

1
2 UNITED STATES DISTRICT COURT
3 EASTERN DISTRICT OF LOUISIANA

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5 IN RE: OIL SPILL BY THE
6 OIL RIG *DEEPWATER HORIZON*
7 IN THE GULF OF MEXICO ON
8 APRIL 20, 2010

DOCKET NO. MDL-2179
SECTION "J"
NEW ORLEANS, LA
OCTOBER 15, 2013

9 *****

10 IN RE: THE COMPLAINT AND
11 PETITION OF TRITON ASSET
12 LEASING GMBH, ET AL

DOCKET NO. 10-CV-2771
SECTION "J"

13 *****

14 UNITED STATES OF AMERICA
15 V.
16 BP EXPLORATION & PRODUCTION,
17 INC., ET AL

DOCKET NO. 10-CV-4536
SECTION "J"

18 *****

19 **DAY 9 MORNING SESSION**

20 TRANSCRIPT OF NONJURY TRIAL PROCEEDINGS
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22 UNITED STATES DISTRICT JUDGE

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I N D E X

EXAMINATION OF:

CURTIS WHITSON

Direct by Ms. Karis 2303

Cross by Ms. Engel 2306

Videotape of **Jamie Loos** 2384**ROBERT ZIMMERMAN**

Direct by Mr. Fields 2385

P-R-O-C-E-E-D-I-N-G-S

OCTOBER 15, 2013

M O R N I N G S E S S I O N

(COURT CALLED TO ORDER)

8:00 A.M.

07:19AM

07:36AM

THE COURT: Good morning, everyone. Please be seated.

08:04AM

Do we have any preliminary matters?

08:04AM

MS. KING: Yes, Your Honor, Rachel King for the United States. I have here the list of exhibits, call-outs, and demonstratives used with Drs. Kelkar and Pooladi-Darvish on Wednesday. These lists have been circulated and there have been no objections.

08:04AM

08:04AM

08:04AM

08:04AM

08:04AM

THE COURT: All right. Are there any remaining objections?

08:04AM

08:04AM

Without objection, those are admitted.

08:04AM

(Exhibit admitted.)

08:04AM

MR. BROCK: Morning, Your Honor. I was just going to mention for planning purposes that we sort of looked at our witnesses and length of examinations.

08:04AM

08:04AM

08:04AM

I don't want to get too far out of my skis here in terms of predictions, but we're hopeful that we will finish our case Thursday afternoon or Friday morning, even with the short week.

08:05AM

08:05AM

08:05AM

08:05AM

I'll have a better sense of that tomorrow by

08:05AM

1 lunchtime, I think. But we'll see how much progress we make 08:05AM
2 today and tomorrow. 08:05AM

3 And, I've advised Mr. O'Rourke and Ms. Himmelhoch 08:05AM
4 of that, and they're going to let me know who their witnesses 08:05AM
5 for Friday will be in the event that we make it that far. 08:05AM

6 We're on the same schedule that we talked about 08:05AM
7 last week. No changes at this point to that. So I thought I 08:05AM
8 would just let you know that for planning purposes. 08:05AM

9 THE COURT: You did switch around your witnesses from 08:05AM
10 what we talked about. 08:05AM

11 MR. BROCK: From what we started with. We've left 08:05AM
12 Dr. Whitson in the place, where we moved him to in order to 08:05AM
13 accommodate the schedule for Thursday, and then we go back to 08:05AM
14 Zimmerman, Gringarten, Merrill, straight down the line. 08:05AM

15 THE COURT: All right. Very well. 08:05AM

16 MR. BROCK: Mike Brock for BP. 08:06AM

17 THE COURT: All right. According to our timekeepers, 08:06AM
18 the United States, as of last week, used 13 hours and 7 minutes; 08:06AM
19 has 31:53 remaining. BP has used 14 hours and 16 minutes; and 08:06AM
20 has 30 hours 54 minutes remaining. 08:06AM

21 Okay. Ms. Karis, good to see you back. 08:06AM

22 MS. KARIS: Thank you, Your Honor. 08:06AM

23 THE COURT: Feeling better? 08:06AM

24 MS. KARIS: I am. Not perfect. I have the Kleenex. 08:06AM

25 Thank you for accommodating our schedule on 08:06AM

1 Friday, and I apologize for any inconvenience. 08:06AM

2 MR. BROCK: That's another reason we need to finish the 08:06AM
3 case, because it's moving back. The further back you go in the 08:06AM
4 courtroom, the more people that are down with the cold. 08:06AM

5 THE COURT: I hope it's moving that way. 08:07AM

6 MS. KARIS: You and me both. I wish it was just moving 08:07AM
7 away. 08:07AM

8 CURTIS WHITSON, being first duly sworn, testified 08:07AM
9 as follows: 08:07AM

10 CASE MANAGER: State and spell your name for the 08:07AM
11 record, please. 08:07AM

12 THE WITNESS: Curtis Whitson, C-U-R-T-I-S 08:07AM
13 W-H-I-T-S-O-N. 08:07AM

14 DIRECT EXAMINATION 08:07AM

15 BY MS. KARIS: 08:07AM

16 Q Good morning, Dr. Whitson. For the record, Hariklia Karis 08:07AM
17 on behalf of BP, conducting the direct examination of Dr. Curtis 08:07AM
18 Whitson. 08:07AM

19 MS. ENGLE: I wanted to remind Your Honor that we do 08:07AM
20 have a motion for summary judgment, and a *Daubert* motion as 08:07AM
21 well, both related to the dissolution of oil question. I just 08:07AM
22 wanted to remind you. I know you said you'd take those under 08:07AM
23 consideration. 08:07AM

24 THE COURT: Yes. I've looked at that, and I'm going to 08:07AM
25 reserve ruling on that issue. I think I have to listen to the 08:07AM

1 witness to understand exactly what he's saying and whether it's 08:07AM
2 a pure legal issue or not. 08:08AM

3 Ms. ENGEL: Understood, Your Honor. Thank you. 08:08AM

4 MS. KARIS: For the record, while Dr. Whitson's 08:08AM
5 testimony will address the motion in limine, BP has submitted a 08:08AM
6 request for a written submission on the summary judgment issue. 08:08AM

7 But I think Dr. Whitson's testimony will at least 08:08AM
8 frame the issues with respect to the motion in limine. 08:08AM

9 THE COURT: Okay. 08:08AM

10 DIRECT EXAMINATION 08:08AM

11 BY MS. KARIS: 08:08AM

12 Q Good morning, Dr. Whitson. Could you begin by telling the 08:08AM
13 Court what you were asked to do in connection with this case? 08:08AM

14 MS. KARIS: And if we can pull up D-23980 to frame 08:08AM
15 that. 08:08AM

16 BY MS. KARIS: 08:08AM

17 A Was asked to build a model to describe the properties of the 08:08AM
18 gas and oil for the Macondo reservoir fluids, and that model is 08:08AM
19 to be used by other experts in their calculations of rates and 08:08AM
20 quantities released to the ocean. That was the first. 08:08AM

21 And the second was to review and evaluate the 08:08AM
22 equation statement of Dr. Zick, who did the same type of work 08:09AM
23 for the U.S. Government. 08:09AM

24 And, finally, I was asked to develop a realistic, 08:09AM
25 physically realistic model, that would describe the 08:09AM

1 transformation or conversion of that reservoir fluid to a stock 08:09AM
2 tank oil volume at the stock tank at issue. 08:09AM

3 Q Now, before we discussed the opinions that you reached in 08:09AM
4 connection with the work you were asked to do, I'd like to talk 08:09AM
5 about your background a little bit. 08:09AM

6 Where are you originally from? 08:09AM

7 A I grew up in Oklahoma, and for about 17 years, before I 08:09AM
8 moved to California to study at Stanford University. And, 08:09AM
9 there, I took a Bachelor's degree in Petroleum Engineering. 08:09AM

10 Q And we're going to talk about your education briefly, but if 08:09AM
11 we can first like at TREX-11496.180, please. 08:09AM

12 Dr. Whitson, is this your curriculum vitae that's 08:09AM
13 attached to your report? 08:10AM

14 A Yes, ma'am. 08:10AM

15 Q And you told the Court briefly about your education, but can 08:10AM
16 you describe more completely your educational background. 08:10AM

17 A Like I said, I had taken the Bachelor of Science degree in 08:10AM
18 Petroleum Engineering at Stanford university from 1974 to '78. 08:10AM
19 And then I went to Norway thereafter and took a Ph.D. degree, 08:10AM
20 which I received in 1984, in Chemical and Petroleum Engineering. 08:10AM

21 Q Why did you go to Norway to get a Ph.D.? 08:10AM

22 A Well, I had a professor at Stanford, Dr. Stanley, who had 08:10AM
23 been in Norway in the early 1970s when the oil industry had just 08:10AM
24 got started. And, when he came to Stanford, he basically used 08:10AM
25 to talk about Norway, and that it was kind of a pioneering area, 08:10AM

1 it was just getting started in the business. So I decided to go 08:10AM
2 there and see what was there. 08:10AM

3 Q And I'm going to ask you to just speak a little louder 08:10AM
4 because I -- it could be my cold, but I'm having a hard time 08:10AM
5 hearing. 08:11AM

6 A Yeah. 08:11AM

7 Q Now, you got your Ph.D. you said from the Norwegian 08:11AM
8 Institute of Technology; is that correct? 08:11AM

9 A Yes, I did. 08:11AM

10 Q Did you write a thesis in connection with obtaining your 08:11AM
11 Ph.D.? 08:11AM

12 A Yes, I did. 08:11AM

13 Q Tell the Court what the subject of your thesis was. 08:11AM

14 A The subject, the title, same thing, is Phase Behavior and 08:11AM
15 Flow of Petroleum Reservoir Fluids. 08:11AM

16 Q Can you also tell us a little bit about your employment 08:11AM
17 history after you finished school. 08:11AM

18 A Well, I got a job there at the University Trondheim when I 08:11AM
19 arrived in 1978, and I've held the position there ever since 08:11AM
20 then. I'm now a department professor. So I've had an 08:11AM
21 employment with them for 35 years. 08:11AM

22 Early on, late 1979, I started working as a 08:11AM
23 consultant to the petroleum industry, and have done so as a 08:11AM
24 petroleum engineering consultant since then. 08:11AM

25 1988, I established the consulting company called 08:11AM

1 PERA, about 25 years ago. And then another company about in 08:12AM
2 2006, which is the software spin-off from that company. 08:12AM

3 In addition to that, I do industry courses, both 08:12AM
4 public and in-house courses, for oil companies maybe two to five 08:12AM
5 times a year, one-week courses where I talk about advanced phase 08:12AM
6 behavior and development of fluid characterizations within an 08:12AM
7 equation statement. 08:12AM

8 Q Let's talk about each of those three areas that you 08:12AM
9 identified. 08:12AM

10 First, with respect to the teaching, your teaching 08:12AM
11 at the university, you said you'd been there for approximately 08:12AM
12 35 years on staff as a professor. 08:12AM

13 A Yes, ma'am. 08:12AM

14 Q What are the type of courses that you've taught there as 08:12AM
15 they relate to the subjects that you're going to discuss in this 08:12AM
16 case? 08:12AM

17 A Right. Well, pretty much all the reservoir engineering 08:12AM
18 course curriculum, I've taught. PVT, at an introductory and 08:12AM
19 advanced level. All of the standard reservoir engineering 08:13AM
20 courses: Material balance, pressure trans analysis, defined 08:13AM
21 curve analysis. And then one course in production engineering. 08:13AM

22 Q All right. And then you mentioned you have a consulting 08:13AM
23 company called PERA? 08:13AM

24 A Yes, ma'am. 08:13AM

25 MS. KARIS: If we could look at D-24584 please. 08:13AM

1 BY MS. KARIS: 08:13AM

2 Q Does this demonstrative accurately describe the different 08:13AM
3 areas of business that PERA engages in? 08:13AM

4 A Yes, it does. 08:13AM

5 Q And tell us how the business of PERA relates with respect to 08:13AM
6 the issues that you're going to discuss in this case. 08:13AM

7 A Well, pretty much all of our work relates to building models 08:13AM
8 to describe reservoir fluids and their properties of gas, oil, 08:13AM
9 and water, typically for complex fluid systems where the oil 08:13AM
10 companies have struggled themselves to come up with such a 08:13AM
11 model. And that's kind of our bread-and-butter line of 08:13AM
12 business, really. There's not a lot of people who are doing 08:13AM
13 that. 08:14AM

14 Q Can you give us a sense of some of who PERA's clients are in 08:14AM
15 the oil and gas industry. 08:14AM

16 A I think essentially all of the international and national 08:14AM
17 oil companies we've worked for at one time or another. 08:14AM

18 Also larger independent companies and even some 08:14AM
19 smaller oil and gas companies domestically in the U.S. 08:14AM

20 MS. KARIS: If we can look at D-23968, please. 08:14AM

21 BY MS. KARIS: 08:14AM

22 Q Does this demonstrative accurately reflect some of the 08:14AM
23 clients for which PERA has conducted business, including 08:14AM
24 creating modeling such as the modeling that you've performed in 08:14AM
25 this case? 08:14AM

1 A Yes. This would be a subset of all of the companies that 08:14AM
2 we've worked for. 08:14AM

3 Q And for how many years have you been performing consulting 08:14AM
4 for the oil and gas industry creating equation of state models 08:14AM
5 similar to what you did in this case? 08:14AM

6 A Certainly over 30 years. I think the first would have been 08:14AM
7 around 1981. 08:14AM

8 Q And then you reference that, in addition to teaching at the 08:14AM
9 university and having PERA, you also teach courses to the 08:15AM
10 industry? 08:15AM

11 A Yes, I do. 08:15AM

12 Q Tell us who some of the clients are that you teach courses 08:15AM
13 to. 08:15AM

14 A Well, where I've been asked to come in to a specific 08:15AM
15 company, a so-called in-house course, that would probably be 08:15AM
16 somewhere around 15 companies through the years, maybe 15 or 20. 08:15AM

17 But if you include the public courses where you 08:15AM
18 could have five or ten different companies represented there, 08:15AM
19 through all the years, it's probably most every oil company sent 08:15AM
20 somebody to one of the courses I've taught. 08:15AM

21 Q What is the subsequent matter of the courses that you teach 08:15AM
22 to the oil and gas industry? 08:15AM

23 A Most of the courses are advanced phase behavior and U.S. 08:15AM
24 fluid characterization. But there's a couple of other courses I 08:15AM
25 teach regularly. There's gas condensate. And, more recently, 08:15AM

1 about the shale gas, this kind of a newer course. 08:15AM

2 Q Is it fair to say that you teach courses for the industry 08:15AM

3 about subjects that are comparable or the same as what you're 08:15AM

4 going to testify here about today? 08:16AM

5 A Yes, ma'am. 08:16AM

6 Q All right. And I would like to talk a little bit about what 08:16AM

7 you've published. 08:16AM

8 Have you published any books? 08:16AM

9 A Yes. I've written two books. One on well performances and 08:16AM

10 the Phase Behavior Monograph of the Society of Petroleum 08:16AM

11 Engineers. 08:16AM

12 MS. KARIS: We can look at D-23974, please. 08:16AM

13 BY MS. KARIS: 08:16AM

14 Q Are these the two books that you've published? 08:16AM

15 A Yes, ma'am. 08:16AM

16 Q The one on phase behavior, there's been a reference to it as 08:16AM

17 a monograph. 08:16AM

18 A Yes. 08:16AM

19 Q What is a monograph? 08:16AM

20 A Well, the Society for Petroleum Engineers have I think about 08:16AM

21 30 of these now. They're taking a specific topic, and you're 08:16AM

22 supposed to provide the technology, the methods, the references 08:16AM

23 on how to conduct a particular engineering task. 08:16AM

24 And, in this case, it's the calculation of phase 08:16AM

25 behavior or estimated properties of gas, oil, and water. 08:16AM

1 Q And so are you one of the authors of the books that the 08:16AM
2 Society of Petroleum Engineers uses in order to conduct or 08:17AM
3 instruct on phase behavior? 08:17AM

4 A Yes, ma'am. 08:17AM

5 Q In addition to the books that you have published, have you 08:17AM
6 also published papers, including some that are listed in your 08:17AM
7 curriculum vitae? 08:17AM

8 A Yes. 08:17AM

9 Q Tell the Court approximately how many papers you've 08:17AM
10 published. 08:17AM

11 A Well, it's over 100 papers, many, or maybe most of which, 08:17AM
12 have been published in the journals, in presentations, and 08:17AM
13 conferences. 08:17AM

14 Q And how many of those publications deal with the issue of 08:17AM
15 fluid phase behavior? 08:17AM

16 A Oh, I guess the great majority. Eighty percent or 08:17AM
17 something. I've never tallied it up, but the vast majority of 08:17AM
18 those would be in this area. 08:17AM

19 Q And then, finally, have you been recognized with any awards 08:17AM
20 in the industry for your contributions in the field of phase 08:17AM
21 behavior? 08:17AM

22 A Yes. There's been some awards I've received. 08:17AM

23 MS. KARIS: If we can look at 11496.180.1, please. 08:18AM

24 BY MS. KARIS: 08:18AM

25 Q And again, from your CV, are these some of the professional 08:18AM

1 awards that you have received from the industry, recognition of
2 your contribution to the industry?

