly increases -- increases the area of the pipe. Well, that's -- that's unphysical. I mean, there is a restriction there, and this restriction, whatever you look -- whatever way you look at it, this restriction cannot take away -- pretend that -- that there is no -- that -- that the restrictions are there.

And if we say that the -- that the area of the choke is larger than the available pipe, then we are sort of taking away restriction. I mean, this is -- this is not physical. There is no way in which you can remove the restrictive influence of something which is placed inside a pipe even though it's got a number of holes which added together give the flow area which is larger than the pipe.

Page 126:24 to 130:04

Q. Dr. Schulkes, we were -- we were talking earlier about the second paragraph and the -- the last sentence that started with: "Based on this the flow rate must become less sensitive to changes in choke opening when the opening is larger than approximately 50%."

In what way does that represent the gasket?

MR. CERNICH:

Objection, form.

A. Well, in -- in what way does it represent the gasket?

EXAMINATION BY MS. SALTZBART:

Q. Right, because the gasket is actually smaller than the 50 percent, right?

A. The gasket -- yeah, but I mean, we're modeling the choke here, we're not modeling the gasket, right?

Q. But you've limited -- your testimony today is that you've limited your model to 50 percent open to reflect the upstream and downstream piping, correct?

A. Yes.

Q. Okay. In what way does your model reflect the gasket in that choke line?

A. Well, it doesn't. I mean, we -- we -- we have looked at the -- the system where -- with -- with the gasket included.

When -- when we look at these fluid calculations, these computational fluid dynamics calculations, that is the only system in which the gasket was included.

But in our choke calculations, we cannot include the gasket because that's an obstruction --

THE REPORTER:

Wait, wait, wait. Excuse me. I'm sorry. I'm sorry. Could you slow down.

"In our choke calculations we cannot"?

THE WITNESS:

-- includes the gaskets because that's an obstruction which is entirely separate from the -- from the choke we are looking at.

THE REPORTER:

Thank you.

EXAMINATION BY MS. SALTZBART:

Q. Could you have -- so in your -- in your model you're not accounting for the 3-inch piping itself, but you're accounting for the 3-inch pipe by way of limiting the choke opening; is that right?

00129:01 A. No, that's not correct. We are -- in the model we specify the upstream pipe diameter, we specify the downstream pipe diameter, and in between there is -- there is flow restriction. And this flow restriction is -- is a restriction whatever way you look at it.

Even though the combined flow area of the holes in the choke exceeds the flow area of the pipe upstream and downstream to choke, the choke is still a flow restriction. I mean, we cannot pretend that placing an object in the -- in the -- in a pipe suddenly reduces the pressure drop in the pipe. I mean, this is quite a significant obstruction in the pipe.

And -- and basically what -- what we're saying here is all -- if you -- if you have an obstruction in the pipe, even though you made the combined areas of the holes larger than the pipe diameter up or the pipe area upstream and downstream, it's still an obstruction. I mean, you -- it's still obstructing the flow.

Q. Is the gasket a limitation to flow in the choke line?

A. Yes, it is.

00130:01 Q. And is the gasket a smaller diameter than the 3-inch piping that is both upstream and downstream of it?

A. It is.

00130:08 Q. But your model does not represent
09 the geometry of the gasket, correct?
10 A. We can -- with our model we would
11 have been able to compute the pressure drop over
12 the gasket in quite an easy way because that's an
13 orifice choke.
14 Q. If the gasket is 42 percent of the
15 maximum choke opening, why wouldn't you limit the
16 choke to 42 percent rather than 50 percent?
17 A. We could have. I mean, we did a lot
18 of discussions on what -- what is -- what -- what
19 should the opening of the choke be, at which
20 point it still gives meaningful results. And --
21 and we chose the opening of the choke to the
22 value, which when the flow area in the choke is
23 equivalent to the flow area in both upstream and
24 downstream of the choke, that's -- that's where
25 we said the maximum flow opening should be --
00131:01 should be that.
02 We felt that opening the choke
03 further and increasing the available flow area
04 into the -- into the choke doesn't -- it doesn't
05 decrease the -- the resistance, because the
06 resistance then translates to other positions in
07 the choke and no longer in the holes.
08 Q. But isn't -- doesn't the gasket
09 serve as a -- a limitation on the -- on the flow
10 through that line?
11 A. Oh, yeah, absolutely.
12 Q. So if you're representing the -- the
13 3-inch pipe by limiting the choke valve to
14 50 percent open, why didn't you represent the
15 gasket by limiting the choke valve to 42 percent
16 open?

Page 131:19 to 132:06

00131:19 A. I -- I have not been part of the
20 detailed, scientific discussions, which have
21 ongoing -- which have been ongoing in relation to
22 determining whether we should use 40 percent or
23 50 percent of -- of the choke opening on the --
24 on the -- the cage choke or the CC40 choke.
25 I think that there may be -- there
00132:01 may be something to be said for reducing it
02 further; I don't know. I mean, there -- it's not
03 a -- it's a very -- it's an incredibly
04 complicated system, and there's no clear-cut
05 answer as to what should be done in this
06 particular case.

Page 132:08 to 135:24

00132:08 Q. You would agree with me that the

gasket is a fixed geometry in that line, correct?
A. Yeah.
Q. And you would also agree that the gasket has a smaller diameter than the 3-inch pipe upstream and downstream of it?
A. That's right.
Q. Okay. Who made the decision to open -- or to limit the choke opening to 50 percent to represent the 3-inch pipe?
A. Dr. Schuller.
Q. Did you discuss with Dr. Schuller in your preparation for your testimony today why he made that decision?
A. Yes. Spent a lot of time on that.
Q. Okay. Can you -- can you summarize those discussions for us?
A. I've -- I've been trying to. I must say when I -- when I started reading the -- the report and I was probably as confused as you are as to what had happened there.
But afterwards I -- I understood the fact that maybe what you -- what you -- what you have to do is to accept that there is a -- there is a pipe and inside the pipe there is a -- there is a restriction. This is the CC40 choke, right?
This restriction causes a pressure drop whatever you do. You can make a restriction with many holes in it which have a combined flow area larger than the diameter upstream and downstream from the -- from the choke, but still there is a restriction in the pipe.
And if you have combined holes with a flow area which is larger than the diameter of the pipe, what happens is that the flow restriction in the choke moves to a different point. And if you -- if you, for example, ever -- this -- this cage choke geometry, you have -- it is -- it is a -- it's a bit of pipe which is concentric to the -- to the 3-inch pipe.
I'm not sure if you can read -- look at the -- the diagram of this particular choke to try to explain -- yeah, it's -- I mean, if -- the thing is -- what I'm trying to say is you cannot get something out of nothing. I mean, if you -- you cannot make a choke which has less restriction than you have in a plain pipe. You -- you will agree with that?
Q. Well, I'm -- I'm interested in -- in the decision to use 50 percent as opposed to a 42 percent.
A. Or 60 percent. I mean, there is -- there is -- there's some scientific judgment which -- which lies behind this -- this choice. And we -- we have based the 50 percent on the fact that when this choke is 50 percent open and has a a flow area which is equivalent to the

3-inch pipe, that -- that's the motivation for the 50 percent.
Q. I understand that. Do you -- did you speak with Dr. Schuller about why he didn't choose the -- the 42 percent, which would approximate the diameter of the gasket that was a fixed geometry in that line?
A. It's an entirely different -- different obstruction. It's completely separated from the job. So I mean, there would be no reason to actually use that because that's a -- that's a pressure loss effect which happens quite a few pipe downs -- upstream from a choke.
Q. You don't think that the -- the small -- the gasket is the smallest diameter in this line; is that correct?
A. Yes, that's right.
Q. Okay. And all flow has to pass through that -- that -- the smallest diameter?
A. Yeah.
Q. And that doesn't serve as a limitation to flow on -- in this line?
A. It does, absolutely.
Q. Is it your --
A. You have -- you have additional limitations, right? You first have the gasket where you could have pressure loss over the gasket, and then you get the choke, then you get pressure loss over the choke. And then you get the pipe, it's downstream from the choke, where you also get a pressure loss. There's many sources of pressure loss in the system. And what we were asked to do is to estimate what is the pressure loss over this particular choke we're looking at.

Page 136:11 to 136:14

Q. So why doesn't the gasket control the flow through this line?
A. Well, the gasket has enormous influence on the flow.

Page 136:22 to 136:24

A. It has -- the gasket has a significant influence on what -- what is flowing through the line.

Page 137:09 to 137:10

Q. It's Exhibit 11033; is that correct?
A. That's right.

Page 138:18 to 141:01

00138:18 Q. And these Fluent calculations were
19 for a single-phase fluid; is that correct?
20 A. That's -- that's correct.
21 Q. Okay. Dr. Schulkes, you were -- am
22 I pronouncing your last name correctly?
23 A. I don't think you would be able to.
24 Q. I apologize for -- for
25 mispronouncing it.
00139:01 So we -- we've been discussing
02 the -- the model that you prepared that -- that
03 Dr. -- that Mr. Miller is -- is describing in
04 this -- I'm sorry, that Dr. Schuller is
05 describing to Mr. Miller in this second
06 paragraph.
07 And I think Mr. Miller had asked
08 Statoil to prepare a model of the entire choke
09 line; is that correct? Was that your
10 understanding that you were asked to model the --
11 the choke line including the choke valve?
12 A. Well, I'm not sure. I think we were
13 asked to look at the -- at the CC40 choke. But
14 when we were given the information from -- from
15 Dr. Miller, we found out that the system is much
16 more complex than just the -- this CC40 choke.
17 There are significant flow restrictions both
18 upstream and downstream the -- the choke valve we
19 were asked to look at.
20 Q. And -- and you became aware of the
21 complexities of the features on this line because
22 of the -- well, you received the -- the
23 schematics that showed you how this line was
24 actually put together?
25 A. That's right.
00140:01 Q. Is that right?
02 Okay. And then you engaged in -- in
03 modeling with Fluent to try to understand what
04 other features in this line may control the flow
05 rate?
06 A. That's right. We were -- the A
07 model Fluent calculations was to have a more
08 full -- a more complete understanding of where --
09 of the contribution of the different restrictions
10 in the system.
11 Q. And that included the gasket,
12 correct?
13 A. That's right.
14 Q. Okay. And that also included
15 frictional pressure losses in the 3-inch pipe?
16 A. Yeah.
17 Q. Okay. Dr. Schulkes, you see a
18 paragraph that starts with "Calculation" -- I'm
19 sorry. We're back on Tab 28, Exhibit --
20 A. Uh-huh.

Q. -- 11027. And you'll see a paragraph, it looks like it's the fourth paragraph down, that starts with, "Calculations with a stand-alone Hydro choke model have been made with the following assumptions"?
A. That's right.

Page 141:06 to 142:06

Q. Do you know if Dr. Schuller had to assume a contraction coefficient, also referred to as a CC?
A. I am not aware of that, but he may have. I would assume that he stated here all his -- all his -- all his assumptions.
Q. Would you need a contraction coefficient if you didn't have experimental data?
A. If you -- you can -- based on -- on information we have received from -- from Wayne Miller, I think you can assume -- you can make assumptions about what sort of choke you have.
Q. Okay. So you didn't need to assume a particular contraction coefficient for this particular application of Hydro?
A. You shouldn't if you can use the contraction coefficients which are -- which are used standard.
Q. I'm sorry, they're standard?
A. Well -- I mean, for a given -- for a given choke, you have these contraction coefficients, and I believe that this information was supplied to Reidar Schuller by Wayne Miller.
Q. Okay. And it's just not reflected as an assumption listed in one of these bullets?
A. That's right.

Page 147:19 to 150:17

Q. Well, it looks like if you went from 3374, which is at 50 percent open, to 100 percent open, you --
A. Yeah.
Q. -- you kept -- you kept the gauge -- I'm sorry, you kept the valve set at 50, but you used pressures that reflected 100 percent open, correct?
A. Yes.
Q. Okay. And I'm just trying to understand why -- why you would have done that. Why -- why didn't you just stop your model with the data that you had at 50 percent open if -- if --
A. Well, I assume -- but I'm not sure. I assume that the gauge pressure values, which are listed at this table, are based on the

shut-in test. So these gauge pressures are actually measured. So that's what we -- I mean, the -- there are many uncertainties here, but we assume that the measured gauge pressure is one of the few uncertainties we're actually dealing with.