3 A Yes, ma'am, they are.

4 Q There's one there that's referenced Anthony F. Lucas Gold
5 Medal for the SPE in 2011.

6 Tell the Court what that is.

7 A Well, it's kind of the highest technical award given by the
8 Society of Petroleum Engineers and AIME, so it was a very
9 special honor to get that award. Maybe technical award.

10 MS. KARIS: Your Honor, at this time I tender
11 Dr. Whitson as an expert in hydrocarbon fluid phase behavior and
12 its properties.

13 MS. ENGEL: Subject to our two pending motions and
14 cross examination, we have no objection.

15 THE COURT: I'll accept him as an expert.

16 MS. KARIS: Thank you, Your Honor.

17 BY MS. KARIS:

18 Q Dr. Whitson, I'd like to discuss some of the opinions now
19 that you've reached in this case. Let's begin with
20 TREX-11496.1, please.

21 Is this the expert report that you prepared that
22 contains the opinions that you intend to give in this case?

23 A It's the cover page from that report, yes.

24 Q Right. This is the cover page?

25 And then does Exhibit 11496 contain the opinions

1 and the analyses that you've done in connection with the work
2 you've done in this case?

3 A Yes, it is.

4 MS. KARIS: And if we can now look at D-24604.

5 BY MS. KARIS:

6 Q Can you give us a high level overview of what your opinions
7 are in connection with this case.

8 A Well, my first opinion is that the model that we built for
9 the reservoir fluid description in the Macondo reservoir is very
10 accurate. We're very proud of what was developed, and I believe
11 it accurately depicts the properties needed by the experts to
12 make calculations of rates and amounts that spilled into the
13 ocean.

14 The second thing is that we evaluated the work of
15 Dr. Zick, his equation of state model, and found a couple of
16 quite serious flaws. In particular, its ability to calculate or
17 replicate the measurements of a shrinkage factor by the
18 laboratories.

19 And this would have, of course, a very important
20 impact on the decisions made by the Court here. So that was, I
21 think, a fairly serious problem that was identified in that
22 evaluation.

23 And then the final thing I did is to build a model
24 that I believe represents accurately the realistic process by
25 which reservoir fluid that entered the seabed and surfaced,

1 passed through, and led to the ultimate stock tank oil volume. 08:20AM

2 Q So, in discussing your opinions, does the first half of your 08:21AM
3 work relate to developing an equation of state model and then 08:21AM
4 critiquing Dr. Zick's equation of state model? 08:21AM

5 A That's what was done, yes. 08:21AM

6 Q In relying on that state model, did you then also prepare 08:21AM
7 something called a separator process? 08:21AM

8 A An oceanic separator process based on our equation state 08:21AM
9 model. 08:21AM

10 Q Let's start with the first half of the work that you did; 08:21AM
11 that is, constructing the equation of state model that 08:21AM
12 accurately depicts the behavior of a Macondo fluid -- a 08:21AM
13 reservoir fluid, as you've put on your slide here. 08:21AM

14 Before we get into the specifics of your 08:21AM
15 characterization, I'd like to discuss a couple basic concepts 08:21AM
16 with respect to equation state modeling. 08:21AM

17 First, let's start with the concept of the PVT, 08:21AM
18 the acronym. What is PVT as it relates to equation of state 08:21AM
19 models? 08:22AM

20 A Well, the letters stand for pressure, volume, and 08:22AM
21 temperature. But, in petroleum engineering, what we mean by 08:22AM
22 that is obtaining properties of gas, oil, and water, like 08:22AM
23 density, viscosity, and the relative amounts of the gas and oil 08:22AM
24 phases. That's what we mean by PVT. Equation of state can be 08:22AM
25 very accurate to make calculations of those properties. 08:22AM

1 Q And do the experts in this case trying to quantify how much 08:22AM
2 oil flowed from the Macondo reservoir need PVT, pressure volume 08:22AM
3 temperature data? 08:22AM

4 A Well, all of the experts use models or equations to make the 08:22AM
5 calculations of either rate or total amount that was released 08:22AM
6 into the ocean. 08:22AM

7 In all of those equations, you need the properties 08:22AM
8 of density of each phase, gas and oil, the viscosities of each 08:22AM
9 phase, gas and oil, and the amounts of each phase, gas and oil. 08:22AM

10 Those are really the only properties you need to 08:22AM
11 make those calculations in some form or another. Different 08:22AM
12 experts needed some properties; other experts needed other 08:23AM
13 properties; some experts needed all of the properties. But they 08:23AM
14 basically couldn't make the calculations without those 08:23AM
15 properties. 08:23AM

16 Q You told us what PVT data is. Now tell us what an equation 08:23AM
17 of state model is. 08:23AM

18 A Well, it's an equation or kind of a complicated set of 08:23AM
19 equations. But it's really just a vehicle, a means to get those 08:23AM
20 properties calculated accurately, with a consistency that 08:23AM
21 doesn't differentiate whether it's being a gas or an oil or 08:23AM
22 near-critical fluid, as you may have heard the term. It is all 08:23AM
23 encompassing. It can calculate the properties of really any 08:23AM
24 kind of fluid system at any set of conditions. 08:23AM

25 Q Does an EOS, equation of state model, predict how fluid 08:23AM

1 properties change as that fluid moves through different 08:23AM
2 pressures and temperatures from the reservoir, then to the 08:23AM
3 surface? 08:23AM

4 A That's its intention, is that it's able to calculate these 08:24AM
5 properties over a wide range of pressure temperature, and then 08:24AM
6 potentially change in composition, as would be experienced in an 08:24AM
7 oceanic separation process, for example. 08:24AM

8 MS. KARIS: Let's look at D-24586. 08:24AM

9 BY MS. KARIS: 08:24AM

10 Q Using this demonstrative, can you explain to the Court what 08:24AM
11 an equation of state model is designed to do in this case. Walk 08:24AM
12 us through what we're seeing here. 08:24AM

13 A Basically, we start down with this red symbol down in the 08:24AM
14 lower right-hand corner. This plot is showing pressure on the y 08:24AM
15 axis. 08:24AM

16 MS. KARIS: If I may approach? 08:24AM

17 BY MS. KARIS: 08:24AM

18 A There we go. So there is the starting point, and pressure 08:24AM
19 and temperature. You can see that the pressure is increasing as 08:24AM
20 we go down. And the initial reservoir pressure there is just 08:24AM
21 short of 12000 psi. 08:24AM

22 And then the stock tank conditions, where we're 08:24AM
23 trying to quantify the volume of oil, is at 60 degrees 08:25AM
24 Fahrenheit. 08:25AM

25 We've got temperature here on the x axis starting 08:25AM

1 at the reservoir of 243 Fahrenheit, and it's going to go down to 08:25AM
2 60 Fahrenheit. And a pressure of just 15 psi. 08:25AM

3 So the point is that we're going to go from here 08:25AM
4 to there in a path that's not well defined. May change over 08:25AM
5 time. The experts that are making the calculations need to have 08:25AM
6 the properties, these PVT properties, anywhere in the shaded 08:25AM
7 area. Anywhere. Literally anywhere. 08:25AM

8 Now, the samples that were collected pre-incident 08:25AM
9 from the reservoir were sent to laboratories, and they made 08:25AM
10 property calculations in the laboratory at all of these yellow 08:25AM
11 circles: Densities, viscosities, and phase volumes. So we have 08:25AM
12 data from the laboratories at all these points, but we need data 08:25AM
13 everywhere in the shaded area. 08:25AM

14 The equation of state will provide us the ability 08:26AM
15 to calculate those properties anywhere in the shaded area, but 08:26AM
16 only after we have tuned that equation of state model to the 08:26AM
17 measured data at the other points. 08:26AM

18 Basically, it's a litmus test that the equation of 08:26AM
19 state can do a good job where we have measurements. So the 08:26AM
20 assumption is that it'll be able to calculate properties where 08:26AM
21 we don't have measurements. 08:26AM

22 Q We're going to talk briefly about how you went about filling 08:26AM
23 in these shaded parts here. But, to be clear, the yellow dots, 08:26AM
24 are those based on data that was collected, samples that were 08:26AM
25 collected and data that was tested at different labs? 08:26AM

1 A That's right. There were three different laboratories and 08:26AM
2 four different samples. One laboratory did analysis and 08:26AM
3 measurements of properties, densities, and so forth on two 08:26AM
4 samples. The other two laboratories each had one sample. 08:26AM

5 They have all conducted a suit of standard 08:26AM
6 experiments to get us these properties that we need to tune the 08:26AM
7 equation of state. 08:27AM

8 Q Are equations of state similar to the one that you have you 08:27AM
9 graphed here customarily built in the oil and gas industry? 08:27AM

10 A It's become standard about the last -- since around 1985, it 08:27AM
11 started become the standard method of developing the PVT models. 08:27AM

12 Q Can you tell the Court how long it took you to develop the 08:27AM
13 equation of state model that we're going to be talking about 08:27AM
14 today? 08:27AM

15 A Just short of three months. 08:27AM

16 Q Now, you referenced some data, lab data, you relied on. 08:27AM

17 A Yes, ma'am. 08:27AM

18 MS. KARIS: Let's look at TREX-8583.3, please. 08:27AM

19 BY MS. KARIS: 08:27AM

20 Q Do you recognize this document? 08:27AM

21 A Yes, ma'am. This is one of the Pencor samples or Core Lab 08:27AM
22 samples. 08:27AM

23 Q And, to be clear, when were the samples that we're going to 08:27AM
24 be talking about collected? 08:27AM

25 A They were collected pre-incident, pre before the blowout. 08:27AM

1 They were collected when the well had been drilled before they 08:28AM
2 put the production pipe in the well. 08:28AM

3 Q And when were those samples tested? 08:28AM

4 A I think the laboratories received the samples around April, 08:28AM
5 and they finished them in June. I know most of the reports were 08:28AM
6 delivered around middle of June. 08:28AM

7 Q So fair to say collected pre-incident but tested 08:28AM
8 post-incident? 08:28AM

9 A That's right. 08:28AM

10 Q And, by incident, I mean the blowout. 08:28AM

11 A The start, yeah. 08:28AM

12 Q Now if we can look at TREX -- 08:28AM

13 A And they were collected at two depths very close to each 08:28AM
14 other. All four of these samples were collected. 08:28AM

15 Q And the exhibit that we're looking at here, 8583, is this 08:28AM
16 the Core Lab test results for the testing that was done on one 08:28AM
17 of those samples? 08:28AM

18 A Yes. 08:28AM

19 MS. KARIS: And now if we can look at 8584.3. 08:28AM

20 THE WITNESS: They kind of look alike, I think. 08:29AM

21 BY MS. KARIS: 08:29AM

22 Q Is this another one of the lab test reports that was, again, 08:29AM
23 sample collected pre-incident but tested post-incident? 08:29AM

24 A Right. That's right. 08:29AM

25 MS. KARIS: And if we can now pull up 8583.1.1. 08:29AM

1 BY MS. KARIS: 08:29AM

2 Q Does this indicate to you when these test reports came out? 08:29AM
3 June 10th there? 08:29AM

4 A Yeah. They're actually dated, the reports themselves. But 08:29AM
5 they're middle of June, yeah, that's right. I think the 08:29AM
6 Schlumberger sample came in a little bit earlier. 08:29AM

7 Q Talk about the Schlumberger sample, 11575.1. Again, is this 08:29AM
8 the lab report from Schlumberger from sample collected 08:29AM
9 pre-incident but tested post-incident? 08:30AM

10 A Yes. 08:30AM

11 Q And then, finally, the last lab report 97 -- 08:30AM

12 A Dated May 19th. 08:30AM

13 Q Sorry. The date at the bottom right-hand corner here. 08:30AM

14 A And then it's updated there in the middle. So, I think it 08:30AM
15 was finally June, the final report. 08:30AM

16 There you go. 08:30AM

17 Q And then the last test report, 9734.20. 08:30AM

18 A Yeah. The Intertek, I think there were a couple of samples 08:30AM
19 issued. The separator test and the viscosity and constant 08:30AM
20 composition test was a separate report. This is the separator 08:30AM
21 test. 08:30AM

22 Q Okay. So we've now looked at the four, at least the covers, 08:30AM
23 of the four test reports. Did you rely on those reports in 08:30AM
24 building your equation of state model? 08:30AM

25 A That's basically what we relied on, that's right. For 08:30AM

1 building equation of state, that's what we use. 08:31AM

2 MS. KARIS: Let's look at D-24591, please. 08:31AM

3 BY MS. KARIS: 08:31AM

4 Q Can you tell the Court what kind of testing did the labs 08:31AM
5 perform and report on in those four reports that we just looked 08:31AM
6 at. 08:31AM

7 A Okay. So, all four samples, all three laboratories 08:31AM
8 conducted the so-called constant composition test. It's a test 08:31AM
9 that provides the densities at single phase, where the fluid is 08:31AM
10 single phased. So initial pressure and temperature run down to 08:31AM
11 about 6500 pounds. That's what gives us the densities. 08:31AM

12 And it gives us two phases. And the amounts of 08:31AM
13 the two phases is below that 6500 pound saturation pressure. So 08:31AM
14 the laboratories measure these tests at reservoir temperature on 08:31AM
15 down to 100 Farenheit. 08:31AM

16 The separation tests were also conducted by all 08:31AM
17 three labs on all four samples. And, there were two types of 08:31AM
18 separation tests, which are important in coming up with measure 08:32AM
19 of shrinkage factor. One is a single-stage flash, and that's 08:32AM
20 also used to help get the composition of the reservoir fluid. 08:32AM

21 The other is a four-stage separation process, 08:32AM
22 which the main intension is to come up with a shrinkage factor 08:32AM
23 to tune the equation state with. 08:32AM

24 And then there were some initial measurements made 08:32AM
25 for viscosities by the three labs except Schlumberger. And the 08:32AM

1 difference liberation was conducted on the two samples by
2 Pencor.

3 Q Now, given the timing of these tests, was there anything in
4 these reports to suggest that the four-stage separation test
5 indicated how the reservoir was going to be produced, had it
6 been produced?

7 A I never saw any documentation to that effect, no. So it's
8 -- you know, that's not usually the way it works. You know,
9 we're --

10 Q Tell us how it usually works in connection with what lab
11 tests are requested.

12 A Well, the lab may or may not conduct a multi-stage separator
13 test. It's done really to give data to help tune the equation
14 of state to make sure it can calculate accurate shrinkage
15 factor.

16 Often, you discover, you'd would never know what
17 kind of separation conditions you're going to use to sell the
18 oil. Sometimes they don't even ask for a separator test. It
19 just varies from lab to lab.

20 At least I never saw any documentation that this
21 was the intention of the company, to produce the field at these
22 conditions, though.

23 Q And we'll be talking more about the four-stage separation
24 briefly. But, before we go there, can you tell us, now that
25 we've looked at what an EOS is designed to do and what data

1 you've relied on, how you went about building your equation of 08:33AM
2 state. 08:33AM

3 A Well, to build an equation of state, you need data. That's 08:33AM
4 all you need. You need the PVT measurements and the 08:33AM
5 compositions, the sample upon which the measurements were made. 08:34AM
6 That's really it. You need -- that's the data. 08:34AM

7 And then you need, of course, to understand what 08:34AM
8 you're doing. And you need skill-set and understand the methods 08:34AM
9 to develop an equation of state. 08:34AM

10 But, without data, you can't build an equation of 08:34AM
11 state. 08:34AM

12 Q Now, after building an equation of state, how do you know if 08:34AM
13 you have a good model? 08:34AM

14 A You compare the model, the equation of state model, against 08:34AM
15 the measured data. If you match those measured data, 08:34AM
16 particularly those data that are accurately measured and those 08:34AM
17 that are important to the particular process, then you know you 08:34AM
18 have a good equation of state. 08:34AM

19 Q Now with respect to the shrinkage factor, for example, 08:34AM
20 coming from the equation of state, is there some litmus test you 08:34AM
21 have for evaluating the accuracy of your equation of state 08:34AM
22 model? 08:34AM

23 A Well, the shrinkage factor in all fields we work on is kind 08:34AM
24 of the most important measurement made, because it's going to 08:34AM
25 translate what they discover, the reservoir volume, the 08:35AM

1 geologists give them to potentially sellable oil volume. So 08:35AM
2 that's always an important number. The laboratories know that. 08:35AM

3 Now, most of the revenues derived in any field 08:35AM
4 will come from the oil. So measuring the oil volume accurately 08:35AM
5 is really the key. And that's what they measure in the 08:35AM
6 shrinkage test and the multi-stage separator. 08:35AM

7 So gas has much less volume. So getting the 08:35AM
8 property, the gas volume accurate, you should expect some 08:35AM
9 accuracy, but they don't pay as much attention to gas volumes as 08:35AM
10 they do to oil volumes. 08:35AM

11 Q After building your equation of state, can you compare your 08:35AM
12 model to the measured data with respect to shrinkage to see how 08:35AM
13 good your model was? 08:35AM

14 A Yes. 08:35AM

15 Q Can you tell us about that analysis. 08:35AM

16 A Well, I mean, basically we want to get the shrinkage factor 08:35AM
17 within a couple percent at the most, within 2 percent. I mean, 08:36AM
18 the company's expect it. And we generally -- the data are that 08:36AM
19 accurate. We're generally always able to deliver that kind of 08:36AM
20 accuracy for all the samples. 08:36AM

21 Now, here, there are four samples. We do studies 08:36AM
22 where there are 40 samples or 80 samples. But they expect that 08:36AM
23 shrinkage factor to be predicted within 1, 2 percent for all 08:36AM
24 samples. 08:36AM

25 Q And how did your model compare? Did you conclude whether it 08:36AM

1 was a good model or not? 08:36AM

2 A Well, for the shrinkage, it was a good model. I mean, we 08:36AM

3 had an unbiased prediction. Some of the numbers were less than 08:36AM

4 a percent, some more than a percent. But it was within our goal 08:36AM

5 of achieving the accuracy of the plus/minus 2 percent. 08:36AM

6 Q Are you aware that Dr. Zick constructed an equation of state 08:36AM

7 model, the United States' expert? 08:36AM

8 A Yes. 08:36AM

9 Q And did you compare Dr. Zick's equation of state model with 08:36AM

10 the measured lab data that you were looking at? 08:36AM

11 A Yes, I did. 08:37AM

12 MS. KARIS: Let's look at D-24595, please. 08:37AM

13 BY MS. KARIS: 08:37AM

14 Q Can you tell the Court what you found when you evaluated 08:37AM

15 Dr. Zick's equation of state model and compared it to the 08:37AM

16 measured lab data? 08:37AM

17 A Well, there's two things. First, every sample of the four 08:37AM

18 samples, he overpredicted the shrinkage factor. For every 08:37AM

19 sample. So it was a biased error. 08:37AM

20 And the magnitude of error was, on average -- it 08:37AM

21 says there 4 to 5 percent -- was 4.5 percent. It's a lot of 08:37AM

22 error, and it's all on the high side. So I was very surprised 08:37AM

23 when I saw it. 08:37AM

24 We could never deliver this to an oil company in a 08:37AM

25 regular situation. 08:37AM

1 Q And you talked about overpredicted shrinkage. And we've 08:37AM
2 discussed this previously, sort of it's counterintuitive. If 08:37AM
3 you're overpredicting shrinkage, what is the effect of that with 08:37AM
4 respect to predicting stock tank barrels? 08:38AM

5 A Well, you'd be predicting too much stock tank oil. 08:38AM

6 Q Let's talk about some of the details that you just 08:38AM
7 referenced when you said it's overpredicted. 08:38AM

8 MS. KARIS: Your Honor, at this time, I'd like to put 08:38AM
9 up a demonstrative that we produced to the United States. There 08:38AM
10 was an objection. 08:38AM

11 The alternative is, we can write it on the white 08:38AM
12 board. It's just numbers that Dr. Whitson uses from his report 08:38AM
13 to compare his data to Dr. Zick's data. 08:38AM

14 THE COURT: What's the objection? 08:38AM

15 MS. ENGEL: I'd have to see the demonstrative. 08:38AM

16 MS. KARIS: Sure. D-24589A, and then there is a 08:38AM
17 companion one. That's single stage, and then we have one for 08:38AM
18 the four stage. D-24589A, please. 08:38AM

19 MS. ENGEL: Our objection was simply that we got this 08:39AM
20 on Sunday morning, I believe, when Dr. Whitson was originally 08:39AM
21 supposed to take the stand last week. 08:39AM

22 THE COURT: So it's moot now. 08:39AM

23 Okay, go ahead. 08:39AM

24 MS. KARIS: Thank you, Your Honor. 08:39AM

25 BY MS. KARIS: 08:39AM

1 Q Now, Dr. Whitson, can you please tell us what this 08:39AM
2 demonstrative titled EOS models compared to lab data for single 08:39AM
3 stage is demonstrating. 08:39AM

4 A Okay. Well, the four top numbers in black text, those are 08:39AM
5 the measurements from the laboratory of the shrinkage for a 08:39AM
6 single-stage process. They range from 42.4 in the one sample to 08:39AM
7 as much as 44 for the Intertek sample. 08:39AM

8 Q Okay. So let me stop you there. Are these the shrinkage 08:39AM
9 factors for single stage then that are reported or that you 08:39AM
10 calculated? 08:39AM

11 A No, no. Those are the measured laboratory data. Those are 08:39AM
12 the measured numbers. So you've got 100 barrels of reservoir 08:39AM
13 fluid initial conditions. That's how many stock tank barrels of 08:40AM
14 oil that they measured would result from that, and the average 08:40AM
15 of those four measurements is 43.4 stock tank barrels. 08:40AM

16 Q So does this come straight from the reports? 08:40AM

17 A Straight from the reports. This is what they measured. 08:40AM

18 Q Now you have your equation of state average. Tell us what 08:40AM
19 you're demonstrating here, 43.4 plus .2 percent. 08:40AM

20 A So the deal is that we take our equation of state, and for 08:40AM
21 each of those four samples we calculated a number. Okay? For 08:40AM
22 each of those four samples which are not shown, our equation of 08:40AM
23 state. 08:40AM

24 But then we take the average of those four 08:40AM
25 calculated numbers, and we get 43.4. Okay? 08:40AM

1 So then our average of the four samples is 43.4. 08:40AM
2 And it's almost spot-on to the average of the four laboratory 08:40AM
3 data. 08:40AM
4 Q And then can you tell us how Dr. Zick's equation of state 08:40AM
5 model, his average, how it compared to the measured lab data. 08:40AM
6 A Yes. 08:41AM
7 Q For single stage. 08:41AM
8 A Okay. So he reports in -- he uses an average fluid in most 08:41AM
9 of his report. Not a fluid that was actually in the lab report, 08:41AM
10 but he kind of takes an average of the four fluids that he has. 08:41AM
11 I don't remember exactly how he does that. 08:41AM
12 Then he makes these calculations, for example, in 08:41AM
13 single-stage flash with that average fluid. That gave the 44.5 08:41AM
14 number. 08:41AM
15 Now, if instead you look at his calculations from 08:41AM
16 his equation of state in those four tests and you put those four 08:41AM
17 numbers up against the lab reporting numbers there, that average 08:41AM
18 would only be 1.1 percent different than the lab numbers, not 08:41AM
19 2.8. It would only be 1.1. 08:41AM
20 The reason I didn't put that number there is 08:41AM
21 because the 44.5 number is the number that he continuously puts 08:41AM
22 in the report. But it's a little bit unfair in that case, 08:41AM
23 because his equation of state was within 1.1 percent on average 08:41AM
24 of those one-stage shrinkage factors. 08:42AM
25 Q Let's now talk about his four stage, which was one of the 08:42AM

1 processes that he recommended for the Court to adopt. 08:42AM

2 MS. KARIS: Let's look at D-245908, please. 08:42AM

3 BY MS. KARIS: 08:42AM

4 A So this is -- 08:42AM

5 Q I'm sorry, let me stop you for a second. Is this report the 08:42AM
6 measured data from the four samples for the four stage separator 08:42AM
7 process? 08:42AM

8 A Yes, ma'am. That is in black. 08:42AM

9 Q And tell us what we see here. 08:42AM

10 A So, those in black there, those are the four measurements. 08:42AM

11 Now, the laboratories all use the same set of 08:42AM
12 conditions for the four stages. So, you can compare all the Red 08:42AM
13 Delicious apples, you can compare those four numbers. 08:42AM

14 And then we just take the hermetic average of 08:42AM
15 those four laboratory numbers, and we get 47.3. 08:42AM

16 If we take our equation of state and calculate for 08:42AM
17 the four tests, the four states, we simulate the laboratory test 08:42AM
18 and we average our four numbers and we get 47.9. So it's 1.3 08:43AM
19 percent high. 08:43AM

20 Again, what we would label Zick EOS average, this 08:43AM
21 is his average sample, his average composition, which wasn't 08:43AM
22 measured in a lab. Just an average composition put through that 08:43AM
23 four-stage separator process. He puts the 49.9 number as his 08:43AM
24 calculated number, which is 4.4 percent high. 08:43AM

25 But the more proper comparison, as I've talked 08:43AM

1 about last time, is if you look at his simulation in the four 08:43AM
2 different tests, put those up against the lab data, calculate 08:43AM
3 the average deviation to that, that's 4.7 percent. 08:43AM

4 So it's a little bit higher than that. It's close 08:43AM
5 to 5 percent biased in error. And each one of those 08:43AM
6 calculations he has for those four samples is high. It's higher 08:43AM
7 than the laboratory measurement. 08:43AM

8 Q And so, if Dr. Zick proposed as an alternative that the 08:43AM
9 Court use his EOS average for the four stage, what would that 08:44AM
10 result in based on the measured lab data in terms of predicting 08:44AM
11 stock tank barrels? 08:44AM

12 A Well, that number 4.4 wouldn't apply. It would be more like 08:44AM
13 4.7, closer to 5. 08:44AM

14 Q Is that an overprediction? 08:44AM

15 A Overprediction of stock tank oil. 08:44AM

16 Q Is 4.4 or 4.7 overprediction significant, in your opinion? 08:44AM

17 A It's big. I mean, it means a lot of oil. It means a lot of 08:44AM
18 money. And oil companies, in a normal situation where you want 08:44AM
19 to produce, you want to have that number right. You wouldn't 08:44AM
20 accept this kind of average, deviation, in the shrinkage factor. 08:44AM

21 So it's just -- I don't know why it's so high, but 08:44AM
22 it's high. 08:44AM

23 Q Let's look at TT -- 08:44AM

24 A If I can make just a comment? 08:44AM

25 Q Sure. 08:44AM

1 A The problem is, if you're going to use the four-stage flash, 08:44AM
2 you just use the data. Take the average and use the data. You 08:45AM
3 don't need a model. You don't my model; you don't need his 08:45AM
4 model. So, if you just stick to the four-stage flash or 08:45AM
5 single-stage flash, you just use the data. 08:45AM

6 The problem is that, if you use these equations of 08:45AM
7 state and it's got an underprediction/overprediction bias, and 08:45AM
8 you use it to simulate another process where there's no 08:45AM
9 laboratory check of how accurate it's calculating, that's the 08:45AM
10 problem. 08:45AM

11 So, if you do some other kind of oceanic process, 08:45AM
12 any kind of other separator process and you have a general bias, 08:45AM
13 that bias is going to carry over into the other simulated 08:45AM
14 process. That's the problem. 08:45AM

15 THE COURT: Ms. Karis, let me interrupt for a second. 08:45AM
16 Let me ask you so I can understand. 08:45AM

17 So these four samples that we're talking about, 08:45AM
18 these are the actual oil samples that were taken from the 08:45AM
19 Macondo well before the blowout? 08:46AM

20 THE WITNESS: That's right. 08:46AM

21 THE COURT: They were tested afterwards. 08:46AM

22 THE WITNESS: That's right. 08:46AM

23 THE COURT: And they were tested by four different 08:46AM
24 labs. 08:46AM

25 THE WITNESS: Three different. 08:46AM

1 THE COURT: Three different labs, I'm sorry. Using 08:46AM
2 different methods of separation. 08:46AM

3 THE WITNESS: Well, the three labs used the same four 08:46AM
4 stage set of -- the same process for four different samples. 08:46AM

5 THE COURT: You talked about single stage and four 08:46AM
6 stage. 08:46AM

7 THE WITNESS: Correct. 08:46AM

8 THE COURT: So, as I understand it, I assume the goal 08:46AM
9 or the object for the oil company would be generally to produce 08:46AM
10 as much sellable oil as they can from the well; correct? 08:46AM

11 THE WITNESS: That's right. 08:46AM

12 THE COURT: So is it always the case that this 08:46AM
13 four-stage separation method produces more stock tank than a 08:46AM
14 single stage? 08:46AM

15 THE WITNESS: Well, you have the six-stage separation 08:46AM
16 process by the Pencor lab, which is a differential process, six 08:47AM
17 stages, that produces much less. 08:47AM

18 But the four stage and a traditional separator 08:47AM
19 multiple-stage test will generally produce more. 08:47AM

20 THE COURT: I guess what I'm trying to understand is, 08:47AM
21 if your goal is to produce as much sellable oil as you can, 08:47AM
22 seems logically you would use the separation method that would 08:47AM
23 produce the most sellable oil; correct? 08:47AM

24 THE WITNESS: That's correct. 08:47AM

25 THE COURT: And what method would that be? I know I'm 08:47AM

1 oversimplifying things here for you, but...

08:47AM

2 THE WITNESS: Well, at this point in time, you wouldn't
3 know, because there would be so many other considerations. It
4 might be a three-stage separation process with completely
5 different conditions than what we have here that might be the
6 optimal for a given field, for this field.

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7 THE COURT: Well, based on the lab data that was taken
8 before the blowout, it looks like between the single stage and
9 the four stage, the four stage obviously produces more oil.

08:48AM

08:48AM

08:48AM

10 THE WITNESS: Yes, sir.

08:48AM

11 THE COURT: Okay. Go ahead.

08:48AM

12 THE WITNESS: Yes, sir.

08:48AM

13 MS. KARIS: If we can look at TT.1759.1.

08:48AM

14 BY MS. KARIS:

08:48AM

15 Q I guess, before we look at this testimony, to follow-up on
16 Judge Barbier's caution, in terms of which tests were requested,
17 single stage, four stage, had those been identified before the
18 incident, or were those identified after the incident in
19 connection with the testing?

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20 A Well, they were identified when they sent the samples to the
21 laboratory.

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08:48AM

22 Q And that would have been after the incident?

08:48AM

23 A Yes.

08:48AM

24 Q And, so at the time the testing was specified, did that

08:48AM

25 testing to you in any way indicate what, if any, plan there was

08:49AM

1 in terms of how they were going to try and produce Macondo had 08:49AM
2 there not been a blowout? 08:49AM

3 A Yeah. It seldom is the actual process they end up producing 08:49AM
4 to sell the oil with -- I mean, it might be four stage, it might 08:49AM
5 be two stage. You don't know. I mean, it's going to produce 08:49AM
6 more oil as a single stage. 08:49AM

7 But, which multiple stage process they're going to 08:49AM
8 use, nobody knew then, and nobody knows now. So that's the 08:49AM
9 problem. 08:49AM

10 Q Now, we were talking about the significance of the 08:49AM
11 overprediction of the one stage and the four stage that 08:49AM
12 Dr. Zick, his EOS, demonstrated. 08:49AM

13 I want to show you Dr. Zick's testimony. He was 08:49AM
14 asked: For purposes of your separation analysis, can you 08:49AM
15 summarize how your equation of state compares to Dr. Whitson's? 08:49AM
16 And he says: Our equations of state have differences in the 08:49AM
17 details; but, overall, they both reproduce the behavior of the 08:50AM
18 Macondo fluid reasonably well. The differences between them, at 08:50AM
19 least as far as the shrinkage factors, are relatively 08:50AM
20 insignificant, only about 3 percent, which relative to the 08:50AM
21 uncertainties in the -- it says PTB, but I think it should be 08:50AM
22 PTV data. 08:50AM

23 A PVT. 08:50AM

24 Q I'm sorry -- PVT data, I believe, in my opinion, are not 08:50AM
25 significant. 08:50AM

1 Do you agree with Dr. Zick's comment there? 08:50AM

2 A No. There's several problems here. 08:50AM

3 The first thing is that it doesn't -- what matters 08:50AM
4 is how the equation of state compares against the data, not one 08:50AM
5 equation of state against the other. That's the first one. 08:50AM

6 The second thing is that his shrinkage factors 08:50AM
7 that he's quantifying here are not from initial pressure but 08:50AM
8 from saturation pressure, which is only like -- initial pressure 08:50AM
9 is close to 12000 pounds; saturation pressure is closer to 6000 08:51AM
10 pounds. So there more error in the shrinkage than what's being 08:51AM
11 indicated here. 08:51AM

12 The third point is that 3 percent. That's a lot. 08:51AM
13 I mean, for accurately measured data, data that is bottom line 08:51AM
14 important in every situation, well, 3 percent, or in reality 4 08:51AM
15 and a half percent, it's just not good enough. Means too much 08:51AM
16 money, too many barrels. It's not acceptable. 08:51AM

17 Q Is an overprediction of 4 and a half to 5 -- 4.4 to 4.7 08:51AM
18 percent something that you would deem acceptable for providing 08:51AM
19 an equation of state model to a client of PERA's or yours? 08:51AM

20 A No. I'd be out of business a long time ago if I did that. 08:51AM

21 Q Let's now turn to the second half on the work that you did, 08:51AM
22 and that is in connection with the separator process. We go 08:52AM
23 back to D-24604. 08:52AM

24 And, again, just to orient us, tell us what the 08:52AM
25 second half of your work in this case pertains to. 08:52AM

1 A Well, I was trying to come up with a realistic model of how 08:52AM
2 the reservoir fluids passed from the point they entered the sea 08:52AM
3 at the seabed to ultimate stock tank conditions, modeling that 08:52AM
4 process of changing pressure and temperature through a large 08:52AM
5 body of water. That's what I tried to do. 08:52AM

6 Q Now, what, in your opinion, was the separator process that 08:52AM
7 you believe to be most appropriate for performing the conversion 08:52AM
8 from reservoir fluid to stock tank barrels? 08:52AM

9 A Well, it should be -- in my whole life as an engineer and a 08:52AM
10 scientist, all I've tried to do is model the real processes. 08:52AM
11 That's all I do. I try to take a real process and create a good 08:52AM
12 model to describe that process. That's what I've always done. 08:53AM

13 So, when I took on this project, that was the 08:53AM
14 first thought, try to model the actual process. That's what I 08:53AM
15 did. That's why I called it the oceanic process. 08:53AM