Q. What other -- you just said there are many uncertainties here. What other uncertainties can you identify?

A. You -- are you talking about the whole system now or what are you -- which...

Q. I'm just wondering what you meant when you said there are many uncertainties here, but you felt the gauge pressure wasn't one of them.

00149:01 A. Well, if we look at the system where we are basically dealing with -- if -- if you -- looking at the -- the data supplied by Wayne Miller, but look on the -- on the previous page where it says "Choke Line Schematic," in this particular system, we are trying to model how much fluid flows through this complex system, right?

And in this complex system here, we have a succession of 3-inch pipes, we have a gasket, we have bends, we have an outflow into the open -- open sea. And in order to model this particular system accurately, you would have to know everything with a reasonable degree of accuracy. And that also means that you have to understand what is the pressure loss in the bends. What is the -- in our calculations, we have been given an -- an outflow pressure which is essentially the -- the pressure on the bottom of the sea. But we know that in -- in the case where you -- where fluid flows from a pipe into an open space, there are -- the pressure picture around this outflow system is very complex. And we probably do not -- we do not think that the pressure boundary condition which we have been

00150:01 given is necessarily a very accurate pressure condition.

So there are quite a few effects in the system here which introduce uncertainties. And these relate to the bends, these relate to the -- the detailed complex physics in this particular choke. They relate to pressure losses in the downstream area of the choke or the -- the movement from the fluids -- of the fluids from the 3-inch pipe into the open sea. There are many, many complicated issues here which we are really struggling to have a good answer on.

Q. Did -- did you try to -- to try to estimate or bound the uncertainties that you just identified with -- with modeling this choke line of the capping stack?

17 MR. CERNICH:

Page 150:19 to 152:01

00150:19 A. What we did is when we received this
20 information from the Lawrence Livermore
21 laboratory with this schedule of what the
22 geometry looked like and we understood that the
23 system was more complex than just choke which we
24 were -- we were -- we thought we were asked to
25 look at, we did additional calculations with
00151:01 fluids -- Fluent to understand where -- what is
02 the contribution of the different restrictions.
03 We did calculations with a program called OLGA,
04 which is a multiphase flow simulator with the
05 same purpose to try to understand what -- what is
06 happening in the system in addition to doing
07 calculations with a Hydro choke model.
08 So we -- we had not done a -- sort
09 of a detailed error analysis of how accurate we
10 believe our result is, but we've done a
11 significant amount of additional work to try to
12 understand the physics in this very complex
13 system.
14 Q. You identified at -- at least three,
15 possibly four, different factors that -- that add
16 to or contribute to uncertainty with flow rate
17 calculations of this line. You talked about
18 bends, you talked about complex -- complex
19 physics, pressure losses downstream. Is that --
20 is that correct? Am I recalling your testimony?
21 A. That's right.
22 Q. Okay. Are you able to -- do you
23 have any type of sense based upon your
24 substantial experience in this area what kind of
25 uncertainty you could ascribe to modeling flow
00152:01 through this line?

Page 152:04 to 153:08

00152:04 A. Well, I can refer to some of the
05 papers which -- which we discussed earlier.
06 The -- one of the -- for example, the paper in
07 Exhibit 11 -- 11002 where we have -- where we
08 discuss experimental results from our flow loop.
09 And we see that in a case where we basically have
10 full control, we know what goes in, we know what
11 goes out. We have accurate pressure
12 measurements. We have a very accurate choke
13 which we are working with.
14 And with this particular system
15 where we basically have full control over what
16 we're doing, we still see that we have a -- an
17 area of about 5 percent. That's what is shown in
18 Figure 11.

EXAMINATION BY MS. SALTZBART:
Q. I'm sorry, Dr. Schulkes, I just want to -- to get to Figure 11 quickly. And -- and that's for the modified slip?
A. That's right.
Q. Okay. And that -- again, that's -- that's for a -- a very well-controlled and designed experiment?
A. That's right.
Q. And --
A. That's right.
Q. -- the -- the geometry in -- in these experiments, did it have piping with diameters that were larger than -- than the choke valve on the line?

Page 153:11 to 153:25

A. This -- that was not the case. In these experiments we had upstream/downstream piping with the same diameter, we had choke valves with a flow area which was less than the pipe. And we had accurate pressure measurements. We had very accurate flow measurements.
So in this case we know -- basically know everything with a high degree of precision. And we see that in a system like that we're still dealing with accuracies -- inaccuracies of, yeah, 5 to 8 percent.
EXAMINATION BY MS. SALTZBART:
Q. I'm sorry. 5 to 8 percent?
A. Well, that's what you -- if you look at the error bars in this --

Page 154:06 to 154:11

Error bars.
A. Or these -- these -- these bar -- these -- what's it called -- these bar diagram in Figure 11. It's in -- in the range of what, somewhere below 10 percent but between 5 and 10 percent.

Page 155:10 to 155:21

Q. All right. So, then, let's -- let's talk about -- I -- I understand that you didn't do any particular type of uncertainty analysis for your calculations. But, again, based -- based upon the experimental data that you have for a very well-controlled, carefully designed system, you still had somewhere in the range of 5 to 8 percent.
Do you think that uncertainties for

flow rate calculations for the choke line of the capping stack that was installed on the Macondo well would be more than, let's say, 10 percent?

Page 155:24 to 156:08

A. My -- and this is -- this is done extrapolating from what I know on -- on -- of our system, but I would imagine that the uncertainties we're dealing here are significantly larger than 10 percent.
EXAMINATION BY MS. SALTZBART:
Q. 20 percent?
A. I would guess that they are closer to 20 percent than 10 percent.
Q. Above 15 percent?

Page 156:11 to 157:02

A. I mean, it's -- it's difficult to give an answer. As I said, we're -- we're dealing with exceedingly complex systems, and I have not done an analysis of the different contributions of the sources of error which -- which contributes significantly here.
But, again, based on -- on our experimental experience with a very well-controlled system where we know everything and we're still dealing with inequities of, say 5 to 8 percent.
Then in the current case, we're discussing where we are dealing with uncertainties of many -- at many places and many forms, I must conclude that there are -- uncertainty in -- in those calculations are significantly larger than what we're seeing here.

Page 157:04 to 157:18

Q. Okay. Dr. Schulkes, did -- do you know if -- if Mr. Miller ever asked about any uncertainties associated with the calculations that you performed for Lawrence Livermore?
A. No, he did not. We gave our results in the mail, which is the dated 25th of August, I believe. And I think Reidar Schuller, he received a short mail saying thank you. But other than that there's been no discussion of the results whatsoever.
Q. Did Dr. Schuller discuss with you any concerns he may have had about not communicating any uncertainties associated with your calculations to Mr. Miller?
A. No, he did not.

Page 158:05 to 159:04

00158:05 Q. Dr. Schulkes, we were previously
06 discussing the exhibit at Tab 28 marked 11027.
07 And I'd like to continue with some questions on
08 this document. Okay. And we were discussing
09 earlier the -- the bullets in the fourth
10 paragraph are the assumptions that Dr. Schuller
11 used, and it's possible he used a -- a
12 contraction coefficient and didn't list it here.
13 Otherwise, you felt that this was a complete list
14 of the assumptions that -- that he had made for
15 his model; is that correct?
16 A. I would believe so, yes.
17 Q. Okay. Do you know if Dr. Schuller
18 varied any of these assumptions in any of the
19 modeling runs that he performed?
20 A. Well, he did significant variations
21 on the choke diameter. Other than that I think
22 he -- he used the assumptions as they are listed
23 here.
24 Q. Did he perform any type of
25 sensitivity analyses?
00159:01 A. As far as I'm aware, he did not.
02 Q. If he had done that, would he have
03 documented his work?
04 A. He certainly would have.

Page 159:11 to 159:13

00159:11 Q. Is performing a sensitivity analysis
12 by varying parameters, is that a way of
13 understanding uncertainty with a model?

Page 159:16 to 160:10

00159:16 A. It is, but you only address a very
17 specific part of the uncertainty.
18 EXAMINATION BY MS. SALTZBART:
19 Q. And -- and that specific part would
20 be the -- the parameter that you're varying?
21 A. Well, it's -- it's -- as I indicated
22 before, there are uncertainties related to -- to
23 bends. There are uncertainties related to
24 outflow pressure. There are uncertainties
25 related to how much -- what are the exact value
00160:01 of the gas-liquid ratio is.
02 If he would have done uncertainty
03 of -- run for variations with the model, he would
04 have only addressed uncertainties which are
05 specifically related to the choke model, not the
06 other uncertainties.
07 Q. Oh, I -- I understand. So he would

not have addressed uncertainties with -- with the bends?
A. That's right.

Page 160:13 to 160:15

Q. Is -- is a sensitivity analysis something that Statoil would routinely perform when it's calculating flow through a choke valve?

Page 160:18 to 160:18

A. Not routinely, no.

Page 160:20 to 160:22

Q. In what circumstances would Statoil perform a sensitivity analysis for a flow rate calculation?

Page 160:25 to 161:10

A. I -- I would think that in a situation we are discussing now, that the sensitivity analysis would be part of the -- would be part of the work which we -- which we would do to understand where the uncertainties are and the influence of uncertainties.
EXAMINATION BY MS. SALTZBART:
Q. And is that because in your view there are several factors that contribute to an overall uncertainty with this -- this choke line in its entirety?

Page 161:13 to 164:05

A. Well, as what I've stated before, we -- the choke is -- is only one of the flow restrictions and if you want to say something about the amount of fluid which is flowing through the system, then understanding the different contributions of the various restrictions is -- is important and its associated uncertainties.
EXAMINATION BY MS. SALTZBART:
Q. Would you have done an uncertainty analysis if Mr. Miller had asked you to do one?
A. That's -- that's really a difficult question to answer because the -- the uncertainty analysis requires information which is very difficult to obtain in this case. We will -- I mean, doing an uncertainty analysis or a sensitivity analysis in relation to our model

then would have been relatively easy. But an uncertainty analysis related to the whole system, I think that would have been quite a demanding -- demanding exercise. I think if we would have been asked to do it, it would have taken on the form of a project which -- which had a lot -- much larger scope than what we were asked to do here.

Q. Dr. Schulkes, when you use the term "the whole system," what are you specifically referring to?

A. Well, basically the system which we received from Wayne Miller where we go from -- I think it's a 4-inch pipe to a 3-inch pipe through a gasket, through bends, through the choke, again into a 3-inch pipe, and then flow out to the -- to the open sea. It's that system which we are -- are referring to.

Q. Okay. And it was your testimony that to do an uncertainty analysis for this system that you just described would require information which is very difficult to obtain. Do you remember saying that?

A. Yes.

Q. What information in your view would you need that you felt was difficult to obtain in order to do an uncertainty analysis?

A. Well, we can look at the -- for example, the -- the -- the system where the -- the fluid flows from the pipe into the open sea. There, you have a hydrocarbon system, the system of gas and liquid which flows into the open sea and leads to a significant modification of the flange around -- around the exit of the pipe.

In order to -- basic -- basically what we were given is a pressure -- a pressure value at the -- at the outlet of the pipe. But this pressure value is basically a value which is valid a long way away from the pipe. And close to the pipe, close to the exit, there's lots of dynamic effects, flow-related effects that influence the pressure. And a simple thing like determining the pressure at the outlet is -- is -- is, in fact, quite a complicated question to answer.

Q. Are there other components of this analysis in addition to the -- the exit pressure immediately at the -- the exit at that point -- of the pipe that you think you would need in order to do a more fulsome uncertainty analysis?

A. Yeah, you would --

Page 164:07 to 165:12

Objection, form.