16 Q I was going to ask you, what is that process that you 08:53AM
17 believe to be most realistic? 08:53AM

18 A Well, I mean, I call it oceanic process. It's just a 08:53AM
19 multi-stage process that takes into account what actually 08:53AM
20 happened from seabed to surface. 08:53AM

21 Q Why is a separation process needed in this case? 08:53AM

22 A Well, my understanding is that the penalties to be levied 08:53AM
23 are to be levied on an oil at stock tank conditions. The oil 08:53AM
24 that entered the seabed is not stock tank conditions, so has to 08:53AM
25 be a conversion. 08:53AM

1 Q So is it for the purpose of then converting reservoir fluid 08:53AM
2 oil to stock tank conditions? 08:53AM

3 A That's right. 08:53AM

4 Q How does the EOS model that we have been talking about this 08:53AM
5 morning relate to the work that you did in connection with the 08:53AM
6 separator process? 08:54AM

7 A Well, the separator process, the oceanic separator process 08:54AM
8 obviously is not modeled in the laboratory. We have to use the 08:54AM
9 equation of state to make those calculations of the oceanic 08:54AM
10 process. 08:54AM

11 So its reliability, its accuracy, is paramount to 08:54AM
12 getting a good shrinkage factor through the oceanic process. 08:54AM

13 Q So, if you're going to recommend an oceanic process like you 08:54AM
14 and Dr. Zick ultimately did, is it important to have an accurate 08:54AM
15 equation of state model? 08:54AM

16 A That's right. 08:54AM

17 Q And, if your equation of state model overpredicts shrinkage 08:54AM
18 factors, what effect do you expect that to have any oceanic 08:54AM
19 separator process that's recommended? 08:54AM

20 A Well, if you have an EOS model that's got kind of carrying a 08:54AM
21 biased overprediction or underprediction, but let's say 08:54AM
22 overprediction as in the case of Dr. Zick's, that's going to 08:54AM
23 carry over into the oceanic process. 08:55AM

24 You don't know whether that overprediction's going 08:55AM
25 to get bigger, because you go from four stages to 130 stages. 08:55AM

1 But, you know, you will never be able to know for sure, but that 08:55AM
2 it's going to get less doesn't make any sense. 08:55AM

3 MS. ENGEL: Your Honor -- I'm sorry, I don't mean to 08:55AM
4 cut you off. The United States filed a motion regarding 08:55AM
5 Dr. Whitson's improper surrebuttal opinions, which you granted. 08:55AM
6 I'm afraid we're starting to step into this area where Dr. 08:55AM
7 Whitson is criticizing Dr. Zick's oceanic separation, which is 08:55AM
8 improper surrebuttal under your order. 08:55AM

9 MS. KARIS: Your Honor, two points. 08:55AM

10 One is, we do intend to make a separate offer of 08:55AM
11 proof with respect to Dr. Whitson's testimony responding to Dr. 08:55AM
12 Zick. 08:55AM

13 But, that said, this is not intended to go into 08:55AM
14 Dr. Zick's oceanic separator process, because we acknowledge the 08:55AM
15 Court's order. This is intended to say, if an oceanic -- in 08:55AM
16 general, if an equation of state model overpredicts, what effect 08:56AM
17 would that have on an oceanic separator? 08:56AM

18 THE COURT: Sounds like you're criticizing him without 08:56AM
19 putting a name on it. You're saying, what if somebody did what 08:56AM
20 Dr. Zick did. 08:56AM

21 MS. KARIS: I can move on, Your Honor. We're not going 08:56AM
22 to get into Dr. Zick 's oceanic separator. 08:56AM

23 THE COURT: Yeah, we'll move on to another subject. 08:56AM

24 BY MS. KARIS: 08:56AM

25 Q Dr. Whitson, can you tell the Court, first, with respect to 08:56AM

1 an oceanic separator, or any separator process, how does the 08:56AM
2 concept of equilibrium fit into this separator process analysis? 08:56AM

3 A Well, thermodynamic equilibrium, what that really means is 08:56AM
4 that the separation process consists of going from reservoir 08:56AM
5 conditions to stock tank conditions. It will go through one or 08:56AM
6 more stages, get there. 08:56AM

7 At each stage, you have to have a pressure and 08:56AM
8 temperature defined and what's coming into that stage. 08:57AM

9 Now, thermodynamic equilibrium, what that means, 08:57AM
10 is that the stuff that's there in that stage at the pressure and 08:57AM
11 temperature, Mother Nature is going to decide whether there's 08:57AM
12 two phases, gas and oil, which it will be. 08:57AM

13 And then Mother Nature is going to decide how much 08:57AM
14 of the methane is going to go into the gas and how much of the 08:57AM
15 methane is going to go into the oil. In other words, it's going 08:57AM
16 to leave the oil and go into the gas. 08:57AM

17 Likewise, ethane, some of the ethanes will go from 08:57AM
18 the oil into the gas. 08:57AM

19 What will happen then is that that oil is going to 08:57AM
20 shrink because the gas is getting created. That determination 08:57AM
21 of how much gas stays as a result and how many of the molecules 08:57AM
22 go from the oil phase into the gas phase, that's what we call 08:57AM
23 equilibrium thermodynamics. And it's just basically Mother 08:57AM
24 Nature doing her thing. 08:57AM

25 Q How does that concept then of equilibrium fit into your 08:57AM

1 assessing or recommending a separator process in this case? 08:57AM

2 A Well, it plays a role because you're basically trying to do 08:58AM

3 this thermodynamic equilibrium at each stage in those 130 stages 08:58AM

4 of the seabed to the surface. 08:58AM

5 Q We've heard reference to a single stage versus a 08:58AM

6 multi-stage. What is the difference between those two? 08:58AM

7 A Well, the separation process is going from reservoir to 08:58AM

8 stock tank through one or more stages. 08:58AM

9 So, if it's a single stage, you've just got one 08:58AM

10 stage straight to stock tank conditions. If it's a multi-stage, 08:58AM

11 you have at least one or more intermediate stages before you get 08:58AM

12 to stock tank conditions. 08:58AM

13 Q Is multiple phase and multiple stage the same concept? 08:58AM

14 A Multi-phase flow is something really completely different. 08:58AM

15 Multi-phase flow is like you got gas and oil flowing together in 08:58AM

16 a pipe or in a reservoir. 08:58AM

17 Multi-stage separation is what we've been talking 08:58AM

18 about here. 08:59AM

19 Q So, when we are talking about the separation process, is the 08:59AM

20 correct terminology multi-stage rather than multi-phase? 08:59AM

21 A That would be multi-stage separation, yeah. 08:59AM

22 Q Based on the concept of equilibrium that you just described 08:59AM

23 and the fact that these are these various single-stage, 08:59AM

24 multi-stage separator processes, why did you choose to create a 08:59AM

25 oceanic separator process in this case as the most accurate for 08:59AM

1 reflecting reservoir to stock tank barrels? Why did you think
2 that one was the most accurate?

3 A Like I said, I'm just used to modeling real processes, and
4 that was the real process. The reservoir fluid entered the
5 seabed and went to the surface. That's what I do.

6 I just tried to take into account the
7 thermodynamic equilibrium at all stages from seabed to surface.

8 Q Look at D-23988.

9 Given that you recommended or proposed an ocean
10 separator model, an oceanic separator model as the most
11 realistic, can you, using this demonstrative, explain to the
12 Court what your oceanic process shows with respect to the
13 reservoir fluid that ultimately went to stock tank barrels.

14 A This is the wellhead down here. So we know the pressure,
15 and it's going to be -- the reservoir fluid's going to be two
16 -phased when it hits the seabed. What's going to happen is that
17 oil coming out of that exit point is going to see lots of water.
18 Okay?

19 That oil's going to mix with the water. The gas
20 will take -- it's showing going off here, and we we're taking
21 the oil upwards. Now, at a higher elevation, there's lower
22 pressure.

23 So now you've got oil from the exit point and
24 water at a lower pressure. So, this thermogenic equilibrium,
25 Mother Nature's going to say, Well, what's going to happen here?

1 Well, that oil is going to create a gas phase. 09:01AM
2 There are going to be components from the oil that create that 09:01AM
3 gas phase, mainly methane, ethane, and propane, the light 09:01AM
4 components in the oil, is going to form that gas phase. That 09:01AM
5 oil is going to shrink because of that, because you're losing 09:01AM
6 material. 09:01AM

7 In addition, Mother Nature is going to say, well, 09:01AM
8 some much those components, mainly the light ones, are going to 09:01AM
9 go into the water phase. That's just part of thermodynamic 09:01AM
10 equilibrium. 09:01AM

11 So, at the end of that equilibrium, at that stage 09:01AM
12 2, you've got some of the components that have formed the gas 09:01AM
13 phase, some of the components have moved into the water. 09:01AM

14 Now we're at the end of the stage where we're 09:01AM
15 going to remove everything but the oil. We are going to remove 09:02AM
16 the gas and remove the water. And then that shrunken oil is 09:02AM
17 going to go up to higher elevation, a new pressure, it will see 09:02AM
18 new water, create a new equilibrium. We'll get a new gas phase. 09:02AM
19 The oil will shrink accordingly again. You get components going 09:02AM
20 into the water there. Take the gas away, the water goes away, 09:02AM
21 and that oil goes up. And that process just keeps going on to 09:02AM
22 the surface. 09:02AM

23 Q Now, you just discussed the effect of the water. And we've 09:02AM
24 heard previously when Dr. Zick was here with respect to your 09:02AM
25 oceanic model, that your oceanic model includes the effects of 09:02AM

1 solubility.

09:02AM

2 A That's right.

09:02AM

3 Q Can you explain to the Court why your model includes the
4 effects of solubility.

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09:02AM

5 A Well, solubility is just the result of this thermodynamic
6 equilibrium. Equilibrium is the law of nature. You mix the oil
7 and the water together, bring it to equilibrium, you get a gas
8 phase, an oil phase and a water phase. So that's the
9 consequence of physics.

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10 Q In your opinion, if you're going to use an oceanic separator
11 model, you need to include the effect of the water?

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09:03AM

12 A Well, why model the oceanic process if you've got no water
13 in the ocean? I don't know what you mean.

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09:03AM

14 Q Was it important in order for you to have an accurate
15 oceanic separator model to include the effect of solubility on
16 the reservoir fluid as it's converted to stock tank barrels?

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17 A Well, yeah. Because when the oil mixes with the water, some
18 of the components are going to go over into the water. So you
19 need to include that effect.

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20 Because you'll lose material, you will lose mass
21 from the oil. The oil will shrink some because of that. So I
22 don't know --

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09:04AM

23 MS. KARIS: Now, if we can pull up TT.1828.1.

09:04AM

24 BY MS. KARIS:

09:04AM

25 Q And, again, this is Dr. Zick commenting on your oceanic

09:04AM

1 separator.

09:04AM

2 He was asked: And you agree that when
3 hydrocarbons interact with the seawater, some of the
4 hydrocarbons will dissolve into the seawater; correct?

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5 He says: Yes; I think that's undeniable, but we
6 don't know how long it would take.

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09:04AM

7 Let's start with, is there any disagreement
8 between you and Dr. Zick as to whether solubility is a real
9 effect, or, as he says, undeniable?

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10 A No. We both know it's undeniable.

09:04AM

11 Q Now, how did you go about quantifying then what the effect
12 of solubility was on your oceanic separator?

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09:04AM

13 A Okay. So what we did was that we took this reservoir fluid
14 through 130 stages of separation to the surface. That created a
15 stock tank oil from that process.

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16 That stock tank oil was then -- basically, we
17 looked at that stock tank oil and we looked at the evidence
18 published from samples of oil collected during the spill at
19 different depths below the sea level, and we saw from that
20 publication what components they claim dissolved completely or
21 significantly into the ocean.

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22 Those components were removed from that stock tank
23 oil and recalculated its volume accordingly. That's all we did.
24 It's a two-step process: The process to get the stock tank oil,
25 and the second step was to remove those components that clearly

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1 had been dissolved into the ocean.

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2 Q So the second part of Dr. Zick's comment was: We don't know
3 how long it would take. Did you rely on published literature in
4 order to inform you as to the length of time it would take for
5 those components to dissolve?

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6 A Well, there are a number of publications we read discussing
7 this solubility in water. The Ryerson publication is in our
8 report, and it quantifies specifically the degree of dissolution
9 of individual components into the seawater from samples
10 collected below the surface at different depths during the
11 spill.

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12 The interpretation of that data seemed to be very
13 clear.

09:06AM

09:06AM

14 Q Let's look at TREX --

09:06AM

15 MS. ENGEL: Excuse me, Your Honor. Dr. Whitson did not
16 quantify the time dependence, how long it would take for oil to
17 dissolve in his reports. So I'm afraid we're going beyond the
18 four corners a bit here.

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09:07AM

19 MS. KARIS: The Ryerson publication and his reliance on
20 it and what that told him about the amount of time is explicitly
21 in his report.

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09:07AM

22 MS. ENGEL: And I also asked him explicitly in his
23 deposition whether he considered how long it would take for any
24 of these components to dissolve, and he said no.

09:07AM

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09:07AM

25 MS. KARIS: I think he can be crossed on that, Your

09:07AM

1 Honor. I think he'll explain exactly what he put in his report 09:07AM
2 and what he discussed -- 09:07AM

3 THE COURT: Where is that in his report? 09:07AM

4 MS. KARIS: I don't have his report. 09:07AM

5 BY MS. KARIS: 09:07AM

6 Q Dr. Whitson, you have your report up there. If you can 09:07AM
7 point the Court to where you refer to the Ryerson publication. 09:07AM

8 MS. ENGEL: While they're looking for that, Your Honor, 09:08AM
9 at his deposition, on page 278, starting at line 17, I asked: 09:08AM

10 Does the analysis in your report take into account the amount of 09:08AM
11 time it would take C1 through C5 to dissolve? Answer: No. 09:08AM

12 Does it take into account the amount of time it 09:08AM
13 would take the aromatics in C7 through C12 to dissolve? No. 09:08AM

14 Did you try to estimate the amount of time that it 09:08AM
15 would take for C1 through C5 and the aromatics to dissolve? No. 09:08AM

16 MS. KARIS: Your Honor, at page 31 of his report -- 09:08AM
17 and, to be clear, Dr. Whitson is not offering an opinion on how 09:08AM
18 many hours or days it would take. I think his reference is, 09:08AM
19 given the timing of when the Ryerson data was collected and his 09:08AM
20 reliance on it, it expressly, at page 31, goes into what effect 09:08AM
21 that data and those samples collected had. 09:08AM

22 I'm happy to rephrase, but this is expressly what 09:08AM
23 he talked about in his report. He was questioned at length 09:09AM
24 about what implications the Ryerson publication cited at 09:09AM
25 footnote 14 of his report had in his ability to say 10 percent 09:09AM

1 plus or minus 3. 09:09AM

2 MS. ENGEL: In the course of that questioning, he 09:09AM
3 specifically said he didn't consider how long it would take to 09:09AM
4 dissolve. 09:09AM

5 MS. KARIS: Perhaps I can rephrase, Your Honor. 09:09AM

6 THE COURT: All right. I will sustain the objection. 09:09AM
7 If you want to try it again, you can. 09:09AM

8 MS. KARIS: Sure. 09:09AM

9 MS. ENGEL: Thank you. 09:09AM

10 BY MS. KARIS: 09:09AM

11 Q First of all, did you reach an opinion, did you quantify the 09:09AM
12 effect of solubility on your oceanic separator process? 09:09AM

13 A Yes, we did. 09:09AM

14 Q What was your quantification as stated in your report? 09:09AM

15 A That oil, that stock tank oil that resulted from the 09:09AM
16 130-stage separation process shrunk by a factor of between 7 and 09:09AM
17 13 percent due to the solubility affect. 09:09AM

18 Q And did you rely on published literature cited in your 09:10AM
19 report in order to quantify the effect of solubility on your 09:10AM
20 oceanic separate process? 09:10AM

21 A Yes. 09:10AM

22 Q If we can look at 144128.1. Is this the Ryerson paper that 09:10AM
23 you referenced? 09:10AM

24 A Yes, it is. 09:10AM

25 Q Tell the Court for what purpose you relied on this Ryerson 09:10AM

1 publication that's at 144128.1, please. 09:10AM

2 A Well, this paper's -- it's clearly addressing quantitatively 09:10AM
3 the effect of dissolution of these components in the ocean. In 09:10AM
4 the time period during the spill, samples were collected at 09:10AM
5 several locations close to the spill, at several depths, and the 09:10AM
6 samples all concluded the same thing as far as the components 09:10AM
7 that were completely or partially dissolved into the ocean. 09:10AM

8 This is just data. I mean, it's inclusive in that 09:11AM
9 regard. 09:11AM

10 MS. KARIS: And if we can look now at a chart published 09:11AM
11 in the Ryerson paper, 11574N.4.2. 09:11AM

12 BY MS. KARIS: 09:11AM

13 Q First of all, do you recognize this chart from the Ryerson 09:11AM
14 publication? 09:11AM

15 A Right. 09:11AM

16 Q And, to be clear, is this data reporting oil samples 09:11AM
17 collected from the Macondo reservoir? 09:11AM

18 A Yes, they are. Well, you can see the dates, June 10, June 09:11AM
19 8; various depths. 09:11AM

20 Q So were these samples collected while the spill was ongoing? 09:11AM

21 A Yes. 09:11AM

22 Q Using this chart, can you tell the Court what affect this 09:11AM
23 chart had on your oceanic separator process? 09:11AM

24 A Okay. The easiest way to understand this is look at the top 09:11AM
25 figure here on the right side, this red curve here. It says, 09:11AM

1 fraction dissolved.

09:11AM

2 What that means is that it's the fraction of that
3 component -- for example, methane is the first component -- a
4 fraction of that component that was originally in the original
5 reservoir fluid, stock tank oil, that dissolved into the ocean.

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09:12AM

09:12AM

09:12AM

6 So, if the value is 1, they're implicating that
7 that component was totally dissolved in the ocean for the
8 samples collected. So you've got 1 for values of methane,
9 ethane, propane. Those are the first three hydrocarbons.

09:12AM

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09:12AM

10 In our model, the one case that reduced 7 percent
11 stock tank oil volume, reduction, was simply by taking our stock
12 tank oil, 130-stage separator stock tank oil, and removing those
13 three components. Resulted in the 7 percent reduction in the
14 stock tank oil volume.

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15 Q Let me stop you there. Why did you remove those three
16 components?

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09:12AM

17 A Because these, you see these things are --

09:12AM

18 Q C1 through C3?

09:12AM

19 A Yeah. I mean, C1 through C3 are these first three
20 components here. You see that it says: Fraction dissolved.
21 100 percent is dissolved from methane, ethane, and propane. So
22 that's why we did one case with that.

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23 Q Now, did you also calculate a middle case?

09:13AM

24 A The middle case we said that additionally C4 and C5
25 dissolved completely, which is not the case. When you look at

09:13AM

09:13AM

1 C4 and C5, they're only partially dissolved. But we wanted to 09:13AM
2 bracket in a sense the range of effect, and that's what we did. 09:13AM

3 So we did a second case. We included C4, which is 09:13AM
4 butanes, and C5 which is pentanes. We are not saying that all 09:13AM
5 of those were necessarily dissolved, but that was like the 09:13AM
6 second case. 09:13AM

7 What we know is that, in addition to C1, C2, C3, 09:13AM
8 there was partial dissolution of very many components. So we 09:13AM
9 basically did three cases to try to quantify the effect on the 09:14AM
10 stock tank oil volume. 09:14AM

11 Q And then did you have a third case? 09:14AM

12 A And the third case is including these. You see the fourth 09:14AM
13 component here, Benzene, toluene. The aromatics, the so-called 09:14AM
14 light aromatics, I think there's four or five of them, those 09:14AM
15 have a strong preference for dissolving in the ocean. 09:14AM

16 So, in the third case, we took methane through C5 09:14AM
17 and the light aromatics and let all of those dissolve as an 09:14AM
18 upper limit case. That resulted in 13 percent reduction in 09:14AM
19 stock tank oil volume. 09:14AM

20 So those were the bracketing of the -- given that 09:14AM
21 you have varying solubility of all these components that we 09:14AM
22 looked at, we looked at the, in a sense, the upper limit of 09:14AM
23 effect on stock tank oil volume. 09:14AM

24 MS. KARIS: Now look at 11574. 09:14AM

25 THE COURT: Let me ask a very simple, basic question. 09:14AM

1 What do you mean by dissolved? Does that mean 09:14AM
2 it's totally gone? Because I can dissolve something in water 09:15AM
3 and it's still in the water. 09:15AM

4 THE WITNESS: Right. 09:15AM

5 THE COURT: For example, salt. Doesn't mean the 09:15AM
6 water's not salty. So I'm trying to get an understanding of 09:15AM
7 what you mean by dissolve. 09:15AM

8 Does it mean the chemical has totally gone away, 09:15AM
9 doesn't exist anymore in the water, or it's just so diluted that 09:15AM
10 it doesn't -- 09:15AM

11 THE WITNESS: No. The easiest is take this thing here. 09:15AM
12 Okay? Originally, if we filled it up from the tap, it would 09:15AM
13 just be H₂O. Okay? 09:15AM

14 We pour out half of it and it fills with air, 09:15AM
15 nitrogen, oxygen, and CO₂. Screw on the cork. We shake it up. 09:15AM
16 Okay? So what's happened? Some of the nitrogen, CO₂, and 09:15AM
17 oxygen have now dissolved into the water. 09:15AM

18 If we sent that water to do a an analysis, a 09:15AM
19 chromatographic analysis of that water, it would not only find 09:15AM
20 H₂O -- hopefully it won't find anything else - but H₂O, CO₂, 09:16AM
21 nitrogen, and oxygen, they're all dissolved in different amounts 09:16AM
22 in the water. Doesn't mean they're gone, they're just in the 09:16AM
23 water phase instead of being in the air phase. 09:16AM

24 THE COURT: So here you say the analogy is these gases 09:16AM
25 are now in the water phase as opposed to the oil phase; is that 09:16AM

1 what you're saying? 09:16AM

2 THE WITNESS: Exactly in the same way that, when you 09:16AM
3 release the gas, methane are no longer in the oil phase, they're 09:16AM
4 in the gas phase. This is the exact same process. That's why 09:16AM
5 the oil is shrinking, for two reasons. 09:16AM

6 THE COURT: Okay. 09:16AM

7 BY MS. KARIS: 09:16AM

8 Q So is the dissolution that you've just described comparable 09:16AM
9 to removing the gas that is coming out of the gas and oil coming 09:16AM
10 from the reservoir? 09:16AM

11 A That's right. I mean, Mother Nature comes in and says, Some 09:16AM
12 of you methane molecules got to go into gas, and some of you got 09:17AM
13 to go in water. There's no choice. You're left with less 09:17AM
14 methane molecules in the oil. And likewise for every other 09:17AM
15 component. 09:17AM

16 Q So, if you are determining the amount of reservoir fluid 09:17AM
17 that is converted or should be converted to stock tank barrels, 09:17AM
18 why, in your opinion, would you remove these dissolved 09:17AM
19 components from that analysis? 09:17AM

20 A Well, because this data suggests that those components end 09:17AM
21 up being in the water phase. Just all that gas that evolves 09:17AM
22 shrinking the oil most, that gas ends up dissolving in the 09:17AM
23 water, too, eventually. 09:17AM

24 It first forms gas phase; but, eventually, most of 09:17AM
25 it, if not all of it ends up dissolving in the water as well 09:17AM

1 over time.

09:17AM

2 Q And I apologize if I've asked this before, but are you
3 treating these components the same way you would be treating the
4 gas phase?

09:17AM

09:17AM

09:17AM

5 A That's what Dr. Zick said is undeniable. Mother Nature is
6 saying that methane has to go -- some of the methane has to go
7 in the water. It has no choice. So...

09:17AM

09:18AM

09:18AM

8 Q Now --

09:18AM

9 THE COURT: That increases the volume of these
10 chemicals as opposed to if it just went to the surface and
11 separated in the normal method?

09:18AM

09:18AM

09:18AM

12 THE WITNESS: Could you repeat that? I'm sorry.

09:18AM

13 THE COURT: In other words, if this blowout hadn't
14 occurred, the same oil at some point when it was produced would
15 have been separated by some method?

09:18AM

09:18AM

09:18AM

16 THE WITNESS: Okay, right.

09:18AM

17 THE COURT: Gases would have been separated from the
18 oil.

09:18AM

09:18AM

19 THE WITNESS: That's right.

09:18AM

20 THE COURT: Some of that would have been methane,
21 propane, so forth.

09:18AM

09:18AM

22 THE WITNESS: Yeah.

09:18AM

23 THE COURT: So the effect of this --

09:18AM

24 THE WITNESS: -- dissolving in the water.

09:18AM

25 THE COURT: I'm trying to understand how or why it

09:18AM

1 increases the volume of the gases if it happens as it's going 09:18AM
2 through the water as opposed to in a normal separation method. 09:19AM

3 THE WITNESS: Well, the gases will form, regardless. 09:19AM
4 But what happens is that you not only lose methane and ethane, 09:19AM
5 propane, and so forth forming these gases, but also lose some of 09:19AM
6 the methane, ethane, propane dissolving into the water phase. 09:19AM

7 If you went straight to the surface in some kind 09:19AM
8 of a separation process, the amount of methane left in the stock 09:19AM
9 tank oil would be different according to one stage, four stage, 09:19AM
10 three stage, and up. 09:19AM

11 But the amount of methane in the stock tank oil 09:19AM
12 and the amount of ethane in the stock tank oil for a normal 09:19AM
13 process, for a normal surface process, will depend on how many 09:19AM
14 stages, pressure and temperature of each stage. 09:20AM

15 It's controlled by this composite multi-stage 09:20AM
16 separation process with thermodynamics only being gas and oil. 09:20AM
17 When we add the water, it adds an extra degree of complexity to 09:20AM
18 the situation, and you're losing more of the hydrocarbons than 09:20AM
19 you would otherwise. Because the water can dissolve. Just like 09:20AM
20 this water dissolves the air components. The ocean water 09:20AM
21 dissolves the hydrocarbon components. It's just kind of the way 09:20AM
22 it is. 09:20AM

23 BY MS. KARIS 09:20AM

24 Q So, Dr. Whitson, based on your oceanic separator, why was it 09:20AM
25 appropriate then to account for solubility and remove these 09:20AM

1 components in doing this stock tank conversion? 09:20AM

2 A The water's there, and there's lot of it. And, relative to 09:20AM
3 the large amounts of oil and gas that went into the ocean, 09:21AM
4 there's just like so much more water. 09:21AM

5 So the solubility affect in the water obviously is 09:21AM
6 a real effect, and it's of some magnitude, so... 09:21AM

7 You can try to quantify that magnitude. 09:21AM

8 Q And did you seek to quantify that in the opinions that 09:21AM
9 you've rendered in this case? 09:21AM

10 A Yes, I did. 09:21AM

11 Q If we can now look at 11496.19.1. Is this the conclusion 09:21AM
12 that you reached with respect to quantifying the effect of the 09:21AM
13 water on the reservoir fluid when we convert it to stock tank 09:21AM
14 barrels? 09:21AM

15 A Yes. 09:21AM

16 Q Can you tell the Court then what your conclusion was with 09:21AM
17 respect to that quantification as stated in your report? 09:21AM

18 A Well, it basically says that if you assume the methane 09:21AM
19 through pentane case, which is the middle case, completely 09:21AM
20 dissolving into the ocean, then you have this 10 percent 09:21AM
21 reduction in stock tank oil. You end up with about 43 -- a 09:22AM
22 shrinkage factor of about 43. 09:22AM

23 If you take the lower case where you only take out 09:22AM
24 the methane and propane, then you end up with about 44 stock 09:22AM
25 tank barrels. 09:22AM

1 And if you take out the methane through pentane 09:22AM
2 and the aromatics, goes down to 42 barrels, stock tank barrels. 09:22AM

3 So, he's giving a range, and this is just 09:22AM
4 summarizing the middle case. 09:22AM

5 Q So is your middle case then the 43 stock tank barrels? 09:22AM

6 A Yes. 09:22AM

7 Q And it says here in your report that PERA has calculated 09:22AM
8 that the final stock tank oil volume will be approximately 10 09:22AM
9 percent less than the laboratory four-stage separator, reaching 09:22AM
10 a final stock tank oil volume close to that of the single-stage 09:22AM
11 process, which is approximately 43 stock tank barrels. 09:22AM

12 Tell us why you made that comparison to the 09:22AM
13 single-stage process. 09:23AM

14 A Well, I mean, it was just it was the number -- it was the 09:23AM
15 number closest -- you had the laboratory numbers, you had the 09:23AM
16 differential liberation, you had the one-stage separation, you 09:23AM
17 had the four-stage separation. 09:23AM

18 So we were just kind of pointing to that's the 09:23AM
19 number that this was closest to was the 43 stock tank barrels. 09:23AM
20 Had nothing to do with a single-stage process. It just happened 09:23AM
21 to be that that's kind of where it was pointing to. 09:23AM

22 Q Now, Dr. Zick testified that, in your conclusion there of 43 09:23AM
23 stock tank barrels, you had removed all of the light alkanes, 09:23AM
24 the methane through pentane, and all the light aromatics up to 09:23AM
25 C12; is that accurate? 09:23AM

1 A No. No. That was the case where you had 13 percent 09:23AM
2 reduction. That would have brought it to 42 stock tank barrels 09:23AM
3 shrinkage factor. 09:24AM

4 Q And so, the 10 percent that you suggest, is that removing 09:24AM
5 only the components that the Ryerson data suggests that would 09:24AM
6 completely dissolve or almost entirely dissolved? 09:24AM

7 A Methane through pentane only. 09:24AM

8 Q Just to wrap this up, you did review and respond to 09:24AM
9 Dr. Zick's initial report in which he recommended a four-stage 09:24AM
10 process; correct? 09:24AM

11 A That's right. 09:24AM

12 Q Before he did the oceanic separator? 09:24AM

13 A Yes. 09:24AM

14 Q Now, Dr. Zick referenced the four-stage separator as an 09:24AM
15 alternative option because he claims that's how the fluids would 09:24AM
16 have been produced in normal fashion. 09:24AM

17 Do you agree with that statement? 09:24AM

18 A Well, I didn't read anything that suggests they were going 09:24AM
19 to produce it with a four-stage separator, so I don't know where 09:24AM
20 he got that. 09:24AM

21 Q And, if a four-stage separator process is used, what figure 09:24AM
22 do you believe to be the most appropriate for the four-stage 09:25AM
23 separator process? 09:25AM

24 A I believe in data. I mean, if you have measurements -- 09:25AM
25 you've got three laboratories, four samples -- you use the 09:25AM

1 laboratory data. The shrinkage factor, I think that number was 09:25AM
2 47.3 on average. The shrinkage factor for the four-stage 09:25AM
3 separator. 09:25AM

4 MS. KARIS: Last demonstrative, D-23987-1A.1, please. 09:25AM

5 BY MS. KARIS: 09:25AM

6 Q Can you tell the Court what this slide demonstrates as it 09:25AM
7 pertains to your opinions in this case. 09:25AM

8 A Okay. So we're taking the same reservoir fluid from initial 09:25AM
9 conditions to stock tank conditions using different approaches. 09:25AM
10 That's what this is showing. 09:25AM

11 Over there on the left it says differential 09:25AM
12 liberation. That test was conducted in the laboratory by Pencor 09:26AM
13 for two of the samples. It's a six-stage, multi-stage 09:26AM
14 separation process. Each stage is at reservoir temperature. 09:26AM
15 Pressure goes from reservoir down to stock tank conditions. 09:26AM
16 That results in 30 to 33 shrinkage factor. That's at the low 09:26AM
17 end. 09:26AM

18 At the upper end, we've got what's flagged as the 09:26AM
19 Zick numbers of the shrinkage factor. The one on the right 09:26AM
20 would represent his oceanic process of 50.7 I believe was his 09:26AM
21 number. The one on the left is his prediction of the four-stage 09:26AM
22 separator. 09:26AM

23 Now, we know that the equation of state by Dr. 09:26AM
24 Zick is biased, overpredicting close to 5 percent. That's just 09:26AM
25 a fact when you compare it against the four-stage separator test 09:26AM

1 data. If you correct those calculations by 4 and a half, 5 09:27AM
2 percent, you are going to put all of these calculations right in 09:27AM
3 the midst of all those measured four-stage separator test data. 09:27AM

4 That's where they're all going to move if you take 09:27AM
5 away his bias in his equation of state. The four-stage 09:27AM
6 separator data there varied basically from 46 -- I don't 09:27AM
7 remember the exact numbers -- but the average was 47.3 was the 09:27AM
8 average of the four laboratory test four-stage separator. 09:27AM

9 So it's in there. You've got the four stage 09:27AM
10 numbers in there. 09:27AM

11 Then, in the green here, we've got single-stage 09:27AM
12 flash measurement lab data. That ranged from 42 to 44. There, 09:27AM
13 there. The oceanic process that I calculated, depending on how 09:27AM
14 much solubility is allowed to occur, methane to propane is 44. 09:28AM

15 If you include methane to pentane, goes to 43. 09:28AM
16 And, if you include also the aromatics, in addition to methane 09:28AM
17 to pentane, you get 42. 09:28AM

18 So that summarizes basically the spread of all the 09:28AM
19 numbers. 09:28AM

20 Q Dr. Zick testified, quote: It's my opinion that the oceanic 09:28AM
21 separation process is the most appropriate, because I believe 09:28AM
22 that's how the fluids would be separated by the conditions they 09:28AM
23 would encounter within the ocean. 09:28AM

24 First, do you agree with that statement? 09:28AM

25 A Well, yes. If you leave the water in the ocean. 09:28AM

1 Q And, if you want to use what even Dr. Zick called as the 09:28AM
2 most appropriate because of how the fluids are separated by the 09:28AM
3 conditions they encounter in the ocean, which of the figures on 09:28AM
4 demonstrative 23987-1A.1 is most representative of what actually 09:28AM
5 occurred in the ocean? 09:29AM

6 A Well, I believe my numbers of the oceanic process are the 09:29AM
7 best description of what in reality happened. And you've got a 09:29AM
8 range from 42 to 44 shrinkage factor, depending on how the 09:29AM
9 solubility is treated. 09:29AM

10 Q And is that the same figure, coincidentally as you said, as 09:29AM
11 the single-stage flash data? 09:29AM

12 A It's a pure coincidence, but that is correct. 09:29AM

13 MS. KARIS: I have no further questions. 09:29AM

14 THE COURT: Put that mic up as high as you can. You'll 09:31AM
15 have to speak up a little more forcefully. 09:31AM

16 CROSS EXAMINATION 09:30AM

17 BY MS. ENGEL: 09:30AM

18 Q Bethany Engel for the United States. Good morning, 09:31AM
19 Dr. Whitson. 09:31AM

20 A Good morning. 09:31AM

21 Q So I wanted to start briefly about talking a little bit 09:31AM
22 about your equation of state model. The software you used to 09:31AM
23 developed your equation of state is called Phasecom; correct? 09:31AM

24 A Yes, it is. 09:31AM

25 Q And Phasecom was written and developed by the United States' 09:31AM

1 expert Dr. Zick; right?