A. Where we've been given the PVT file and we based our calculations on -- on this PVT file. And the PVT basically tells us how much -- what is the fraction of gas and liquid given the -- for a given temperature at a given pressure. But there -- the results -- I -- the results of the calculation was influenced by how much gas and liquid is available.

Uncertainty in the PVT simulations could influence the results. How significant these uncertainties are, I can't state because you have to do an analysis of these uncertainties, a sensitivity analysis. I mean, we -- we've been discussing this choke opening for quite some time now. We chose to have a maximum opening of 50 percent.

How -- how good is that? I don't know. I mean, we could -- could have used 40 percent, could have used 60 percent, maybe 70 percent was better. I don't know. We don't have the information available to tell us what the best choice is. And we made an engineering decision to actually put it at 50 percent because of that fact that is an opening -- gives us an opening which is equivalent to the pipe diameter.

But is that the best choice? We -- we don't know. I mean, a lot -- a lot of work would have to be done in order to quantify these uncertainties or quantify the effects of the choices we have made.

Page 165:14 to 167:08

Q. You mentioned the -- the outlet pressure, PVT data, the choke opening. Are there any other aspects to this -- this system, what you've referred to as the whole system, which is composed of the geometry of the choke line, that you would want to assess as part of an uncertainty analysis?

A. Well, you would have to include pressure loss effects at bends. In a -- in a single-phase flow system this is relatively easy. In a multiphase flow system, this is quite complicated.

Well, probably I think I've listed the most important ones.

Q. How long do you think it would take to do an uncertainty analysis for the -- I think we have a list of at least four different components that you've identified would contribute uncertainty to the flow rate calculations?

A. Well, it was -- I don't know. This is guesswork. But it all -- it would take many

months of work to -- to do such -- such work. And even -- even if you spend that time on it, there are -- there are aspects of this problem which probably would require -- if you really want to do a -- give a fairly accurate uncertainty analysis, you'd probably take -- take years. Some -- some aspects of this problem are just very, very, very difficult.

Q. Okay. I'd like to now move to the -- the next paragraph on this first page of Exhibit 11027. It starts with, "A diagram showing flow rate as a function of choke opening is attached."

It goes on to say, "The calculations for the stand alone choke model do not include frictional pressure drops in the piping systems, so these flow rates are over predicted, especially at larger choke openings."

Why -- why can't the stand-alone Hydro choke model model the frictional losses in the piping?

A. Because it's not a full model for a pipe, it's a full model for a choke.

Page 167:12 to 167:24

Q. And you -- you also did not include the -- the losses from flow through the gasket, correct?

A. That's right.

Q. Okay. So that would be another basis that your calculations overpredicted the flow rate?

A. That's right, that's right.

Q. Was that communicated to Mr. Miller that you -- you had not accounted for pressure losses in -- in the gasket and that that was another basis that your calculations overpredicted the flow rate?

Page 168:02 to 168:12

A. I would have to read the mail which -- which Schuller sent to Wayne Miller. It specified here what -- basically what he says here is in the third paragraph of -- on the next page, "The pressure drop across the upstream restriction, having a flow area of 42% of the maximum choke opening, will be large when the choke opens...."

So basically what he's saying is the main restriction will move away from the choke to the gasket.

Page 168:14 to 168:19

Q. I understand. But does that paragraph clearly convey to Mr. Miller that the results from your stand-alone choke model did not include losses from flow through the gasket and that was another reason why your prediction -- or your calculations overpredicted the flow rate?

Page 168:22 to 168:23

A. Well, I think it's -- it's stated as clearly as it is in this particular mail.

Page 168:25 to 169:05

Q. Okay. And, again, on -- on the first page, Dr. Schuller clearly states that the calculations for the stand-alone choke model did not include frictional pressure drops in the piping systems.
A. Uh-huh.

Page 169:21 to 170:02

Q. You agree that -- that the gasket -- flow through the gasket would result in a -- a pressure loss, correct?
A. Yeah.
Q. And -- and failing to include the pressure loss from flow to the gasket would tend to overpredict flow rate calculations?

Page 170:05 to 170:07

A. Neglecting the flow through the gasket would overpredict the flow rate calculations.

Page 170:10 to 170:12

A. That is -- that is entirely correct. And any additional pressure loss would have reduced the flow rate calculations.

Page 171:01 to 171:05

Q. Would it have been more accurate in this sentence -- in this paragraph, rather, to also identify that failing to include pressure losses from the gasket results in overprediction of the flow rate?

Page 171:08 to 171:25

00171:08 A. Well, I believe it's stated quite
09 clearly on the next page.
10 EXAMINATION BY MS. SALTZBART:
11 Q. Okay.
12 A. In the third paragraph there.
13 Q. So it's your testimony that
14 Mr. Miller understood that your -- your model did
15 not account for pressure loss from -- and flow
16 through the gasket, and that this e-mail clearly
17 communicated that to him?
18 A. Well, what Mr. Miller -- well,
19 Mr. Miller understood a lot (inaudible) I can't
20 say anything --
21 THE REPORTER:
22 Understood what?
23 A. -- about this. I believe that the
24 formulation in this particular mail is as clear
25 as it can be.

Page 172:02 to 174:02

00172:02 Q. Okay. The next paragraph below that
03 reads, "The" -- "The choke model predicts
04 sub-critical flow at all operating points, mainly
05 because there is much liquid when the upstream
06 pressure is high. The model is a frozen flow
07 model, so no flashing occurs from the inlet to
08 the minimum cross section at the vena contracta."
09 Did I read that correctly?
10 A. You did.
11 Q. Does the -- does it mean that this
12 is a frozen flow model that you're holding the
13 density of the fluid constant?
14 A. No. What it means is that inside
15 the choke, even though the pressure reduces
16 significantly, you do not change the fraction of
17 the gas. Basically, what happens if -- if you
18 reduce -- reduce the pressure, the -- the liquid
19 starts boiling and you start getting gas coming
20 out of the solution.
21 It's like what you do when you open
22 a champagne bottle, you take off the top and you
23 reduce the pressure. And because of that, you
24 get lots of gas bubbles forming inside the --
25 inside your champagne. But if the pressure is
00173:01 high, the gas doesn't come out. But when you
02 reduce pressure, the gas starts coming out.
03 And that's what happens in the choke
04 as well. You get a significant -- as you move
05 from upstream to choke into the choke, you get a
06 very large reduction in pressure, and you may as
07 a result of that get -- that the gas starts

coming out of solution.
What we assumed in this particular model is that the amount of gas which flows into the choke is given by the upstream positions. You don't get flashing of the fluid, flashing of the gas, gas formation, inside the choke.
Q. Right. So you're not allowing the gas to come out of solution; is that correct?
A. Yeah. On these -- I mean, the liquid is in the -- in the -- in the choke only a fraction of a second. And what we assume is that in this fraction of a second, the amount of gas which is coming out is something which -- that these effects we can't ignore. To what extent it's -- it's a good assumption in all cases is something which can be (inaudible).
THE REPORTER:
Something which what?
THE WITNESS:
Can be debated.

Page 174:04 to 175:01

Q. When the -- when the gas comes out of the liquid phase, does that not have an effect on the density of the liquid phase?
A. It does, it does.
Q. Okay. And you're not able to estimate what kind of an effect that's having?
A. You can more or less estimate it. But to quantify the amount of gas which is coming out of solution is very difficult. We're talking about fractions of a second here, and the -- the physics on these short time scales of flashing -- gas flashing from oil is something which we -- we don't really understand.
Q. So is there any -- is there any model in the marketplace today that -- that could accurately characterize the flashing of gas from the oil phase as it passes through the -- the CC40 choke valve?
A. No.
Q. How would you quantify uncertainty associated with your -- the inability to understand how the -- this fluid is changing as it passes through the valve?

Page 175:04 to 175:16

A. This is -- this is basically one of the -- one of the topics which -- but if you want to answer this question properly, you spend years. This is a very, very difficult thing to answer.
EXAMINATION BY MS. SALTZBART:

Q. If you're holding the -- the density of the fluid -- if you're not allowing -- let me rephrase that.
If you're not allowing the gas to flash out of solution, would that be another basis for your calculations overpredicting a flow rate?

Page 175:18 to 175:25

Objection, form.
A. I'm not sure if it's possible to answer this question here and now. This is -- this is a really -- this is really intricate stuff. It's not -- I will -- I -- if I give an answer, I -- it could be wrong, it could be right. I don't know. So I don't think I want to give an answer.

Page 176:02 to 176:11

Q. Let me ask you this: As the fluid passes through the choke valve, gas is coming out of solution; is that correct?
A. Uh-huh.
Q. Okay.
A. Yeah.
Q. So once the fluid has passed through the valve, what -- the fluid before entering and the fluid after the valve, there'll be more gas out of solution from the oil?

Page 176:14 to 176:18

A. Typically what you'd get is because of the pressure reduction over the valve, you have more gas downstream from the valve than you have upstream from the valve. That is a general -- as a general rule, that's the case.

Page 176:20 to 177:17

Q. And in this particular application -- or maybe it's not even in this particular application, but I'm going to focus on this particular application -- you did not allow the fluid to flash, and so the density remained the same as it passed through the valve?
A. Yeah, that -- that's -- that is true. Now you're talking about what happens inside a valve, right? But we have this PVT file which tells us, okay, with these pressure and temperature conditions upstream we've got this

gas fraction. And with these temperature and pressure conditions downstream the valve we have this gas fraction.

So then there is -- inside the valve, the intricate dynamics of what happens inside the valve is not modeled.

Q. Okay. Dr. Schulkes, were you able to explain to Mr. Miller or Lawrence Livermore, or any of the national labs for that matter, why there was the nonphysical flow behavior of an increase in flow rate as the choke valve was closing?

Page 177:20 to 178:22

A. And this is something -- which we have looked at in detail. And even though it's -- it's -- it's counterintuitive what you're getting here, we don't believe it's unphysical.

And the reason is that basically what we've been discussing just now, this -- this -- what -- what happens in a choke is this -- in these -- these hydrocarbons is you get some significant flashing effects.

And what -- what we're seeing here is that when -- when you open a choke for a given pressure difference, you expect the flow rate to increase. But what is plotted on the vertical axis in this -- this plot here in Exhibit 11027, the PDF file, on the vertical axis, that's not the volume flow rate, but it's the mass flow rate.

And what happens if you start flashing off gas is that the volume increases enormously so the volume flow rate will increase, but your mass flow rate, which is your density times the volume flow rate, may actually decrease. So we've -- we've seen this effect, we've thought about it, and we do not think this is unphysical, but this is related to the intricate dynamics of what happened to the valve, and it's related to flashing, to phase changes in the valve.

Page 180:15 to 181:09

Q. We were -- I think we were talking about the same concept earlier -- earlier today where you indicated that -- that there was no commercial package in existence that you could currently use to model the -- I think what you've called the whole system, which would be all of the components of the choke line; is that correct?

A. That's correct.

Q. Are there any research codes that you're aware of that would allow someone to model the choke line including all the features in the choke valves?
A. No, I'm not aware of those.
Q. Is -- is it your view that to more accurately model flow through this complicated geometry that we've been discussing, which is that -- that whole line of the choke line, that you need a different model than the Hydro -- the stand-alone Hydro choke model?

Page 181:12 to 181:22

A. You need quite a lot of additional functionality. I mean, you -- basically what we now have is a -- a choke model in which the -- the pipe diameter both upstream and downstream is specified, but nothing else. And you don't include any dynamic effects in the pipes or bends or whatever. So the -- the Hydro choke model would be the path of -- of possible model that could be used to model the whole system, but the -- only -- it's only a path. It's -- it's you need much more.

Page 181:24 to 182:02

Q. Right. So the stand-alone Hydro choke model is -- is not an appropriate model to use to model the choke line and all the geometry of the choke line; is that correct?

Page 182:05 to 182:20

Q. You get -- you get part of an answer. The -- the thing is that you -- you are able to model only one -- one section of the choke line with a reasonable degree of accuracy with all the uncertainties, which we've discussed before. But it's by no means second -- by no means to be regarded as the full answer.
EXAMINATION BY MS. SALTZBART:
Q. It's -- it's not capable of providing the full answer; is that correct?
A. Yes, that's correct.
Q. Is it fair to say, then, that the flow rates from the Hydro model that Statoil provided to Mr. Miller should not be relied upon as conclusive estimates of flow through the choke line of the capping stack?