09:31AM

2 A Yes.

09:31AM

3 Q And Dr. Zick's company, Zick Technologies, owns Phasecom;
4 right?

09:31AM

09:31AM

5 A Yes.

09:31AM

6 Q And Phasecom is your software of choice for building
7 equation of state fluid characterizations computations; isn't
8 it?

09:31AM

09:31AM

09:31AM

9 A Absolutely.

09:31AM

10 Q Now, Dr. Zick has done work for your company PERA in the
11 past; correct?

09:31AM

09:31AM

12 A Yes. For the most part, writing computer programs.

09:31AM

13 Q And, as you said on direct, before the Macondo blowout, a
14 number of fluid samples were taken from the Macondo reservoir;
15 right?

09:31AM

09:31AM

09:32AM

16 A Yes.

09:32AM

17 Q And then, after the blowout, the three labs, Pencor,
18 Schlumberger, and Intertek, ran a number of tests on four of
19 those samples; right?

09:32AM

09:32AM

09:32AM

20 A Yes.

09:32AM

21 Q And those tests included both a four-stage separator test
22 and a single-stage flash test on those four samples; correct?

09:32AM

09:32AM

23 A That's correct.

09:32AM

24 Q You would agree that generally speaking a multi-stage
25 separator test like the four-stage test run by the labs produces

09:32AM

09:32AM

1 more stock tank oil than a single-stage flash; right? 09:32AM

2 A In general, yes. 09:32AM

3 Q And, in fact, here, when the labs tested the Macondo fluid, 09:32AM

4 the multi-stage separator test produced approximately 10 percent 09:32AM

5 more stock oil than the single-stage flash test; right? 09:32AM

6 A Nine percent to be exact, using the laboratory average data. 09:32AM

7 Q And it's also true that you came up with approximately a 10 09:32AM

8 percent difference between the four-stage test and the 09:32AM

9 single-stage test when you simulated those using your equation 09:32AM

10 of state; right? 09:32AM

11 A Approximately, yes. 09:33AM

12 Q And that difference is actually about 10 percent, regardless 09:33AM

13 of whether you use your equation of state model or Dr. Zick's 09:33AM

14 equation of state model; right? 09:33AM

15 A I wouldn't use either data. I would use the laboratory's 09:33AM

16 measurements, which gives a 9 percent difference. 09:33AM

17 Q My question was simply, that difference that you modeled of 09:33AM

18 10 percent between the four-stage separation and the 09:33AM

19 single-stage separation, Dr. Zick's EOS also gets about a 10 09:33AM

20 percent difference between those two tests; doesn't it? 09:33AM

21 A I believe that's the correct numbers. 09:33AM

22 Q And you actually, when developing your equation of state 09:33AM

23 model, you tuned it to the shrinkage factors from the 09:33AM

24 multi-stage separator tests; right? 09:33AM

25 A That's correct. 09:33AM

1 Q And, in fact, one of the three main things that you focused 09:33AM
2 on when doing that tuning was the final stock tank oil volumes 09:33AM
3 from those labs, those four stage lab tests; right? 09:33AM

4 A That's correct. 09:33AM

5 Q And the data from that multi-stage flash -- and I think you 09:33AM
6 even said this on direct -- was important, because then your 09:33AM
7 equation of state would then be better tuned to predicting the 09:34AM
8 total stock tank oil volume; right? 09:34AM

9 A If you use another process than the laboratory processes or 09:34AM
10 you don't know, you don't have measured data, then you would 09:34AM
11 expect a well-tuned equation of state that predicts accurately 09:34AM
12 the laboratory shrinkage factors to be more reliable in 09:34AM
13 predicting shrinkage factors for some other unknown process. 09:34AM
14 That's what I meant, and I think that's what I said. 09:34AM

15 Q And that's why you focused on that multi-stage separator 09:34AM
16 test, and particularly the fourth stage of that multi-stage test 09:34AM
17 in tuning your own equation of state; right? 09:34AM

18 A That's our standard practice, not just this one. 09:34AM

19 Q And one of the reasons is because the four-stage separator 09:34AM
20 test is specifically designed to come up with an accurate 09:34AM
21 measure of the shrinkage from reservoir barrels to stock tank 09:34AM
22 barrels; right? 09:35AM

23 A That's correct. 09:35AM

24 Q And then, by contrast, you considered the single-stage 09:35AM
25 shrinkage factors from those lab tests less important than the 09:35AM

1 multi-stage shrinkage factors; right? 09:35AM

2 A Well, we still predicted it within 0.2 percent of the 09:35AM
3 measured data. So I'd say whether we weighted specifically or 09:35AM
4 not doesn't -- you know, it's an indication that the equation of 09:35AM
5 state model does a good job on the single stage as well. 09:35AM

6 Q But, in tuning your model, you didn't give the same weight 09:35AM
7 to those single-stage shrinkage factors as the multi-stage 09:35AM
8 shrinkage factors; right? 09:35AM

9 A In all honesty, I don't remember the exact weight factors I 09:35AM
10 used in March of 2012. 09:35AM

11 Q You're not changing your deposition testimony? 09:35AM

12 A No, I'm not. 09:35AM

13 Q Switching gears slightly, in addition to simulating the 09:35AM
14 single-stage and multi-stage separation, you've discussed this 09:35AM
15 oceanic separation process that you also simulated; correct? 09:35AM

16 A Yes, ma'am. 09:36AM

17 Q And, prior to your work in this case, you've never simulated 09:36AM
18 how oil and gas separate in the ocean; have you? 09:36AM

19 A Not in the ocean. But I would like to comment that the 09:36AM
20 calculation of this gas, oil, and, water equilibrium, the 09:36AM
21 thermodynamic equilibrium, gas or water systems, is a very 09:36AM
22 standard process that is done day-in day and day-out in 09:36AM
23 petroleum operations where there is gas, oil, and water being 09:36AM
24 separated in the separator unit. So there's nothing -- there's 09:36AM
25 no new science here when it comes to that. 09:36AM

1 Q Isn't it your position that it would be speculation by you 09:36AM
2 to state one way or another how gas and oil actually evolved in 09:36AM
3 the ocean? 09:36AM

4 A I don't really understand what you're asking. 09:36AM

5 Q Sure. We can show you your deposition to refresh you. It's 09:36AM
6 412, starting at line 13, please. If you'd go line 13 to 22. 09:36AM

7 And so, at your deposition, I asked: Is that by 09:37AM
8 speculation by you because you don't have expertise in that 09:37AM
9 area, Dr. Whitson? 09:37AM

10 And your response was: Well, it would be 09:37AM
11 speculation by me to state one way or another as to how the gas 09:37AM
12 and oil actually evolved within the ocean. 09:37AM

13 Question: Because you don't have expertise in 09:37AM
14 that area; correct? 09:37AM

15 Yes, that's correct. 09:37AM

16 Did I read that right? 09:37AM

17 A Well, it's obviously right. But the question is, how you 09:37AM
18 mean evolve. If you're talking about the three dimensional 09:37AM
19 evolution of how the gas plume and the oil plume and the bubbles 09:37AM
20 and the drops and the interaction physically with the water and 09:37AM
21 all of those processes, I'm not an expert. 09:38AM

22 I don't think anybody, including Dr. Zick, looked 09:38AM
23 at that part of it, the evolution of the physical 09:38AM
24 three-dimensional movement of the gas and oil. Certainly not. 09:38AM
25 I assume that's what I was referring to. 09:38AM

1 But if I was talking about the thermodynamic 09:38AM
2 equilibrium of a gas, oil, water system, and I said something 09:38AM
3 like that, then I don't understand. Because I know what goes on 09:38AM
4 in the thermodynamic equilibrium of the gas, oil, and water 09:38AM
5 flowing from this spill. That, I think I know very well. 09:38AM

6 So I'm not sure exactly what we were talking about 09:38AM
7 here. 09:38AM

8 Q Okay. So you're not changing your deposition testimony? 09:38AM

9 A I am not, no. 09:38AM

10 MS. ENGEL: Could we actually look at a demonstrative 09:38AM
11 that BP put up? It's D-23988. We actually don't have a copy of 09:38AM
12 it. So, if you all could do it for me, that would be great. 09:39AM

13 BY MS. ENGEL: 09:39AM

14 Q Dr. Whitson, you described this on direct. Is this an 09:39AM
15 accurate depiction of your proposed oceanic separation process? 09:39AM

16 A Well, it's an accurate cartoon, if you will. It doesn't 09:39AM
17 show all the very detail calculations. But, yes, it's a correct 09:39AM
18 depiction. 09:39AM

19 Q So what we're looking at here on the right-hand side is your 09:39AM
20 gas stream coming out of the well; right? 09:39AM

21 A Yes. 09:39AM

22 Q Okay. And then on the left-hand side is your oil stream; is 09:39AM
23 that right? 09:39AM

24 A That's correct. 09:39AM

25 Q And, here, at the different stages, the different pressures 09:39AM

1 and temperatures it encounters in the ocean, the oil stream, you 09:39AM
2 allow gas to evolve off; correct? 09:39AM

3 A Yes. 09:39AM

4 Q You don't allow oil to evolve off on this side, on your gas 09:39AM
5 screen; do you? 09:39AM

6 A That's correct. 09:39AM

7 Q So your oceanic separation process also assumes that oil and 09:39AM
8 gas move to the surface in two separate circles; right? 09:39AM

9 A That's right. Primarily, and really only taking into 09:40AM
10 consideration the oil evolving and basically doing nothing with 09:40AM
11 the gas that evolves from stage two and upwards. Totally out of 09:40AM
12 the problem. 09:40AM

13 Q So in other words -- 09:40AM

14 A But -- 09:40AM

15 Q I'm sorry, go ahead. 09:40AM

16 A But, the one stream from the wellhead at the exit point, the 09:40AM
17 one gas stream from the wellhead at the exit point, we did the 09:40AM
18 calculation that resulted in a slight amount of extra oil, okay, 09:40AM
19 at the surface conditions. 09:40AM

20 Because the temperature at that point was unknown. 09:40AM
21 The higher the temperature, the more of the heavier components 09:40AM
22 could be carried in that gas. So, in a sense, we erred on the 09:40AM
23 high side of the oil volume by doing this. 09:40AM

24 Q So you actually take this gas stream on the right-hand side 09:41AM
25 all the way to the surface, from the seafloor to the surface, 09:41AM

1 and then do the equivalent of a single-stage flash on that gas; 09:41AM

2 right? 09:41AM

3 A Yes. 09:41AM

4 Q And that condenses out, like you said, a small amount of the 09:41AM

5 liquid? 09:41AM

6 A That's right. 09:41AM

7 Q Which you then add to your final stock tank barrels? 09:41AM

8 A That's right. 09:41AM

9 Q And you do that as a simplifying assumption in your mind; 09:41AM

10 correct? 09:41AM

11 A Well, actually, it's not a simplifying assumption, because 09:41AM

12 the normal multi-stage separator process in the industry, okay, 09:41AM

13 takes gas off of each stage and immediately assumes that's going 09:41AM

14 to remain gas. 09:41AM

15 They never make calculations or measurements about 09:41AM

16 the potential condensate that might result from those gases. 09:41AM

17 Ever. 09:41AM

18 For example, in all of the multi-stage, four-stage 09:41AM

19 separation processes the laboratory conducted, they didn't 09:41AM

20 quantify or measure condensate coming off of all of those four 09:41AM

21 stages of gas. 09:42AM

22 Dr. Zick, when he simulated those four-stage 09:42AM

23 separators, did not try to add condensate that he calculated for 09:42AM

24 those four gases that evolved. 09:42AM

25 When I did the four stage calculation of the 09:42AM

1 separator test, those four gases, I did not calculate the
2 condensate that was evolving from those gases.

3 And that is industry standard, okay?

4 So, in this case, the fact that I included that
5 condensate from that first gas phase was complicating; and, in
6 fact, it was erring on the high side. And the reason I did it
7 was very simple. If that temperature was as high as 200
8 Farenheit or 210 Fahrenheit, then I wanted to quantify what
9 amount of condensate it might carry with it.

10 I knew that, at normal lower temperatures of the
11 sea, that it wouldn't carry any significant amount. I wanted to
12 check the calculation, so I included it. It added more oil.

13 Q And, again, my question was actually much simpler. Which
14 is, just in doing this, making this assumption that the gas goes
15 from this seafloor directly to the surface and only then
16 encounters a single-stage flash, you did that as a simplifying
17 assumption in your modeling; right?

18 A Well, it was what I included. You can call it whatever you
19 want. It's just what I did.

20 Q Well, you called it a simplifying assumption in your
21 deposition.

22 A All right.

23 Q You're not changing your testimony on that; right?

24 A No. Not at all. I'll give it -- any label I gave it then
25 is fine.

1 MS. ENGEL: Could we have TREX-114 -- 09:43AM

2 THE COURT: Let me interrupt and ask the witness 09:43AM

3 something. 09:43AM

4 Dr. Whitson, one of the things that occurs to me 09:43AM

5 that makes the calculation of stock tank barrels in this case 09:43AM

6 difficult and unusual probably is that we don't have an oil 09:43AM

7 spill -- typically, an oil spill occurs from the surface, like 09:44AM

8 from a ship or something. 09:44AM

9 THE WITNESS: Yes, sir. 09:44AM

10 THE COURT: Or from a pipeline. 09:44AM

11 Here, it occurred from the ocean floor. 09:44AM

12 THE WITNESS: Right. 09:44AM

13 THE COURT: I'm just trying to understand, if someone 09:44AM

14 wanted to estimate what the conversion factor would be from the 09:44AM

15 volume of reservoir oil as it escaped from the wellhead at or 09:44AM

16 near the ocean floor into the water, but then convert it at that 09:44AM

17 point under some methodology to what that volume there would 09:44AM

18 have been at the surface, converted to stock tank barrels under 09:44AM

19 ordinary conditions, what method would I use to do that? Or is 09:44AM

20 there a method to do that? 09:44AM

21 THE WITNESS: Well, certainly, there are a number of 09:45AM

22 methods you could use. So that's a bit the problem here. If 09:45AM

23 you just want to get to a stock tank oil volume, you could do it 09:45AM

24 in a single flash. Just take it straight to stock tank 09:45AM

25 conditions. 09:45AM

1 THE COURT: Is this sort of what those lab tests did? 09:45AM

2 THE WITNESS: Yes. 09:45AM

3 THE COURT: Those different lab tests? 09:45AM

4 THE WITNESS: Yes. So the simplest way is just to take 09:45AM

5 what comes out of the wellhead, which is the same as what's in 09:45AM

6 the reservoir, straight to the surface and get the stock tank 09:45AM

7 oil volume. That's the simplest way to do it. And, obviously, 09:45AM

8 that's not what I chose to do. 09:45AM

9 THE COURT: And then the question would be, what method 09:45AM

10 would you use to do that? What process of separation? 09:45AM

11 THE WITNESS: Single-stage flash, if you want to go 09:45AM

12 straight from the wellhead to the surface, ignoring the ocean. 09:45AM

13 THE COURT: Okay. Why would you use single-stage 09:46AM

14 flash? 09:46AM

15 THE WITNESS: Well -- 09:46AM

16 THE COURT: As opposed to -- what was the other, four 09:46AM

17 stage? 09:46AM

18 THE WITNESS: Four stage. 09:46AM

19 I'm not saying I would; I'm just saying that's how 09:46AM

20 you could do it. Four stage is arbitrary. It just happened to 09:46AM

21 be conducted in the laboratory. One stage in a sense is 09:46AM

22 arbitrary as well. I mean, it's equally arbitrary. 09:46AM

23 That's why I tried to simulate what actually 09:46AM

24 happened, so it wouldn't be arbitrary. That's why I did what I 09:46AM

25 did. 09:46AM

1 THE COURT: I guess what I'm trying to understand is, 09:46AM
2 are we supposed to be -- am I to measure the volume that entered 09:46AM
3 the water? When it entered the water in this case, it entered 09:46AM
4 the water at the wellhead, not at the surface. 09:46AM

5 THE WITNESS: Yes. 09:46AM

6 THE COURT: And then figure out how to convert that to 09:46AM
7 stock tank barrels. 09:46AM

8 THE WITNESS: That's really what all this discussion is 09:46AM
9 about, yeah. That's right. 09:47AM

10 THE COURT: But the methodology, you know, I understand 09:47AM
11 what you did and what Dr. Zick did in terms of trying to model, 09:47AM
12 quote, what actually occurred as it went up the streams, the oil 09:47AM
13 and gas went up through 5,000 feet of ocean. 09:47AM