Page 182:23 to 183:22

00182:23 A. I think that's what is stated in
24 the -- in the mail from Reidar Schuller that --
25 give me a second. Find out where he says that
00183:01 that -- the estimated flow rates are probably an
02 overestimate -- are an overestimate.
03 EXAMINATION BY MS. SALTZBART:
04 Q. I'm -- I'm sorry, Dr. Schulkes.
05 Where are you in the document?
06 A. Well, I'm just trying -- at some
07 point Reidar Schuller conveyed to Wayne Miller
08 that the flow rates calculated were probably an
09 overestimate. I just have to find the spot where
10 he states this.
11 Q. Is it on the page ending in 154 in
12 the paragraph that says --
13 A. It's -- it's -- yeah, it's -- no,
14 it's Exhibit 11027. And it's the second last
15 paragraph of that -- of that mail where he
16 states: "...so these flow rates are
17 overpredicted."
18 "The calculations for the stand
19 alone choke model do not include frictional
20 pressure drops in the piping systems, so these
21 flow rates over predicted."
22 And he states it very clearly.

Page 184:23 to 185:02

00184:23 Q. Okay. And is it -- is it Statoil's
24 view as -- as testified by you, that the results
25 that Statoil provided to Mr. Miller should not be
00185:01 relied upon as conclusive estimates of flow
02 through the choke line of the capping stack?

Page 185:05 to 185:09

00185:05 A. I'm not sure what -- what lies in
06 the -- in the formulation conclusive estimates.
07 I mean, it is an estimate of what -- what
08 happened in the flow line. I'm not quite sure
09 what is meant by a conclusive estimate.

Page 185:11 to 185:12

00185:11 Q. Do you think it's an accurate
12 estimate?

Page 185:15 to 185:17

00185:15 A. It's as accurate as we -- as -- as
16 we can get -- give given all the -- all the
17 limitations which have been mentioned.

Page 186:01 to 186:03

00186:01 Q. And there's some uncertainty -- you
02 were describing earlier some uncertainty even
03 with how to model the valve; is that correct?

Page 186:06 to 187:25

00186:06 A. How the model was developed?
07 EXAMINATION BY MS. SALTZBART:
08 Q. The valve.
09 MR. WEIGEL:
10 The valve.
11 A. Yeah, how to model the valve, yes,
12 of course, I mean, there are uncertainties to any
13 sort of model.
14 EXAMINATION BY MS. SALTZBART:
15 Q. Right. And weren't you also
16 testifying earlier today that this model failed
17 to include frictional pressure drops from the
18 piping?
19 A. That's right, because it's not a
20 piping model, it's a choke model.
21 Q. And -- right. That's right, because
22 it's a choke model.
23 And didn't you also testify that
24 your calculations failed to include pressure
25 losses from flow through the gasket?
00187:01 A. Yes, that's right.
02 Q. Right. And -- and so it's your
03 testimony that the calculations that you prepared
04 and provided to Mr. Miller are, in fact,
05 overpredictions of a flow rate; is that correct?
06 A. That's exactly what is stated in the
07 mail as well.
08 Q. Okay. So would you say that the
09 flow rate calculations that you performed and
10 prepared and provided to Mr. Miller are without
11 any doubt the flow rate -- flow rate for flow
12 through the choke line of the capping stack?
13 A. They are conclusions of -- of -- of
14 flow through the capping stack with -- with the
15 limitations and -- and such as -- as is pointed
16 out, yes.
17 Q. And it's an overprediction of the
18 flow rate, correct?
19 A. It's clearly stated in the mail. We
20 believe this is -- we have -- there are
21 additional pressure loss effects, which we have
22 not included, and as such values that have been
23 given to Lawrence Livermore are overpredictions
24 of the real -- of what we anticipate is the real
25 flow rates of the system.

Page 188:02 to 188:09

00188:02 I'd like to turn to Tab 34, please.
03 This is Exhibit 11033.
04 Is that what you have in front of
05 you, Dr. Schulkes?
06 A. I do, I do.
07 Q. All right. And you're a recipient
08 of this document; is that correct?
09 A. That's right.

Page 189:09 to 189:12

00189:09 Q. And it's -- it's from R.B. Schuller.
10 That's Dr. Schuller who we've been discussing
11 today?
12 A. That's right.

Page 189:18 to 190:03

00189:18 Q. Do you know if this document was
19 ever finalized?
20 A. Unfortunately, it happens that we --
21 when you start a document, it is automatically in
22 status draft. And we have quite a few documents
23 that are finalized, but -- where the status does
24 not change, unfortunately.
25 Q. Okay. Is it -- is it fair to say,
00190:01 then, this is a final version of this document?
02 A. This -- this is the final version of
03 the report, yes.

Page 190:08 to 195:08

00190:08 Q. Okay. And did Dr. Schuller prepare
09 this report with input from Dr. Gyllensten?
10 A. Yes, he did, because you see in
11 Appendix A, the computational fluid dynamic
12 simulations, which Gyllensten did.
13 Q. And -- and Dr. Gyllensten is an
14 employee of Statoil, correct?
15 A. That's right.
16 Q. And -- and Dr. Schuller, he's not an
17 employee, but he's a contractor for Statoil?
18 A. That's right.
19 Q. So this report appears to have been
20 prepared less than a month from the date that
21 Dr. Schuller provided the results to Mr. Miller
22 on -- on August 25th. Does that sound about
23 right?
24 A. Yes.
25 Q. So would you say that this report
00191:01 was written near the time of the modeling efforts
02 that it discusses?

A. Well, I mean, it must have been written between the 25th of August and -- and the 21st of September. And exactly when, I -- I don't know.
Q. Okay. Would you say that Dr. Schuller and Dr. Gyllensten have personal knowledge of the calculations that are being described in this report?
A. Well, it's impossible not to have it because they have done it.
Q. Does -- do you know why they prepared this report?
A. Yes. Since it's quite obvious that this -- this case here is -- is a sensitive case, and it was already at that stage obvious to us that having -- documenting what we've done was important even though we did not anticipate at that time that we -- I would be sitting here today.
But it was clear to us that -- that this was something which required proper documentation. That's why this report was -- was written.
00192:01 Q. Does -- would Statoil normally prepare a report of modeling calculations that it performs in just the regular course of business?
A. Yes, definitely.
Q. And is that -- that's a policy that Statoil has, that its employees prepare -- or contractors in this case prepare reports about the modeling work that they've done?
A. Any modeling work which is in some way related to operations is to document -- has to be documented.
Q. Has to be documented?
A. And then this -- this is obviously something which is not related to operations, not for a field which is Statoil operated field but another field, and there's a clear necessity to document this -- this type of work.
Q. Would it be fair to say that -- that Dr. Schuller prepared this report as part of his duty -- job duties in this particular case? And -- and --
A. Yes.
Q. -- by "case" I mean this modeling case. Okay.
A. Yes.
00193:01 Q. Okay. So this document, it summarizes the work that Statoil performed for Mr. Miller; is that correct?
A. Yes, but it's -- documents in a way all the work which we have done. If you look at the mail which was sent to Mr. Miller on the 25th of August, it doesn't contain all the details. It's -- this contains a lot of the background

work which we did in addition to what was reported to Wayne Miller.
Q. Was this document or -- or any version of this document ever shared with Mr. Miller or anyone at Lawrence Livermore?
A. No.
Q. I'd like to turn to the second page, please. The -- the first paragraph, I think it describes the stand-alone Hydro choke model. And -- and Dr. Schuller writes: "Calculation were first made with a stand alone version of the Hydro Choke Model where the maximum effective choke opening was limited to 50% as a result of the restrictions in the flow lines. This model did not include losses in the pipes or in the gasket and therefore over predicts the flow rate."
Did I read that correctly?
A. Yes, you did.
Q. Great. And here there's an explicit reference to the gasket; is that correct?
A. That's right.
Q. But in the e-mail that Dr. Schuller sent to -- to Mr. Miller, he didn't explicitly identify the gasket, did he?
A. Again, I would have to read this mail to confirm or not your statement.
Q. That was --
A. That was the --
Q. -- 28?
A. Tab 28.
Q. And it's the paragraph that reads, "A diagram showing flow rate as a function of choke opening is attached. The calculations for the stand alone choke model do not include frictional pressure drops in the piping systems, so these flow rates are over predicted, especially at larger choke openings."
He -- he didn't include the gasket there, right?
A. I mean, if you look at the mail which was sent from Reidar Schuller to Wayne Miller on the 25th, in the second paragraph, he states that "And there is also restriction, the gasket of 2.25 inches in diameter from the choke."
It's not correct to state that he did not mention the gasket, because he did actually explicitly mention the gasket in his mail to Wayne Miller as well.

Page 199:01 to 199:06

Q. Okay. Do you know what conversion Dr. Schuller used to take mass flow to stock tank

barrels?
A. No, I don't know. But I imagine he's -- he's done his sums and knows how to do these calculations.

Page 199:09 to 199:11

A. I imagine that he can transfer between kilograms per second and stock tank barrels per day.

Page 199:13 to 199:18

Q. Do you know whether he was using the -- the conversion that Mr. Miller provided, which was 1 kilogram per second equaled 485 stock tank barrels per day?
A. I would imagine that he's done precisely that.

Page 205:24 to 208:06

Q. Okay. I'd like now to -- to move on to the next paragraph. And it appears that this next paragraph Dr. Schuller is describing a modeling influence. He writes, "The gas mass fraction at inlet varied from zero to" 40 -- "24% giving gas volume fractions as high as 50-60%. The flow geometry was modeled in Fluent for compressible single phase gas flow to see which geometrical factors that governed the flow rate in the extreme case with choked flows. The results showed that the choke valve was only one important factor. The flow could choke in the gasket, and the flow also choked at exit from the piping system."
Did I read that correctly?
A. That's right.
Q. Okay. So it was based upon the modeling in Fluent, Statoil was able to determine that the choke valve was only one important factor. In fact, there were other features of the choke line geometry that affected the flow rate calculations; is that correct?
A. That's correct.
Q. Okay. Did Statoil tell the United States that it performed modeling using Fluent for purposes of your project for Lawrence Livermore?
A. Sorry. Did Statoil?
Q. Did -- did Statoil inform Mr. Miller or anyone that Mr. Miller was working with at Lawrence Livermore, or any other national lab for that matter, that Statoil had used Fluent as part

of the project for Mr. Miller?
A. I'm not aware of that.
Q. Do you know why Statoil didn't communicate that information to Mr. Miller?
A. We were in the middle of additional work. It was not only Fluent simulations, but all the simulations. And, I mean, this we regarded as additional information, which, if it had been important information to the choices we made, we would have informed the Lawrence Livermore about it. But the Fluent simulations, which we did, did not influence the choices we made in relation to using the Hydro choke model; so therefore, we did not think -- did not regard it as necessary to supply this information to Lawrence Livermore.
Q. It wasn't important modeling, though, because it -- in Dr. Schuller's words, the results showed that the choke valve was only one important factor and that the choke -- the
00208:01 flow could choke in the gasket and the flow also choked at exit from the piping system.
Is -- is the use of Fluent the only way in which Statoil was able to -- to understand that these other features were affecting the flow rate?

Page 208:09 to 208:20

00208:09 A. Well, it's not the only way, because we also did the simulations with -- with OLGA. But it was -- and, of course, based on our physical understanding of the problem, it wasn't logical to expect that the gasket also would have a significant contribution, for example, on the -- on pressure drop.
But it was -- it was a -- a combined background information which we gathered in order to try to understand the problem we would have to deal with, and that was the flow through the CC40 valve.

Page 208:22 to 209:14

00208:22 Q. And so -- so Fluent helped you to understand what -- which of the geometries on the line was complicating the analysis; is that correct?
00209:01 A. Well, not so much complicating analysis, but it gave us a better understanding of the whole pressure development in flow line.
Q. And some of the -- the features that, you know, you don't -- you don't like the choice of complicating the analysis, but some -- some of the features that are -- are relevant to

an analysis of flow through the -- through the choke line included the gasket, it also included the frictional pressure losses from the pipes, and, and as Dr. Schuller indicates, the flow also choked at the exit of the piping. And using Fluent enabled you to -- to understand those things; is that correct?

Page 209:17 to 209:17

00209:17 A. It is correct.

Page 209:19 to 213:19

00209:19 Q. Okay. And -- and I understand that you didn't tell Mr. Miller that you used Fluent, but you did, in fact, communicate to Mr. Miller that there were other features of this line other than just the valve itself that were important to understanding flow through the line; is that correct?
00210:01 A. Yeah, that's correct.
Q. Okay. And that included the gasket?
A. Yes, as stated in the mail from Reidar Schuller to Wayne Miller.
Q. Right. And that also included the frictional losses from the piping?
A. I'm not quite sure what's -- what -- what -- what was stated explicitly in this -- in this. I would have to read again what the -- what was said in the mail.
Q. Are you referring back to Exhibit 11027?
A. Yes, that's right. I'm just trying to remember what was written back in this -- in this particular mail.
Well, in this particular mail, in the -- one, two, three, four -- fifth paragraph, under the comments, it's mentioned explicitly, "In addition there are frictional pressure drops in the piping that affect the pressure distribution."
Q. Okay. And -- and he goes on to say, "so this is a complex flow problem where" it's "difficult to determine what actually determines the flow rate"; is that right?
00211:01 A. That is right.
Q. Okay.
A. Yeah.
Q. So -- so even if you didn't tell Mr. Miller that you used Fluent, you certainly communicated to him what you understood at -- as a result of using Fluent. Is that fair to say?
A. That -- that's right. And any -- of course, any engineer knows that if -- if gas or

liquid flows through a pipe that you get a pressure loss. I mean, that -- that is nothing -- that's not rocket science.

Q. Okay. If we could now turn back to the document at Exhibit 34 -- I'm sorry, Tab 34, Exhibit 11033.

A. Uh-huh.

Q. Dr. Schuller writes in the third paragraph, "It was therefore decided to model the piping with gasket and choke valve in OLGA. These calculations were successful, but OLGA considers a flow regime to be stratified in the pipes. This is doubtful since the flow at large openings have high velocities and severe gas/liquid mixing is taking place in bends, gasket area and in the choke. A number of
00212:01 calculations were made with OLGA 6.2 where the geometry was represented as a straight flow path (no bends), but with the correct changes in pipe diameters. The choke was modeled with the version of the Hydro choke model implemented in OLGA."

Did I read all that correctly?

A. Yes, you did.

Q. Can you describe what OLGA is?

A. OLGA is a -- a flow simulator in which specific models are developed to compute pressure drops in multiphase flows in pipelines.

So OLGA, you specify how much gas and liquid is going into the pipe, and then OLGA calculates how much -- at each section of the pipe how much gas and liquid is, in fact, present in each section, not necessarily the same as what you put in, and OLGA calculates pressure drop in the pipe.

Q. And it also -- it calculated the pressure drop through the gasket?

A. Yes, it -- it can do that, yes.

Q. And in this particular application, did Dr. Schuller set it up so that it would include the pressure loss from the flow through
00213:01 the gasket?

A. Yes, I believe that, yes.

Q. Dr. Schuller wrote, "The choke was modeled with the version of the Hydro choke model implemented in OLGA."

What does that mean?

A. Well, this Hydro choke model is a -- is a model which Statoil has developed. But we -- as I indicated at the start of the -- this deposition, the -- what we -- where we often use chokes is that simulation to controlling flows in multiphase pipelines. So for us, it's -- it's natural to have this choke model in the tool which we use to simulate multiphase flow pipe -- multiphase pipe flow.

So OLGA already contained a flow -- choke model, and in about 2004, 2005, they implemented also the Hydro choke model as one of the choke models.

Page 213:25 to 214:12

Q. You said that they implemented the hydro model in -- into OLGA; is that what you just stated?
A. Yes, that's right.
Q. Okay. So it's -- it's a -- a module within OLGA that -- that you can include in -- in setting up a model?
A. That's right, uh-huh.
Q. And the -- the Hydro model that you can implement in OLGA, is that fully consistent with the -- the stand-alone choke model that -- that you were doing separately as part of your work for Mr. Miller?

Page 214:15 to 214:20

A. Not -- not quite. We have -- it turns out that implementing this type of model in the -- in the simulator is not a trivial affair, and we have seen differences between the results predicted from OLGA and the -- and the stand-alone model.

Page 214:22 to 215:18

Q. Can you describe what these differences are that you've seen?
A. What we see is that when you do calculations with OLGA and you predict the pressure drop over the choke, we -- OLGA gives a much larger scatter in the -- in the data than we expect.
Q. Is that -- did you say a larger scatter in the data?
A. Yeah.
Q. What do you mean by a "scatter"?
A. Like -- like what we've done in the -- in one of the papers, which is included in the -- in the deposition. If you plot the measured versus computed flow rates, that in the Hydro choke model everything collects on the -- on the -- on the line, which is diagonal in this plot.
When you do the same calculations with OLGA, you find that there's a -- the -- the collection of -- points on the line is much less well pronounced. You get a large scatter.

Page 216:12 to 217:10

00216:12 Q. Is Dr. Schuller familiar with
13 modeling flow using OLGA with the -- the Hydro
14 module in OLGA?
15 A. Yes, yes.
16 Q. Dr. Schuller indicates, "a number of
17 calculations were made with OLGA 6.2." What does
18 he mean by that, "a number of calculations were
19 made"?
20 A. The results of his calculations are
21 given in Appendix B of Exhibit 11033 where
22 simulations are reported with different choke
23 openings.
24 Q. And that's the -- the 5, 50, 86, and
25 100?
00217:01 A. That's right.
02 Q. Okay. And the representation of
03 100, does that mean that the choke is fully open?
04 A. I cannot answer. I wouldn't know.
05 Q. Dr. Schulkes, how come you don't --
06 you don't know the answer to that question? You
07 spent, in your -- in your testimony, from August
08 until today speaking and meeting with
09 Dr. Schuller. How did you not ask him what --
10 what -- what these representations were?

Page 217:15 to 219:04

00217:15 Q. Well, let me -- let me back up then,
16 Dr. Schulkes.
17 Did you -- did you meet and speak
18 with Dr. Schuller in preparation for your
19 testimony today?
20 A. Yes, I did.
21 Q. Okay. And did you meet with him on
22 a weekly basis?
23 A. I did, almost weekly, yes.
24 Q. Almost weekly. And did that start
25 as early as August of 2012?
00218:01 A. Yes, yes, with certain
02 interruptions.
03 Q. Okay. And -- and these meetings, I
04 think you described earlier, could be all day,
05 but also could be as short as 30 minutes or an
06 hour; is that correct?
07 A. Yeah. There's only one or two
08 instances in which the meeting was for a whole --
09 whole working day.
10 Q. Okay. So how many hours do you
11 think that you -- you spent meeting with
12 Dr. Schuller in preparation for your testimony?
13 A. 15 to 20 hours.
14 Q. Okay. And -- and it's -- it's your

testimony that you just never talked about what these were representing? Because I think we've talked about a number of different figures now where you've been uncertain if the 100 percent meant 100 percent open or 50 percent open. Did this not come up in your conversations?
A. I did not discuss the -- I don't know what the -- what the background for these calculations is. I cannot -- simply cannot say whether it was these calculations were based on the results, which were eventually given to Lawrence Livermore, where the 50 percent -- where the 100 percent open choke was 50 percent open, or whether in the OLGA calculations 100 percent open was 100 percent open. I do not know.

Page 219:06 to 219:12

A. It's -- if I have to guess, it's most likely that it's -- it's the 50 percent open case, the 100 percent open means 50 percent open with -- with the gauge pressures as specified in the mail of Wayne Miller. That would be the natural thing to assume. But it would be wrong for me to say categorically that that's the case.

Page 219:18 to 220:05

Q. All right. If you could turn back, please, to the second page of -- of the document that we've been referring to, it's Exhibit 11033.
I'd like to focus on Figure 1 on this page. It's a -- a plot. It says mass flow rate and then stock tank barrels on the vertical axis, and choke opening on the horizontal axis. Do you see that?
A. Yes, I do see that.
Q. Is -- is it stock tank barrels that's being plotted or is it mass flow rate that's being plotted on the vertical?
A. I believe it's stock tank barrels.

Page 222:13 to 223:14

Q. Okay. So if we were using 42 percent, which is the -- the diameter of the -- the gasket, the -- the flow rates that are predicted by OLGA with the -- the choke model implemented in -- in OLGA, that the flow rates are above 40,000 but certainly less than 60,000, it would be around maybe 45,000. Would you agree with that?
A. Yeah, I might, but I -- I must -- I think we are mixing apples and pears here. I

mean, the -- the fact that there's a gasket upstream of the choke valve with an opening of 40 percent of the flow area, it's got actually nothing to do with -- in relation to the choice we've made, the 50 percent opening we've made -- choice we've made in relation to those C -- CC40 valve -- choke valve.

The 40 to 50 percent choice was entirely based on the fact that at 50 percent choke opening, we've got the flow area which is similar to a 3-inch pipe. And that's -- that's the only consideration. The -- the -- the gas upstream of the choke valve has got nothing to do whatsoever with their -- with their choice. And I don't think it should be -- it should be mixed into the discussion because it's just confusing the whole discussion.

Page 224:01 to 224:08

Q. Okay. The -- the OLGA model enabled Dr. Schuller to include frictional pressure losses from the pipe, correct?

A. In principal it does, yes. But -- but what Dr. Schuller says is that the OLGA code assumes that the flow was stratified and that means that you've got a liquid layer below the gas --

Page 224:18 to 225:12

A. I was responding to the question of whether we could -- were able to -- we're using OLGA to compute the -- the pressure drop in the flow line, and the answer is yes, but we have significant doubts about the calculation the -- results of these calculations because OLGA -- the OLGA code predicts that there is a liquid layer below the gas in the flow line or in this choke line.

And with the velocities we're talking about here for the gas phase, we believe that the stratified flow system where there's a continuous liquid layer on the bottom is not realistic. We would have expected the flow to be what is called dispersed, and that means that there are liquid droplets in the gas phase.

There are quite a few moments, quite a few aspects of our OLGA flow simulations which make us doubt the validity of the results we're getting from the simulation.

Page 225:14 to 225:25

00225:14 Q. Dr. Schuller, did OLGA enable you to
15 calculate the pressure -- the frictional pressure
16 loss from the pipe? I'm sorry. Did I refer to
17 you as Dr. Schuller? Dr. Schulkes. My
18 apologies.
19 A. OLGA enables us to compute the
20 pressure drop in the pipe, but we have got large
21 doubts about the accuracy of this calculation.
22 Q. Okay. And did OLGA enable you to
23 include the pressure loss from flow through the
24 gasket?
25 A. Yes, it did.

Page 226:11 to 226:25

00226:11 Q. And -- and, again, you were able to
12 model those -- those two aspects of this complex
13 flow problem using OLGA; is that correct?
14 A. What -- we're -- yes, we really --
15 we -- we made a -- a model of this flow system in
16 OLGA. We got results from OLGA. And as I've
17 tried to say a few times, the -- the results we
18 got have got very large uncertainties etched into
19 them. So we were very careful in using these
20 results in any discussion with Lawrence Livermore
21 Laboratory.
22 Q. Do you think that there are large
23 uncertainties with the results that you did
24 provide to Mr. Miller of Lawrence Livermore using
25 the stand-alone choke model?

Page 227:03 to 227:03

00227:03 A. Yes, and I've said that before.