14 THE WITNESS: Right. 09:47AM

15 THE COURT: But the fact is, the oil entered the ocean 09:47AM
16 5,000 feet down, not gradually at the top. 09:47AM

17 THE WITNESS: No. But I think that the first stage of 09:47AM
18 both oceanic processes is in a sense that stage you're talking 09:47AM
19 about, the entering stage. So they both used the same stage at 09:47AM
20 the wellhead as the first stage. 09:47AM

21 THE COURT: All right. Go ahead, Ms. Engel. 09:47AM

22 BY MS. ENGEL: 09:47AM

23 Q Sure. And just as to follow-up on Judge Barbier's 09:47AM
24 questions, you're not actually recommending single-stage flash 09:47AM
25 as the process that you would use to do this conversion. You're 09:48AM

1 simply saying that, if you were to take the oil from wellhead 09:48AM
2 directly to surface, that would be the equivalent of a 09:48AM
3 single-stage flash; right? 09:48AM

4 A That's what I was saying, yes. 09:48AM

5 MS. ENGEL: Can we now look at TREX-11496, please. Go 09:48AM
6 to call-out .18.1. 09:48AM

7 BY MS. ENGEL: 09:48AM

8 Q And, Dr. Whitson, do you recognize this language and table 09:48AM
9 from your expert report? 09:48AM

10 A Yes, I do. 09:48AM

11 Q This table reports the stock tank barrels of oil associated 09:48AM
12 with three different separation processes you evaluated; 09:48AM
13 correct? 09:48AM

14 A That's correct. 09:48AM

15 Q And it's single-stage flash you are saying gets you 43.3 09:48AM
16 barrels of stock tank barrels of oil per 100 reservoir barrels. 09:48AM
17 For your oceanic separator, you say it's between 46.7 and 48 09:48AM
18 barrels. And, for four-stage separation, you say it's 47.9 09:49AM
19 barrels; right? 09:49AM

20 A Can I make a comment? 09:49AM

21 Q Sure. 09:49AM

22 A Okay. 09:49AM

23 So, 2 and 3 are the barrels that resulted from 09:49AM
24 this step one of my oceanic process. We took it through the 130 09:49AM
25 stages to the surface to stock tank conditions and ended up with 09:49AM

1 a volume that was approximately, as you see, close to the 09:49AM
2 four-stage separation volume. 09:49AM

3 That was then corrected using the solubility term. 09:49AM
4 In other words, removing the methane, ethane, and propane and 09:49AM
5 finding an adjustment due to the removing of those components 09:49AM
6 that were shown to dissolve by Ryerson. 09:49AM

7 So this is the intermediate volumes that were 09:49AM
8 calculated after the 130-stage separation process, that's 09:49AM
9 correct. 09:49AM

10 Q So, in other words, this shows your shrinkage factors 09:49AM
11 without taking into account the dissolution analysis that you 09:49AM
12 then did? 09:50AM

13 A This is the ocean without water. 09:50AM

14 Q So you don't list differential liberation here; do you? 09:50AM

15 A No. 09:50AM

16 Q And that's because you would not have actually run that test 09:50AM
17 on this fluid if you were in charge of the lab program; would 09:50AM
18 you? 09:50AM

19 A That's true. 09:50AM

20 THE COURT: What do you mean the -- tell me about the 09:50AM
21 ocean without water. You mean without -- but it's actually -- 09:50AM
22 but would it also be the ocean at the bottom of the ocean as 09:50AM
23 opposed to traveling 5,000 feet? 09:50AM

24 THE WITNESS: What I mean by the ocean without water 09:50AM
25 is, if you ignore the laws of nature that this oil is 09:50AM

1 interacting with large amounts of water, and the fact, as both 09:50AM
2 Dr. Zick and I agree, that components will move from the oil 09:50AM
3 into the water. That's what I'm talking about. 09:50AM

4 If you ignore solubility, you're ignoring its 09:50AM
5 impact on the shrinkage of the oil. That's what I mean by no 09:51AM
6 water. 09:51AM

7 BY MS. ENGEL: 09:51AM

8 Q So, again, these are the shrinkage factors before you take 09:51AM
9 into account your solubility or dissolution analysis; right? 09:51AM

10 A Before I take into account the equilibrium thermodynamics of 09:51AM
11 oil/water systems. 09:51AM

12 Q So, on direct, you were talking about -- 09:51AM

13 A If I could just make one comment, a bit of clarification: 09:51AM
14 The thermodynamic calculation itself is gas, oil, and water. 09:51AM
15 The rigorous thermodynamic calculation of gas, oil, and water 09:51AM
16 would have been the preferred method of calculation. 09:51AM

17 But we did not have software that would do 130 09:51AM
18 stages of three phase gas, oil, water calculation to make that 09:51AM
19 calculation at the time I wrote the report. 09:51AM

20 But I have done subsequent to that. 09:51AM

21 Q And that subsequent work was not in your report; correct? 09:51AM

22 A No. It was done subsequent to the rebuttal report of 09:51AM
23 Dr. Zick. 09:52AM

24 Q So we are not going to talk about that today. 09:52AM

25 A No. 09:52AM

1 Q So you said on direct that Dr. Zick's shrinkage, his EOS 09:52AM
2 overpredicted the shrinkage factors by approximately 4 to 5 09:52AM
3 percent; right? 09:52AM

4 A It's closer to 5 than 4. 09:52AM

5 Q But, in your report, you actually say it's between 3 and 5 09:52AM
6 percent; don't you? 09:52AM

7 A You have to show me. 09:52AM

8 Q Sure. 09:52AM

9 MS. ENGEL: Let's go to 11496.23, please. 09:52AM

10 Blow up that paragraph 6. 09:52AM

11 BY MS. ENGEL: 09:52AM

12 Q Here, you're discussing the comparison of your EOS to that 09:52AM
13 of Dr. Zick's; correct? 09:52AM

14 A Yes. Let me read this here. 09:53AM

15 Q Sure. I just want to focus your attention on that last 09:53AM
16 bullet that says: 3 to 5 percent overestimation of the stock 09:53AM
17 tank oil volume for all samples using the laboratories 09:53AM
18 four-stage separation. 09:53AM

19 So this is the 3 to 5 you stated in your report, 09:53AM
20 as opposed to the 4 to 5 you stated on direct. 09:53AM

21 A If you look at table 1, which is the foundation for the 09:53AM
22 statement. That's on page 20. 09:53AM

23 Q Why don't you just explain it without going to the table. 09:53AM

24 A I think it would become clearer if we go to the table. I 09:53AM
25 mean, it's so easy to see the numbers there in all their 09:53AM

1 clarity.

09:53AM

2 Q My question is very simple. Which is just, in your report,
3 you said 3 to 5 percent overestimation.

09:53AM

09:53AM

4 A It should have been written 4.9 percent on average, is what
5 it should have said there.

09:53AM

09:54AM

6 Q So you're changing what your report says?

09:54AM

7 A Well, no. This is indicating, for individual samples, that
8 range might have been 3 to 5. For individual samples. But the
9 average on whole for the four samples is 4.9 percent given in
10 table 1.

09:54AM

09:54AM

09:54AM

09:54AM

11 Q Sure.

09:54AM

12 So if you look all four of the lab samples, all
13 four of the lab's data, you get a range of 3 to 5 percent if you
14 don't average them.

09:54AM

09:54AM

09:54AM

15 A Yeah. I think actually it's larger than the 3 to 5 percent
16 if you actually look at the individual numbers. If we go to
17 table 1, we can actually make those calculations for each sample
18 and see that the range is actually larger than that.

09:54AM

09:54AM

09:54AM

09:54AM

19 So it would be --

09:54AM

20 Q I don't think we need to belabor the point any further,
21 Dr. Whitson.

09:54AM

09:54AM

22 Let's talk about your analysis of dissolution, or,
23 as you call it, solubility. So, after you calculate those stock
24 tank oil volumes that we just looked at a moment ago in that
25 table in your report for the single stage, the oceanic, and the

09:54AM

09:54AM

09:54AM

09:54AM

1 four stage, you then assume an average 10 percent reduction 09:55AM
2 based on dissolving light hydrocarbons and aromatics; right? 09:55AM

3 A There are three cases. We removed, in the first case, 09:55AM
4 methane through propane, and saw that the altered stock tank oil 09:55AM
5 composition resulted in a 7 percent reduced volume relative to 09:55AM
6 the unaffected. 09:55AM

7 Q So your mid-case or your average -- 09:55AM

8 A In the mid-case where I removed -- 09:55AM

9 Q -- was about 10 percent. 09:55AM

10 A Well, in your question, you said methane to pentane and all 09:55AM
11 these aromatics. And I'm trying to say that was not the middle 09:55AM
12 case. 09:55AM

13 The middle case, which gave 10 percent reduction 09:55AM
14 in stock tank oil volume, removed the alkanes, methane through 09:55AM
15 pentane. They did not remove the aromatics, as was in your 09:55AM
16 question. That's why I'm trying to clarify, so we don't get 09:55AM
17 confused here. 09:55AM

18 So, in the third case where we calculated a 13 09:55AM
19 percent reduction in the stock tank oil volume, there, as you 09:55AM
20 stated correctly, methane through pentane and the aromatics were 09:56AM
21 removed. So that's I think -- 09:56AM

22 Q Thank you. 09:56AM

23 So those hydrocarbon components in that low case 09:56AM
24 and mid-case and the high case, even that you assumed dissolved, 09:56AM
25 include things like methane, ethane, benzene, butane; correct? 09:56AM

1 A Okay. Again, there is some confusion here. In the first 09:56AM
2 case, it's only methane, ethane, and propane. Those are all 09:56AM
3 alkanes. There are no aromatics. 09:56AM

4 An aromatic is a grain compound benzene and so 09:56AM
5 forth. So it's a different animal. 09:56AM

6 In the first case, it's all C1, C2, C3, the three 09:56AM
7 lightest alkanes. 09:56AM

8 In the second case, which gives the 10 percent 09:56AM
9 reduction, it's the alkanes from C1 to C5. Again, not including 09:56AM
10 any of the benzenes, aromatics that you're referring to. 09:57AM

11 Only the third case are those compounds, the 09:57AM
12 aromatic compounds you're referring to, included. 09:57AM

13 Q So you said you relied on this article by Tom Ryerson to 09:57AM
14 determine which hydrocarbon components would have dissolved; 09:57AM
15 right? 09:57AM

16 A Well, from the figures we showed, they don't say might have 09:57AM
17 dissolved; they give a chart that says, dissolved fraction. 09:57AM
18 Okay? That's what it says on the figure, dissolved fraction. 09:57AM

19 And one -- I mean, I don't think you have to be a 09:57AM
20 scientist -- means that all of it was dissolved. So what they 09:57AM
21 say is that the dissolved fraction for methane, ethane, propane 09:57AM
22 was 1.0. That means it was all dissolved. As well as for 09:57AM
23 benzene, I think. And toluene also had 100 percent 09:57AM
24 dissolution. 09:58AM

25 So it wasn't like they suggested it might be. 09:58AM

1 They actually gave tables, figures, that showed it was in the 09:58AM
2 samples they collected. 09:58AM

3 Q Okay. So let's look at the Ryerson article then. 09:58AM

4 MS. ENGEL: It's 11574N. And go to figure 4, which is 09:58AM
5 call-out .6.1. 09:58AM

6 BY MS. ENGEL: 09:58AM

7 Q So you recognize this figure from the Ryerson article that 09:58AM
8 you relied on as well? 09:58AM

9 A Yes. We used the figure 4C. 09:58AM

10 Q Okay. So just to orient the Court a little bit, on the 09:58AM
11 right-hand side of this figure 4, it shows the places from which 09:58AM
12 the samples were being taken; correct? 09:58AM

13 So they took an evaporated sample; right? A 09:58AM
14 surface slick sample? A deep plume sample; correct? 09:58AM

15 A Yes. 09:58AM

16 Q And you're saying you're relying on this graph C that's on 09:58AM
17 the bottom left here? 09:59AM

18 A I think we didn't -- I mean, we showed it here today because 09:59AM
19 of what it says on that figure C. It's hard to read it. 09:59AM

20 Q Sure. We can blow that up. It's call-out .6.2. 09:59AM

21 It lists along the x axis here the various 09:59AM
22 components of the hydrocarbons; right? And it starts with 09:59AM
23 things like: Methane, ethane, benzene, propane, toluene, and 09:59AM
24 goes all the way up to these heavier components on the 09:59AM
25 right-hand side; right? 09:59AM

1 A Right. 09:59AM

2 Q Okay. And so doesn't this graph illustrate that Dr. Ryerson 09:59AM
3 and his team found these components, methane, ethane, benzene, 09:59AM
4 propane, toluene, dissolved in the -- detected in the subsurface 09:59AM
5 plumes that they sampled in the Gulf? 09:59AM

6 A Well, the text says primarily soluble mixture detected in 09:59AM
7 subsurface plumes, approximately 35 percent of the leaking mass. 10:00AM
8 Leaking mass, the grey dark line, is the original amounts. 10:00AM

9 So the interpretation of this figure was that 10:00AM
10 these components, as in the previous figure, were those 10:00AM
11 components that were primarily dissolving in the water. 10:00AM

12 Now, in reality, figure 4C, if you look in the 10:00AM
13 text, it is not referenced at all with text. Okay? There's not 10:00AM
14 a single reference to this particular part of the diagram that 10:00AM
15 clarifies what they're talking about. 10:00AM

16 The only text is in this in the red here, which is 10:00AM
17 corresponding. That is our interpretation of that slide. 10:00AM

18 Q So your interpretation is that what shows up in red on the 10:01AM
19 graph, the methane, ethane, benzene, and so on, are from the 10:01AM
20 samples that Ryerson and his team took from the deep subsurface 10:01AM
21 plumes; right? 10:01AM

22 A Well, like I said, there's no text directly linked to it. 10:01AM
23 But, if you compare that figure with the previous figure, I 10:01AM
24 believe it was 2 -- 10:01AM

25 Q Right. 10:01AM

1 A -- which calls dissolved fraction, and is clearly indicating 10:01AM
2 those components, the fraction of which they believe was 10:01AM
3 dissolved in the ocean water. 10:01AM

4 There's a consistency, a clear consistency, 10:01AM
5 between that interpretation of this figure and that figure. 10:01AM
6 That's what I'm saying. 10:01AM

7 The same components they show as being partially 10:01AM
8 or totally being dissolved are also highlighted here in the same 10:02AM
9 manner. 10:02AM

10 Q Okay, thank you. 10:02AM

11 MS. ENGEL: Just to wrap up here, let's go to another 10:02AM
12 demonstrative that BP used on direct. It's D-23987-1A. If you 10:02AM
13 all could pull that up for me, I'd appreciate it. 10:02AM

14 BY MS. ENGEL: 10:02AM

15 Q And so this is what you used to wrap up your direct 10:02AM
16 testimony; right? It shows the shrinkage factor from 100 10:02AM
17 barrels of reservoir fluid; is that right? 10:02AM

18 A Yes, ma'am. 10:02AM

19 Q And so what you list here as in the middle in the green 10:02AM
20 section is the Whitson ocean separator, that takes into account 10:02AM
21 your dissolved fraction; right? 10:02AM

22 A Yes. The numbers would be about 42 to 44, depending on 10:02AM
23 which case we look at, 43 being the 10 percent C1 to C5 case. 10:03AM

24 Q And, if you don't take dissolution into account, your 10:03AM
25 numbers for the oceanic separation are more like 46.7 to 48 10:03AM

1 based on that table we looked at in your report; right? 10:03AM

2 A Well, that would be the step one part of the oceanic 10:03AM
3 separation process that we talked about, that volume. 10:03AM

4 Q Right. Prior to dissolution. 10:03AM

5 So those numbers would fall right here in this 10:03AM
6 orange range that's on a the right-hand side, the four-stage 10:03AM
7 test data; right? 10:03AM

8 A That's correct. 10:03AM

9 MS. ENGEL: I don't have any further questions. 10:03AM

10 THE COURT: Redirect? 10:03AM

11 MS. KARIS: No further redirect, Your Honor. 10:03AM

12 THE COURT: All right. It's almost five after 10:00. 10:03AM
13 Let's take a 15 minute morning recess. 10:04AM

14 (Proceedings in recess.) 10:04AM

15 THE COURT: Call your next witness. 10:26AM

16 MS. KARIS: Your Honor, just before that, I realized, 10:26AM
17 although we'd referenced Dr. Whitson' report, we did not offer 10:26AM
18 it into evidence. So, at this time, I would move Exhibit 11496, 10:26AM
19 Dr. Whitson's, report into evidence. 10:26AM

20 MS. ENGEL: No objection. 10:26AM

21 THE COURT: All right. That's admitted. 10:26AM

22 (Exhibit admitted.) 10:26AM

23 MR. BROCK: Your Honor, at this point, we're going to 10:26AM
24 play a short videotape, it's only around 3 minutes, of Jamie 10:27AM
25 Loos, who is the director of project management for Weatherford 10:27AM

1 Laboratories. She was their 30(b)(6) representative on the 10:27AM
2 analysis by Weatherford of the sidewall cores taken from the 10:27AM
3 Macondo well. 10:27AM