Page 227:05 to 228:06

00227:05 Q. Right. But that wasn't a basis not
06 to share those results with him, was it? You
07 provided them to him?
08 A. Yeah, but there's -- there's no
09 reason to supply additional information which
10 increases or which is -- which we regard as even
11 less certain when the -- the results we obtained
12 from OLGA simulations were so uncertain that we
13 chose not to include those.
14 Q. And -- and it's because of this --
15 the black diamond that -- that makes the results
16 so uncertain?
17 A. It's -- it's the black diamond, and
18 it is the fact that what I said before, that OLGA
19 is -- is predicting a stratified flow regime
20 which we regard as highly unlikely in the system,
21 and you get a completely different fresh drop

from the stratified system as compared to the disperse system.
Q. And so what would have been the -- the -- the harm in sharing the OLGA results implementing the -- the stand-alone choke model in OLGA? What would have been the harm of sharing that information with Mr. Miller?
A. Probably none whatsoever. It's just a choice we made. That's not more complicated than that, I think.

Page 229:01 to 229:05

Q. What flow regimes did the Hydro choke model predict?
A. Well, the Hydro choke model is not a multiphase flow simulator, so it didn't predict any flow regime.

Page 229:16 to 232:02

Q. I'd like to -- to turn to Tab 31, please. It's Exhibit 11030.
Are you familiar with this document?
A. I'm familiar with the figure. I'm not quite sure what -- what this document is.
Q. Is it possible that it's a draft of what eventually became the August 25th e-mail that Dr. Schuller sent to Mr. Miller?
A. It may well be, but given -- given the -- the fact that there's a comment in this -- this draft, it looks like more like a Word document than an e-mail.
Q. Do you know whose comments these are?
A. It looks like this is Mr. Selmer-Olsen.
Q. Okay. And can you turn to the third page. It's the page that ends in 330.
A. Yes.
Q. And if you look at the top of that page, you'll see there's a -- a reference -- a couple of references to OLGA?
A. Uh-huh.
Q. Okay. Do you -- and you don't know who wrote this document?
A. By the looks of it, it's a document which is written by Reidar Schuller.
Q. Okay. Is that because it says, "Best regards, Reidar" --
A. Yes --
Q. -- on the next page?
A. -- that's right, that's right.
Q. Okay. So at the top of the page that ends in 330, Dr. Schuller wrote: "When the

chokes open more than approximately 10%, it seems like the pressure" drop -- "drops in the piping and across the gasket become significant and the OLGA model predicts lower mass flow rates than the stand alone choke model."
Did I read that correctly?
A. Yes.
Q. And then he goes on to write: "We believe that the OLGA predictions give a fair estimate of the operating conditions and response to changes in choke settings."
Did I read that correctly?
A. Yes, that's right.
Q. And did -- did Dr. Selmer-Olsen comment that that text should be removed?
A. Well, he said -- if I can translate it -- I disagree -- I disagree it says. OLGA shows that the choke flow rate for all choke openings. Then the curves for OLGA should be flat form formed, choke openings over 70 percent, and they are -- and that's not the case. That's what he's stating there in his comment.
Q. So it -- it would appear that Dr. Schuller originally had text in about OLGA and -- and that OLGA prediction give a fair estimate and Dr. Selmer-Olsen struck out that text and -- and wrote he disagreed?
A. Yeah, that's right.

Page 233:02 to 235:06

Q. Okay. Can we please turn to Tab 25. This is Exhibit 11024.
Are you familiar with this e-mail?
A. This -- I'm familiar with the e-mail.
Q. Okay. So this is an e-mail that Dr. Schuller sent to you on -- on August 25th. That -- that's the same day that Dr. Schuller then transmitted comments to Mr. Miller, correct?
A. Uh-huh.
Q. And does this e-mail say something to the effect that -- from Dr. Schuller to you, I think the OLGA calculations despite this are pretty good when they include losses in the piping system including narrowing the upstream choke. Is there something to that effect in this e-mail?
A. That's right.
Q. Doesn't he also say something to you to the effect of, I suggest setting the chart below to weighing with comments. What do you think?
A. That's right.
Q. Okay. And -- and -- and this would

00234:01 include OLGA, the -- with the Hydro choke model
02 implemented in OLGA, correct?
03 A. Yeah, that's right.
04 Q. So what was your response to this
05 e-mail?
06 A. I cannot remember. My guess is --
07 but this is pure guess. My guess is that I would
08 have said that he could send it to Wayne Miller,
09 so I see no reason for not sending it, but I
10 cannot remember.
11 Q. Do you know if he did send it to --
12 to Mr. Miller?
13 A. No, I do not know that.
14 Q. But it's -- it's your testimony
15 that -- I know you're -- you're trying to recall.
16 There -- there really wouldn't have been harm in
17 providing this to Mr. Miller?
18 A. That's my opinion, it would have not
19 harmed at all.
20 Q. And -- and, again, this -- this
21 figure, it does show that the OLGA simulation
22 with the Hydro choke model implemented in OLGA
23 predicted lower flow rates than the stand-alone
24 choke model. Is that fair?
25 A. That's fair. And that is what was
00235:01 expected, I mean, again the OLGA model includes
02 obstruction effects due to the gaskets,
03 frictional losses in the pipe. So it's -- it's
04 entirely physical and you should expect that the
05 OLGA model with these additional restrictions
06 will give a lower flow rate.

Page 236:02 to 238:09

00236:02 Did anyone other than the Lawrence
03 Livermore National Laboratories ask Statoil to
04 perform any modeling with respect to the Macondo
05 well?
06 A. No.
07 Q. Did Statoil perform any modeling
08 related to the Macondo well other than the Hydro,
09 Fluent, and OLGA modeling that you've testified
10 about here today?
11 A. No, we did not.
12 Q. In connection with Statoil's work to
13 model the flow rate of the Macondo well, did
14 Statoil receive any data from any party other
15 than the Lawrence Livermore National
16 Laboratories?
17 A. No, we did not.
18 Q. Statoil's work did not depend on any
19 data from Transocean; is that correct?
20 A. That's right.
21 Q. In connection with Statoil's work to
22 model the -- model the flow rate of the Macondo

well, did Statoil ever have any communications with any employees of Transocean?
A. I can only speak for the people which are mentioned in this -- in this case. And that is Dr. Schuller, that is Atle Gyllensten, and myself --
THE REPORTER:
What -- what did you say, Dr. Schuller?
THE WITNESS:
Schuller, Atle -- Atle Gyllensten.
THE REPORTER:
Oh, thank you.
A. Right? G-y-l-l-e-n-s-t-e-n. Right? And myself. And neither of us three have been in contact with Transocean.
EXAMINATION BY MR. WILLIAMS:
Q. You're not aware of anyone else in Statoil who would have been in contact with Transocean?
A. No, I'm not aware of that.
Q. In connection with Statoil's work, did Statoil communicate with any parties other than the Lawrence Livermore National Laboratories or consultants retained by Statoil?
A. None other than the ones -- the one basically that is mentioned that's Dr. Schuller. No.
Q. Were -- were any other parties involved in any way in Statoil's work to model the flow rate of the Macondo well?
A. No.
Q. Other than the Lawrence Livermore National Laboratories, did Statoil send the results and analysis of its work to model the flow rate of the Macondo well to anyone else?
A. No, we did not.

Page 239:13 to 239:17

Q. Do you have -- does Statoil have any knowledge of how the DOE-NNSA Flow Team's efforts were impacted by Statoil's work?
A. No. We did not receive any feedback on the work we've done.

Page 241:10 to 241:18

Q. When I'm talking about Halliburton and ask you questions about Halliburton, I do mean all of its product service lines including Sperry-Sun. Do you understand that?
A. Yeah, I understood -- I understood that. But again, yeah.
Q. And will you answer the questions

17 accordingly?
18 A. I will.

Page 241:22 to 242:02

00241:22 First of all, do you have any
23 knowledge about any conduct on the part of
24 Halliburton that occurred between April 22, 2010,
25 and September 19th of 2010 relating to the
00242:01 attempt to stop the flow of oil from the Macondo
02 well?

Page 242:15 to 242:16

00242:15 A. Nothing more than what was available
16 through open news channels.

Page 245:03 to 245:06

00245:03 Did you ever hear of anyone else
04 having any criticism about any of Halliburton's
05 conduct specifically related to the relief
06 efforts?

Page 245:09 to 245:09

00245:09 A. I cannot recall that I have.

Page 245:12 to 245:20

00245:12 Halliburton was not involved in any
13 of the work that you-all did at Statoil; isn't
14 that correct?
15 A. That's right.
16 Q. And you had no communications with
17 anybody from Halliburton with respect to the work
18 that Statoil did for the Macondo incident,
19 correct?
20 A. That is correct.

Page 245:24 to 246:02

00245:24 When Statoil was initially asked to
25 account for the anomaly at this -- at the -- the
00246:01 CC40, did you -- did you have a -- a time frame
02 in which you had to come up with a conclusion?

Page 246:05 to 246:06

00246:05 A. Can you please specify what you mean
06 by "the anomaly"?

Page 246:08 to 246:17

00246:08 Q. Sure. I'm talking about the --
09 the -- the fact that the -- that when the capping
10 stack was -- I'm sorry. That when -- when the
11 CC40 choke valve was closed and that -- that the
12 flow increased during the initial closer --
13 closure, and then more dramatically decreased
14 as -- as it went from 50 percent to 20 percent
15 open.
16 A. We were actually never asked to
17 specifically address this particular issue.

Page 247:10 to 247:23

00247:10 Q. According to the report that's
11 attached as -- at Tab 24, previously marked as
12 9361 -- have you had a chance to look at that?
13 A. I've not seen it before.
14 Q. That was my next question. Had you
15 ever seen that before today?
16 A. No, well, not -- not before today,
17 no.
18 Q. I'd like to ask you to turn to the
19 page that ends in Bates numbers 1827.
20 MR. WEIGEL: Is that page 34 of the report
21 itself?
22 MS. RICHARD:
23 Yes, it is.

Page 248:04 to 248:07

00248:04 Q. In Section 3.2.3, it addresses the
05 Statoil multiphase analysis of the CS choke
06 valve, correct?
07 A. Uh-huh, yes.

Page 248:12 to 249:11

00248:12 In 3.23 of Exhibit 9361, it states,
13 "Statoil was approached by the DOE-NNSA Flow Team
14 to perform an independent external analysis of
15 multiphase" throw -- "multiphase flow through the
16 CS choke valve on the strength of a published
17 analysis method used to capture multiphase
18 petroleum flows in choke valves."
19 Did I read that correctly, sir?
20 A. Yes, you did.
21 Q. Does that accurately describe what
22 Statoil was approached to do?
23 A. Yes.
24 Q. And had -- if you'll go down to the
25 last line of that paragraph, does it read, "It

00249:01 also allows the inclusion of a detailed valve
02 geometry model which was not part of the DOE-NNSA
03 modeling efforts"?
04 Did I read that correctly?
05 A. Yes, you do. Yes.
06 Q. The next sentence, the first
07 sentence of the last paragraph on that page,
08 states that, "Statoil was given all of the
09 appropriate data made available to the DOE-NNSA
10 Flow Team." Is that accurate that Statoil was
11 given all of that data?

Page 249:14 to 249:18

00249:14 A. We were given the data which allowed
15 us to perform calculations through the choke
16 valve. If we felt that we needed additional
17 information, we would have requested this
18 information.

Page 249:20 to 253:03

00249:20 Q. And, to your knowledge, that was not
21 done, correct?
22 A. That's right.
23 Q. If you'll look at the next page that
24 ends in Bates numbers 1828, the second full
25 paragraph, it states: "Because of HYDRO model
00250:01 limitations, the resulting Statoil model only
02 included the valve, and did not include any of
03 the choke-line plumbing or the exit into the
04 ocean."
05 Did I read that correctly?
06 A. Yes, you did.
07 Q. Is that a factually accurate
08 statement?
09 A. That's right, that is.
10 Q. And if you'll go to the last --
11 second to last sentence, it says: "As such, the
12 Statoil results over-predicted the mass flow rate
13 because the pressure drop across the valve was
14 too high in its analysis."
15 Did I read that correctly?
16 A. Yes, you did.
17 Q. And is that an accurate statement?
18 A. I don't think it is accurate,
19 actually. What is -- I would have liked to
20 phrase it is that there are additional pressure
21 drops in -- in addition to the valve, and there
22 is -- as we have discussed previously, this is
23 the gasket. And you've got pressure drop effects
24 in the -- in the -- due to frictional effects in
25 the flow line in the 3-inch pipes.
00251:01 These -- these additional pressure
02 drop effects which have not been included. It's

not so much that the pressure drop across the valve was too high for this analysis. I think this is an inaccurate statement.
Q. Is the first part of it accurate, that the Statoil results overpredicted the mass flow rate?
A. Yes, that is -- that is -- that is correct.
Q. So you only disagree with the reason given why; is that accurate?
A. Yeah, that's accurate, because the Statoil result focuses mainly or only on the -- on the choke -- on the valve and not on the additional pressure loss effects which exist at various points.
Q. And the last sentence reads: "Regardless of this bias, the Statoil calculations also showed an anomalous flow rate increase as the valve was closed as shown in Figure 10."
Did I read that accurately?
A. Yes, you do.
Q. And is that an accurate statement?
A. No. No, I've explained it before. We do not regard this result as an anomaly. It may be counterintuitive, but we do not think it's wrong.
Q. The next sentence states: "Statoil commented several times on the complexity of this problem and on aspects that might not have been captured by its analysis that might still account for the anomalous-flow-rate increase."
Did I read that correctly?
A. Yes, you did.
Q. And skipping to the pair -- the sentence that starts with "further." The document states: "Further, Statoil asserted that the exit into the ocean ambient might be a complex flow behavior with sonic Fanno flow in the exit line, and expansion shots in the exhaust jet could be expected and would increase the back pressure and lower flow rate. These observations are complicated by the rapid increase in gas volume fraction as the flow expands to ocean ambient pressure."
Did I read that correctly?
A. Yes, you did.
Q. Is -- do you agree with the factual statements set forth in that portion that I just read?
A. Yes, I do.

Page 254:10 to 254:11

Q. I ask you to look at -- at Tab 22.

11 Do you have that before you, sir?

Page 255:04 to 256:08

00255:04 Q. Could you look down at the e-mail at
05 the bottom of the first page that starts --
06 that's on 25th of August at 2239, specifically --
07 A. Uh-huh.
08 Q. -- Paragraph No. 2. This is an
09 e-mail from Mr. Miller to Dr. Schuller and
10 your -- yourself and Mr. Selmer-Olsen, please --
11 correct?
12 A. That's right.
13 Q. The second paragraph states: "Your
14 results are interesting and clearly show the
15 complexity of this flow path. We are all
16 estimating a flow increase as the valve is
17 closed, so this strongly suggests that there is
18 more going on than what we have captured in our
19 models."
20 Did I read that correctly?
21 A. Yes, you did.
22 Q. Did you or someone at Statoil form
23 an opinion of what more was going on than was
24 captured in the models?
25 A. To be quite honest, I don't really
00256:01 understand this particular statement from Wayne
02 Miller. What the model -- the model which was
03 used by Lawrence Livermore shows qualitatively
04 the same as the -- the Hydro model.
05 So it looks like both models seem to
06 capture the same type of physics and show the
07 same behavior. So I'm -- I'm a bit puzzled by
08 this particular statement.

Page 256:13 to 256:15

00256:13 Q. Okay. And, finally, if you'd look
14 quickly at Tab 5 -- and for the record, the tab
15 that we looked at, 22, was Exhibit 11112.

Page 259:09 to 259:11

00259:09 Q. Prior to today did anybody from BP
10 contact Statoil and request an explanation of the
11 Hydro model?

Page 259:14 to 259:14

00259:14 A. No -- no.

Page 259:16 to 259:19

00259:16 Q. Prior to today did anybody from BP
17 contact Statoil and request an explanation of the
18 numbers or calculations that were used in the
19 Hydro model?

Page 259:22 to 259:22

00259:22 A. No.

Page 259:24 to 259:25

00259:24 Q. Would Statoil have been receptive to
25 such a request had one been made?

Page 260:09 to 260:12

00260:09 A. I -- I -- I will not -- I cannot
10 answer because this is -- this is a decision
11 would have been -- which would have been taken at
12 a different level in the company.

Page 260:15 to 260:23

00260:15 Do you know if any information was
16 provided to Statoil from BP regarding any type of
17 pressure or temperature measurements that were
18 used in the Hydro model?
19 A. The only information which we
20 received was through Wayne Miller at Lawrence
21 Livermore Laboratory. Some of this information
22 may have come from BP; I do not know. But we did
23 not receive any information directly from BP.

Page 263:03 to 263:06

00263:03 Q. Okay. If you were asked to
04 calculate the flow in the field, if you were,
05 what type of instrumentation would you request be
06 used and what data would it be used to gather?

Page 263:12 to 263:19

00263:12 A. Basically we would require the same
13 type of information. We'd like to have fluid
14 properties. We'd like to have -- if we talk
15 about flow over a -- over a choke valve, we'd
16 like to have the differential pressure
17 measurements. And we'd like to know the --
18 the -- the -- the water cuts, the water fraction,
19 coming into the -- into the choke.

Page 263:21 to 264:01

00263:21 Q. Does stat --
22 A. And, of course, all the geometry --
23 all the geometry information.
24 Q. Does Statoil possess or know of a
25 tool that could be used to take those
00264:01 measurements in the field?

Page 264:07 to 264:08

00264:07 A. There are typically multiphase flow
08 meters which supply this information.

Page 266:08 to 266:11

00266:08 Q. Good -- good evening, Dr. Schulkes.
09 My name is Scott Cernich, and I represent the
10 United States of America. And this is my
11 colleague, Michelle Greif, who's with me today.

Page 266:14 to 267:03

00266:14 Now, just -- just to start out, it's
15 correct that Mr. Miller from Lawrence Livermore
16 came to Statoil seeking assistance on this
17 project; is that right?
18 A. That's right.
19 Q. And why did Statoil agree to assist
20 Mr. Miller in this matter?
21 A. This accident in the -- in the Gulf
22 of Mexico is something which obviously influences
23 all oil industry. And we felt that by assisting
24 Lawrence Livermore, we would contribute towards,
25 how shall I say, understanding these type of
00267:01 problems probably better than we did before.
02 Q. And can you describe the -- the care
03 that Statoil put into its work on this project?

Page 267:10 to 267:18

00267:10 A. I think we -- we were very careful
11 in -- in trying to give an answer which was
12 astute and as qualified as we could give. We've
13 been discussing today earlier the fact that we
14 were originally asked to just perform
15 calculations with the Hydro choke model. And as
16 we've shown, we've done a significant amount of
17 additional work in order to try to understand the
18 physics -- the complex physics in this system --

Page 267:21 to 268:02

00267:21 A. And -- the complex physics in this
22 system, such as the answer we gave was -- was as
23 good as we felt we could give.
24 EXAMINATION BY MR. CERNICH:
25 Q. And did you approach this matter
00268:01 with the same level of commitment and care that
02 you do with all of your work at Statoil?

Page 268:05 to 268:05

00268:05 A. Yes, we do.

Page 268:07 to 269:06

00268:07 Q. Now, have you worked on other
08 projects that involve nondisclosure agreements?
09 A. Let me think. Have I...
10 Q. Or confidentiality agreements of
11 some sort?
12 A. Yes, yes, definitely.
13 Q. Okay. And what kind of projects
14 were those?
15 A. Confidentiality agreements are often
16 with -- related to suppliers having technology
17 which they would like to have, for example,
18 tested in our flow facility where the supplier is
19 not interested in -- in information about the
20 functioning -- the operational window of their
21 equipment becoming known in the market, and then
22 we are asked to sign a -- a confidentiality
23 agreement to keep this information internal.
24 Q. And so often those types of projects
25 involve proprietary information or proprietary
00269:01 data?
02 A. That's -- that's a typical
03 situation, yes.
04 Q. Did Statoil understand that
05 Mr. Miller would be providing Statoil with data
06 received from BP?

Page 269:09 to 269:13

00269:09 A. I can -- the only thing I can answer
10 is that it's -- when we start on a project, we --
11 we doubted it's likely that we would get
12 information from -- from BP, given that it was a
13 BP-operated well.

Page 269:15 to 269:24

00269:15 Q. And -- and but some of that data
16 might be proprietary data?
17 A. (Moving head up and down.)

18 We -- to what extent -- we assume
19 that the information we were given was
20 information which was allowed to be given or
21 allowed to be shared with Statoil.
22 Q. But you were expected to keep that
23 information confidential?
24 A. That's right.

Page 271:20 to 271:24

00271:20 Q. So I -- I think what you said, I
21 just want to make sure I understand, is that when
22 the choke opening is small, then the
23 overprediction would probably be smaller; is that
24 right?

Page 272:04 to 272:04

00272:04 A. That's right, that's right.

Page 272:06 to 272:07

00272:06 Q. Is there a choke opening when the
07 model ceases to overpredict?

Page 272:12 to 273:02

00272:12 A. We -- we cannot say exactly where
13 that would be, but there was probably a -- a --
14 again, we -- we -- we have to be a bit careful
15 when you say where this model overpredicts. I
16 mean, we -- we're talking about the system here,
17 not -- right? So it's a system consisting of
18 pipes, gaskets, choke, and pipes. It's this
19 combined system which we're trying to -- which,
20 in a way, we're looking at.
21 Statoil was asked to look
22 specifically at the choke, not at the -- not at
23 the combined system. So if your -- your question
24 is, is there an opening at which the Statoil
25 model does not open -- overpredict, then are you
00273:01 referring just to the choke or are you referring
02 to the whole system?

Page 273:04 to 274:06

00273:04 Q. I guess here, just so I'm clear,
05 you're -- this sentence in the e-mail refers to
06 just the -- the choke; is that right?
07 A. That's right.
08 Q. Okay. So then with -- then I -- I
09 guess I'm referring to just the choke when I ask
10 my question.

A. Yeah. Well, with respect to the choke, we feel, as far as we can say, it's -- for a small choke opening, the model functions well. For larger choke openings, and that is approaching 50 percent, we have this issue which has been discussed many times today, is that at some point the choke opening becomes so large that it exceeds the -- the cross-section area of the pipe. And at that point, we start getting uncertainties in relation to where the real flow restrictions are in the choke.

Because in the case of small choke openings, the flow restriction's in -- is in the holes of the gauge choke. But as the flow area of the choke opens, then the flow restriction is no longer only in the holes, but it's the whole geometry of the choke: fluids going into the holes, flowing through center of the choke, and out again. It's this collective contribution of resistance effects which then determines the -- the resistance of the choke.

Page 275:18 to 277:20

Q. And you described the observed increase in mass flow rate as not intuitive, correct?

A. That's right.

Q. But you said you -- that you didn't believe it was nonphysical; is that right?

A. That's right.

Q. And can you explain to me your -- your rationale for that conclusion?

A. What -- what happens when you -- when the choke is, for example, almost closed, is that the pressure upstream the choke increases because the -- the fluid cannot flow out as quickly as pos -- as quickly as you want, so you get a -- you get a buildup of the pressure upstream on the upstream side of the choke.

When you get a buildup of the pressure on the upstream side of the choke, your PVT, your fluid properties dictates that there is relatively little gas -- free gas available upstream from the choke. So this is the case where the choke is almost closed or fully closed, you have relatively little gas upstream; you may have no gas upstream and a lot of liquids.

When you start opening the choke, you start decreasing the pressure upstream on the upstream side of the choke. And when you start decrease -- decreasing the pressure, what happens is that you get flashing. The gas comes out of solution and you -- you increase the amount of gas significantly.

When you increase the amount of gas significantly, you -- the gas has a larger volume and the gas starts flowing; you get quite a large velocities. So the volume flow rate over the choke increases quite significantly.

But when you look at the -- the mass flow rate, which is the -- the density, the mixture density of the fluid, times the volume flow rate, the mass flow rate may actually decrease because of the fact that you now have more gas and less liquids.

And that is what we believe is -- is the explanation for this what is referred as -- as anomalous, what I think is a counterintuitive, but the physical result, that you get a decrease in the mass flow rate through the choke, simply because of the fact that you now are pumping or you have more gas which is flowing through the choke.

Q. So would it also be that you get an increase in the mass flow rate as you close the choke?

Page 277:23 to 278:06

A. You may -- you may get that because when you start closing the choke, you may -- you will start increasing the pressure on the upstream side of the choke, and that means that you are -- you get less gas which is coming out of the solution and, therefore, more liquids, and the -- the mixture which is flowing through that choke consists, therefore, of more liquid and, therefore, the increased mass flow rate.

Page 278:08 to 279:01

Q. So the -- the fluid density increases as the valve is closed?

A. Well, you have to look at the mixture, because what -- what is -- when -- when -- say when -- when the valve is completely closed, it may be such -- depending a bit on where in your PVT diagram you are. But it may be such you have only liquids on the upstream side of the -- of the choke.

When you start opening a choke, you start flashing off gas and you start -- you get a mixture of gas and liquid which flows through the choke. But the gas which flashes off has a large volume and, therefore, it flows -- flows very quickly. And you then get a mixture which flows through the choke with high velocity. But because it contains a relatively large amount of gas and a smaller amount of liquid, then you --

00279:01 your mass flow rates may actually decrease.

Page 280:02 to 281:07

00280:02 Did you choose a flow regime for the
03 Hydro model?
04 A. In the Hydro model, we assume that
05 it's fully dispersed flow. So you either have
06 gas bubbles in the liquid phase or liquid drops
07 in the gas phase.
08 Q. And why did you make that
09 assumption?
10 A. Because life becomes exceedingly
11 difficult if you do anything else.
12 Q. Was there any other basis for that
13 assumption?
14 A. No, it -- it is -- I mean, it is --
15 it is a scientific -- it is -- well, I mean,
16 there's -- there's a good justification for this
17 assumption. What -- what happens in chokes is
18 that you -- the -- the liquids -- the gas and the
19 liquid may be separated upstream on the upstream
20 side of the choke.
21 But what happens is when you get to
22 the entrance -- entrance of the choke, you get
23 very strong acceleration because you -- you --
24 all the fluid has to go through a much smaller
25 opening, and this strong acceleration means that
00281:01 liquid and gas becomes exceedingly very well
02 mixed. And -- so in -- in most cases we believe
03 that that's -- in a choke you have the assumption
04 of fully dispersed flow is a very good
05 assumption.
06 Q. And -- and is that based on
07 empirical data gathered from testing?

Page 281:10 to 281:12

00281:10 A. I think it's -- it's -- it's both
11 supported by a very large amount of empirical
12 data and --

Page 281:18 to 281:25

00281:18 Yes, thank you. I got it.
19 A. It's both this large amount of
20 empirical data and then a large amount of
21 experiments which are done in -- in gas liquid
22 pipe flow systems where you see a different flow
23 velocity -- evident -- the mixture of velocity
24 increases beyond a certain point, you typically
25 get what is called dispersed flow.

Page 282:07 to 282:10

00282:07 Do you know whether BP ever
08 contacted Statoil for assistance in calculating
09 or estimating flow rates while the well was
10 flowing?

Page 282:13 to 282:16

00282:13 A. I -- BP -- as far as I'm aware, BP
14 did not contact -- at least they did not contact
15 the research part of Statoil. Any other contacts
16 to other parts of Statoil, I wouldn't know.

Page 282:18 to 282:21

00282:18 Q. Would you have provided similar
19 assistance to -- to BP as you did to Dr. Miller
20 and Lawrence Livermore had BP contacted you
21 during the -- during the blowout?

Page 282:24 to 283:04

00282:24 A. Most likely, we would have done,
25 but. Again, this is a decision which is taken at
00283:01 the very high level in the company given the --
02 the sensitive -- sensitivity of this particular
03 case. So it's -- it's not a position which I
04 would have taken.

Page 285:14 to 286:11

00285:14 Q. Okay. But you selected a dispersed
15 flow; is that correct?
16 A. Yeah, but I -- that's right. We --
17 in the model we -- we assumed that it's fully
18 dispersed flow, yes.
19 Q. Okay. Is that the only possible
20 flow regime that it could have been?
21 A. We believe that for this particular
22 system, it was the most likely flow regime.
23 Q. Are there any other flow regimes
24 that could have been possible?
25 A. Theoretically speaking, yes, there
00286:01 is a possibility that it would have been
02 stratified flow, but for the -- for this
03 particular case with these high flow velocities,
04 we think that's extremely unlikely.
05 Q. Okay. But it's possible that it
06 could have been a stratified flow, correct?
07 A. In fact, I think, no, that's not
08 correct. I think our scientific judgment is that
09 with these velocities we're looking at in this

system, it's not stratified flow, it's dispersed flow --

Page 286:17 to 287:07

Q. -- that specific --
What about in the choke line itself from the 4-inch -- I guess actually it starts from an 18-inch, right, from the --
A. Yes.
Q. -- main bores?
A. In the 18-inch flow line, stratified flow is -- is -- is quite likely because there the velocities are relatively flow. As you go down in the diameter of the pipe, the velocity increases quite significantly. And in the 3-inch pipe, we believe that it's likely that it's dispersed flow, but we would -- we would have to do more detailed calculations to really be sure which flow regime we are and the choke is fully dispersed.

Page 287:25 to 288:18

Q. What about the 3-inch pipe? Do you feel that --
A. Well, from --
Q. Go ahead. I'm sorry.
A. Yeah, from -- from what we've seen in the 3-inch pipes and the velocities there, we believe that in the 3-inch pipe, it is unlikely to be stratified and we would expect it to be dispersed.
Q. But you said you needed -- when you were testifying earlier, you said you needed to do a little more work around that to know for sure whether it was dispersed and stratified?
A. Yeah, but in a 3-inch pipe Reidar Schuller has done the calculations and we had -- this had been discussed and we've discussed it earlier, and he has stated that it's most likely to be dispersed flow, and I trust his judgment there.

Page 291:18 to 292:02

Q. Okay. So you have no knowledge whether the flow rates of oil increased as the valve was closing?
A. Put like that, we have not done any experimental work which confirms that the mass flow rate may increase as a result of flows in the valve. But we do not think this result, which is predicted not only by our model, but

00292:01 also by Lawrence Livermore's model, whatever that
02 model was, we don't think that's unphysical.

Page 293:08 to 293:14

00293:08 Q. So as the -- the gas is coming out
09 of solution, the fraction of gas of the fluid is
10 increasing as the fraction of liquid in the fluid
11 is decreasing?
12 A. Yes. So -- so the -- the -- the
13 amount of gas which is present increases
14 enormously.

Page 293:22 to 294:18

00293:22 Q. Okay. So -- but the -- as the gas
23 is coming out of solution, you're not getting an
24 increase in the liquid phase?
25 A. No, no. That's impossible. I
00294:01 mean --
02 Q. Right.
03 A. -- that would be counter -- that
04 would be contravening mas balance, so that's not
05 possible.
06 Q. Great. Thank -- thank you.
07 All right. I'd like you to turn to
08 Tab 38 in the binder from BP. It's Exhibit 9361.
09 You were discussing this earlier with the
10 attorney for Halliburton. I'd like you to turn
11 to page 36, please.
12 A. Okay.
13 Q. And the -- the Bates number for this
14 page is -- it ends in 1829. Is that the page
15 you're on, Dr. Schulkes?
16 MR. WEIGEL:
17 Yeah, we're here.
18 A. Yeah.

Page 296:01 to 296:04

00296:01 Q. Were you aware that the results of
02 your work had been memorialized in a document
03 that had been published as an official Sandia
04 report?

Page 296:07 to 296:07

00296:07 A. No.

Page 296:09 to 297:18

00296:09 Q. Okay. And you'd not seen a version
10 of -- of this document prior to today; is that

correct?
A. No. That's correct.
Q. At the bottom of page 36, the -- the paragraph starts with, "Overall, the Flow Team recommends that a flow rate of around ~53,000 bopd +/- 10% be accepted, with the 10% variation accounting for a multiphase effects and other factors such as accuracy of pressure measurements and surface ship collection data. Given the limited time available to perform these studies and the limited experimental data to work with, the Flow Team did not believe a full uncertainty analysis was warranted."
Did I read that correctly?
A. Yes.
Q. What we were discussing earlier, an uncertainty analysis of your work, you -- you explained that -- that Statoil had not -- had not performed an uncertainty analysis; is that correct?
A. That's correct.
Q. And -- and you further testified that given a variety of -- of different uncertainties with parameters of this particular flow path, that you would put the uncertainty for your work above 10 percent, and you thought closer to 20 percent; is that correct?
A. That's right.
Q. Okay. Do you think it's reasonable that as we just read that there's a -- a plus or minus 10 percent uncertainty associated with the flow rate that was calculated by the DOE Tri-Labs team?

Page 297:21 to 299:24

A. I'd like to state that I do not know the basis for this -- this estimate. So for me, it's -- it's rather difficult to associate an uncertainty to work where I do not -- where I'm not familiar with what -- what is it based on.
Having said that and referring to my earlier statements, I would have assumed that the uncertainty in this -- this prediction was larger.
EXAMINATION BY MS. SALTZBART:
Q. And can you quantify how -- how much larger than 10 percent?
A. I mean, this is -- again, this is -- this is pure guesswork given that I don't know the basis of -- of the -- the calculations which are presented, but I would maintain my earlier estimate of -- of probably close to 20 percent rather than 10 percent.
Q. Okay. I'd like to refer you to

the -- the Figure 10, which is still on this page 36. Do you see that figure?
A. I do.
Q. Okay. And it's plotting on the vertical mass flow rate, and then it says "stock tank barrels per day." And on the horizontal, it's plotting choke opening?
A. Uh-huh.
Q. Does this appear to be the figure that you provided to Mr. Miller on August 25th?
A. It does look like it, yes.
Q. Okay. And now, instead of saying BP approximate data, it says DOE-NNSA Flow Team results?
A. Uh-huh.
Q. Okay. And could you please turn back a -- a page to page 34?
A. Yes.
Q. Okay. And do you see the -- the three lines that are plotted here?
A. Yes, I do see that.
Q. Okay. And this is on the vertical oil flow bopd and all the horizontal choke valve percents open area, and it goes from zero to 100?
A. Yes.
Q. Okay. And do you see starting at the farthest right-hand side, at 100 there's no indication of turns, and then if you move to the left, it says two turns?
A. That's right.
Q. Okay. So if you were interpreting this figure, would it be your belief that the 100 was reflecting fully open, and that the -- at two turns the choke has started to be closed?
A. Yes.

Page 300:03 to 300:13

Q. Okay. I'd like to flip back now to page 36. Do you see --
A. Okay.
Q. Okay. Thank you.
Do you see that the -- the triangles from the DOE-NNSA team are -- are being plotted here?
A. Yes.
Q. Okay. And -- and they start at the 100 percent open?
A. Yes.

Page 301:01 to 301:14

Q. If you -- could you please compare the two figures, their figure from page 34 and then the figure on page 36 that appears to

provide both results?
A. Uh-huh.
Q. Are you able to say whether the triangles follows the same trend that the plots on the -- in the figure -- on page 34, Figure 9? Does that follow the same trend?
A. Yes, they do follow the same trend.
Q. Okay. And -- and, again, if you were interpreting the Figure 9 on page 34, it appears to start at 100 percent open; is that correct?

Page 301:17 to 302:03

A. Yes.
EXAMINATION BY MS. SALTZBART:
Q. Okay. And it's your testimony, though, that -- that your plot that's also reflected in Figure 10 on page 36 always limits the valve opening to 50 percent?
A. Yes.
Q. Okay. Do these two plots seem inconsistent if one is limited to 50 percent, which is yours, and -- and the plot from the DOE-NS -- NSA Flow Team, which has the -- a plot of the valve completely open?

Page 302:06 to 302:06

A. Yes.