4 I think that's probably all I need to say. 10:27AM

5 THE COURT: All right. 10:27AM

6 MR. BROCK: And I have the transcript and the thumb 10:27AM
7 drive that I'll pass up now as well. 10:27AM

8 (Videotape Played.) 10:27AM

9 MR. BROCK: Your Honor, our next witness is 10:30AM
10 Dr. Zimmerman, who is here and can come up. 10:30AM

11 ROBERT W. ZIMMERMAN, being first duly sworn, 10:30AM
12 testified as follows: 10:30AM

13 THE CLERK: Take a seat. State and spell your name for 10:30AM
14 the record. 10:30AM

15 THE WITNESS: Yes, my name is Robert W. Zimmerman. 10:30AM

16 THE COURT: Spell your name for us, please. 10:30AM

17 THE WITNESS: R-O-B-E-R-T, middle name is Wayne, 10:30AM
18 W-A-Y-N-E, surname is Zimmerman, Z-I-M-M-E-R-M-A-N. 10:30AM

19 THE COURT: Let me just announce, so everybody can be 10:31AM
20 aware of it, we will break right at noon today. Okay? So 10:31AM
21 wherever we are in the testimony. Okay? 10:31AM

22 MR. FIELDS: Thank you, Your Honor. 10:31AM

23 THE COURT: For our lunch recess. 10:31AM

24 MR. FIELDS: Your Honor, my name is Barry Fields, and I 10:31AM
25 will be conducting the direct examination of Professor Robert 10:31AM

1 Zimmerman on behalf of both BP and Anadarko. 10:31AM

2 DIRECT EXAMINATION 10:31AM

3 BY MR. FIELDS: 10:31AM

4 Q Dr. Zimmerman, would you please introduce yourself to the 10:31AM
5 Court. 10:31AM

6 A I'm Professor Robert Zimmerman. 10:31AM

7 Q Where are you currently employed or what do you do for a 10:31AM
8 living? 10:31AM

9 A I'm processor of rock mechanics at Imperial College in 10:31AM
10 England. 10:31AM

11 Q Would you please describe at a high level what you were 10:31AM
12 asked to do by BP and Anadarko as part of your retention in this 10:31AM
13 case. 10:31AM

14 A I was asked to look at and evaluate various pieces of data 10:31AM
15 that were collected on rocks from the Macondo reservoir, and it 10:31AM
16 was collected by Weatherford Laboratories. 10:32AM

17 I was asked to analyze that data and bring to bear 10:32AM
18 my knowledge of the subject of pore volume compressibility for 10:32AM
19 the purposes of coming up with an estimate of the pore volume 10:32AM
20 compressibility of the Macondo reservoir. 10:32AM

21 Q Before getting into the details of your opinions and the 10:32AM
22 reasons for your opinions, let's discuss a little bit about your 10:32AM
23 background. 10:32AM

24 MR. FIELDS: Would you please display D-23661. 10:32AM

25 BY MR. FIELDS: 10:32AM

1 Q Professor Zimmerman, would you please provide the Court with 10:32AM
2 an overview of your educational background since high school. 10:32AM

3 A Well, I received a Bachelors of Science degree in mechanical 10:32AM
4 engineering from Columbia University, and then received a Master 10:32AM
5 of Science degree in mechanical engineering, also from Columbia 10:32AM
6 University. 10:32AM

7 In 1984 I received a Ph.D. in the field of solid 10:32AM
8 mechanics from the department of mechanical engineering at the 10:32AM
9 University of California at Berkley. 10:33AM

10 And the title of my Ph.D. thesis was the effect of 10:33AM
11 pore structure on the pore and bulk compressibilities of 10:33AM
12 consolidated sandstones. 10:33AM

13 Q Now, I wanted to focus briefly on your Ph.D. in solid 10:33AM
14 mechanics that you received from the University of California, 10:33AM
15 Berkeley. 10:33AM

16 First of all, what is solid mechanics, and how 10:33AM
17 does that differ, if at all, from rock mechanics? 10:33AM

18 A Well, mechanics, most generally, is the field that studies 10:33AM
19 the way that physical and material bodies change their shape or 10:33AM
20 size, deform and possibly break when they're acted upon by 10:33AM
21 various forces, pressures, and stresses. So, at the highest 10:33AM
22 level, that's what mechanics is. 10:33AM

23 There two subfields of mechanics, solid and fluid 10:33AM
24 mechanics. Referring as the names imply, whether one is 10:33AM
25 focusing on solid or fluid materials. 10:33AM

1 Rock mechanics can be thought of as a subfield of 10:33AM
2 solid mechanics. So it is the field that studies how rocks 10:33AM
3 change their size, shape, and possibly break when they are acted 10:34AM
4 upon by different pressures and stresses and forces. 10:34AM

5 Q Let's look at D-23662. Using this demonstrative, can you 10:34AM
6 walk us through your academic and work experience since 10:34AM
7 obtaining your Ph.D. from the University of California at 10:34AM
8 Berkeley. 10:34AM

9 A Immediately after receiving my Ph.D., I became assistant 10:34AM
10 research engineer in the petroleum engineering laboratory at 10:34AM
11 Berkeley. That's essentially what people would call a 10:34AM
12 post-doctoral position. For two years I did research in that 10:34AM
13 laboratory. 10:34AM

14 From 1986 to through 1988 I was a lecturer in the 10:34AM
15 department of mechanical engineering at the University of 10:34AM
16 California at Berkeley teaching courses such as rock mechanics, 10:34AM
17 fluid mechanics, applied mathematics, and other such courses. 10:34AM

18 Starting in 1987 and through 1995 in a full-time 10:35AM
19 capacity, I was a scientist at the Lawrence Berkeley National 10:35AM
20 Laboratory. That's a U.S. national laboratory that's affiliated 10:35AM
21 with the University of California, but functions under the 10:35AM
22 auspices of the U.S. Department of Energy. I have also 10:35AM
23 continued there part time for several years thereafter. 10:35AM

24 But, in terms of my full-time job, in 1995, I 10:35AM
25 moved to Imperial College in London, England, where I initially 10:35AM

1 was appointed as the governor's lecturer in rock mechanics and 10:35AM
2 petroleum engineering. The lecturer title in the UK is roughly 10:35AM
3 equivalent to what Americans would call assistant professor. 10:35AM

4 In 1998 I was promoted to the position of reader 10:35AM
5 in rock mechanics. Again, the reader position in the British 10:35AM
6 university is roughly equivalent to associate professor in the 10:35AM
7 American context. 10:35AM

8 In 2004 I move to the Royal Institute of 10:35AM
9 Technologies in Stockholm, Sweden. That is, I think, generally 10:36AM
10 thought of as the premier technical university, engineering 10:36AM
11 university, in Scandinavia. 10:36AM

12 I was the professor of engineering and geology and 10:36AM
13 the head of the division of engineering geology and geophysics 10:36AM
14 for a little bit over three years, 2004 until the end of 2007. 10:36AM

15 In January of 2008, I returned to Imperial College 10:36AM
16 in London, where I was promoted to my current position, which is 10:36AM
17 professor of rock mechanics. 10:36AM

18 MR. FIELDS: Would you display D-3663? 10:36AM

19 BY MR. FIELDS: 10:36AM

20 Q You've obviously been a professor or assistant or associate 10:36AM
21 professor for a number of years. Are these the types of courses 10:36AM
22 that you have taught over the years? 10:36AM

23 A This is a list of some of the courses that I have taught 10:36AM
24 either at Berkeley, at Imperial College, or in the Royal 10:36AM
25 Institute of Technology at Stockholm. 10:36AM

1 As you see, for example, courses -- and these are 10:36AM
2 pretty much exactly the actual titles of the courses: Rock 10:37AM
3 mechanics, rock physics, fluid flow through porous media, et 10:37AM
4 cetera, as one can see on the slide. 10:37AM

5 Q We heard from Professor Blunt, I believe, and perhaps 10:37AM
6 others, that the Macondo reservoir rock is like sandstone. Have 10:37AM
7 you taught about sandstones and the compressibility of the 10:37AM
8 sandstones? 10:37AM

9 A Yes. The specific topic of compressibility of sandstones 10:37AM
10 would appear in my course on rock mechanics and would appear in 10:37AM
11 my course on rock physics. It would appear in a course that I 10:37AM
12 have taught on fluid flow and porous media. 10:37AM

13 So, yes, this does appear in several of the 10:37AM
14 courses that I've taught over the years. 10:37AM

15 Q Now, in addition to the courses you've taught, have you also 10:37AM
16 been involved in research in the area of rock mechanics over the 10:37AM
17 years? 10:37AM

18 A Yes. I have been involved in research during the period of 10:37AM
19 my Ph.D. and subsequent to that essentially continuously. It's 10:37AM
20 always been a large part of all of my job functions, and I've 10:38AM
21 conducted research primarily in the area, in various areas of 10:38AM
22 rock mechanics. 10:38AM

23 I would point out that rock mechanics, as I 10:38AM
24 mentioned earlier, it's in general the field that studies the 10:38AM
25 mechanical behavior and deformation and motion of rocks. It has 10:38AM

1 specific applications to the petroleum industry in topics, such 10:38AM
2 as pore volume compressibility, wellbore stability, hydraulic 10:38AM
3 fracturing, et cetera. 10:38AM

4 So this has been -- rock mechanics in general has 10:38AM
5 been a major theme of my research for the past 30 years. 10:38AM

6 Q One of the earlier slides that we looked at had a bullet 10:38AM
7 point that talked about the fact that you had over 200 papers. 10:38AM
8 Are those all peer-reviewed papers? 10:38AM

9 A No. That's a total number of my published papers. I would 10:38AM
10 say somewhere over 90 of them have been published in 10:39AM
11 peer-reviewed scientific journals. Another 90 or so papers have 10:39AM
12 appeared in -- generally, in sort of proceedings of conferences, 10:39AM
13 such as SPE. About 13 or 14 of them I believe appeared as part 10:39AM
14 of SPE conferences. 10:39AM

15 So, the other papers, essentially what scholars 10:39AM
16 would call conference proceedings papers. But over 90 of them 10:39AM
17 have appeared in the peer-reviewed scientific literature. 10:39AM

18 MR. FIELDS: Would you display D-23665. 10:39AM

19 BY MR. FIELDS: 10:39AM

20 Q Are these images of books that you have written about rock 10:39AM
21 mechanics or rock compressibility? 10:39AM

22 A Well, yes. The book on the left is entitled, 10:39AM
23 *Compressibility of the Sandstones*. I published that in 1991. 10:39AM
24 It was published by Elsevier Scientific Publishers, which I 10:39AM
25 believe is the world's largest scientific publishing company. 10:39AM

1 It was published as part of a series called 10:39AM
2 developments in petroleum science. It was volume 29 in that 10:39AM
3 series, and this book deals exclusively with the issue of 10:40AM
4 compressibility of sandstones. 10:40AM

5 On the right is a copy of a fourth edition of the 10:40AM
6 book *Fundamentals of Rock Mechanics*. I'm the co-author of that, 10:40AM
7 along with JC Jeager and Cook. 10:40AM

8 That fourth edition was published in 2004, 2007 -- 10:40AM
9 excuse me, published by Wylie Blackwell, and it's generally and 10:40AM
10 essentially universally regarded as the most sort of 10:40AM
11 authoritative and complete book in the field of rock mechanics. 10:40AM

12 Q There was also on the prior slide a reference to citations. 10:40AM
13 Approximately how many times have your papers or books been 10:40AM
14 cited by other engineers or scientists? 10:40AM

15 A Well, the Institute of Scientific Information keeps track of 10:40AM
16 citations to published works that appear within -- whereby the 10:40AM
17 citations appear within peer-reviewed scientific journals. 10:41AM

18 According to the Institute of Scientific 10:41AM
19 Information, my books and papers have been cited about 3,000 10:41AM
20 times. 10:41AM

21 There's also an index, a widely used index, called 10:41AM
22 Google Scholar. Google Scholar counts citations that appear in 10:41AM
23 other sources other than scientific peer-reviewed journals, such 10:41AM
24 as, for example, Google Scholar would count citations that 10:41AM
25 appear within SPE conference papers. According to Google 10:41AM

1 Scholar, my books and papers have been cited about 5,000 times. 10:41AM

2 MR. FIELDS: Can we pull up D-23666, please. 10:41AM

3 BY MR. FIELDS: 10:41AM

4 Q Will you please tell us about the editorial positions that 10:41AM

5 you hold on various journals. 10:41AM

6 A Well, yes. Since 2006, I have a been the editor in chief of 10:41AM

7 the *International Journal of Rock Mechanics and Mining Sciences*, 10:41AM

8 which is the leading journal in the field of rock mechanics. 10:41AM

9 That's the journal that you see on the right of that screen. 10:41AM

10 Since the late 1990s, I have been on the editorial 10:42AM

11 board of a journal called *Transport in Porous Media*, which is a 10:42AM

12 journal that focuses on flow of fluids through media and porous 10:42AM

13 materials. 10:42AM

14 And for the last four years or so, I believe, I've 10:42AM

15 been on the editorial board of the *International Journal of* 10:42AM

16 *Engineering Science*. 10:42AM

17 MR. FIELDS: Please display 23667. 10:42AM

18 BY MR. FIELDS: 10:42AM

19 Q Are these a sample of the various professional national 10:42AM

20 organizations to which you belong? 10:42AM

21 A Yes. I've been a member of the SPE, I believe, for a little 10:42AM

22 bit over 30 years now. 10:42AM

23 I am a member of both the American Society of 10:42AM

24 Mechanical Engineers and the American Society of Civil 10:42AM

25 Engineers. 10:42AM

1 I'm a member of the American Geophysical Union, 10:42AM
2 which is actually a world wide organization of earth scientists. 10:42AM

3 I am also a member of the American Rock Mechanics 10:42AM
4 Association. I believe I've been a member since that 10:42AM
5 organization was founded in the late 1990s. 10:43AM

6 The American Rock Mechanics Association is a 10:43AM
7 constituent part of the International Society for Rock 10:43AM
8 Mechanics. So, by virtue of being a member, I'm also a member 10:43AM
9 of the International Society for Rock Mechanics. 10:43AM

10 Q With respect to the International Society for Rock 10:43AM
11 Mechanics, are you on any types of commissions at that 10:43AM
12 particular organization? 10:43AM

13 A Well, yes, I am. In fact, in 2009, when the International 10:43AM
14 Society For Rock Mechanics initiated a commission called the 10:43AM
15 commission for petroleum geomechanics, I was actually the first 10:43AM
16 person asked to be the president of that commission. 10:43AM

17 I felt, due to other time commitments, that was 10:43AM
18 not possible. But I did join as a member of that commission. 10:43AM
19 So I am the member of the commission of petroleum geomechanics 10:43AM
20 for the ISRM. 10:43AM

21 Q And briefly, what does that commission do? 10:43AM

22 A Well, that commission -- and I should preference it by 10:43AM
23 saying in this context geomechanics and rock mechanics are 10:43AM
24 essentially equivalent terms. 10:44AM

25 That commission tries to organize workshops in 10:44AM

1 various areas of rock mechanics as they apply to petroleum 10:44AM
2 engineering. Tries to organize special sessions within larger 10:44AM
3 conferences. It was in the process of trying to organize some 10:44AM
4 special publications devoted on specific issues of rock 10:44AM
5 mechanics applications to the petroleum industry. 10:44AM

6 MR. FIELDS: Please display 23668. 10:44AM

7 BY MR. FIELDS: 10:44AM

8 Q Let's focus for a minute on one of the awards that you've 10:44AM
9 received in the rock mechanics area. Will you tell us briefly 10:44AM
10 about the Biot medal that you received? 10:44AM

11 A Yes. In 2010, I have received a Maurice A. Biot medal from 10:44AM
12 the American Society of Civil Engineers. That's a medal that's 10:44AM
13 awarded annually to researchers anywhere in the world, not 10:44AM
14 necessarily restricted to the members of the ASCE, for lifetime 10:44AM
15 research contributions in the field of mechanics and the 10:45AM
16 mechanical behavior of the porous materials. And, as the 10:45AM
17 citation mentions, a quote here on the screen from the citation 10:45AM
18 points out that I've had a major -- according to the ASCE, I've 10:45AM
19 had a major impact on rock mechanics and the theory of 10:45AM
20 poroelasticity. 10:45AM

21 Q So two questions on this slide. 10:45AM

22 One, there is a reference to porous materials. Do 10:45AM
23 you see that? 10:45AM

24 A Yes. 10:45AM

25 Q What are the porous materials? And, more specifically, is a 10:45AM

1 sandstone a porous material? 10:45AM

2 A Yes. A porous material is a material which is not 10:45AM
3 completely solid. I.e., if one thought about for example a 10:45AM
4 piece of steel and looked at a piece steel under a microscope, 10:45AM
5 you would just see more steel. You wouldn't see any void space, 10:45AM
6 any pores in it. 10:45AM

7 Porous materials, on the other hand, are materials 10:45AM
8 that have void spaces within them. Typically those void spaces 10:45AM
9 are interconnected to each other, and typically they are filled 10:45AM
10 with fluids. 10:45AM

11 So possibly the most typical and common type of 10:46AM
12 porous material would be a reservoir type rock. Soils are also 10:46AM
13 porous materials. Biological materials such as human bone is 10:46AM
14 actually porous material. 10:46AM

15 So it's a wide range of materials, but certainly 10:46AM
16 reservoir sandstones are a type of porous material. 10:46AM

17 Q There is a reference also from the ASCE citation that talks 10:46AM
18 about the theory of poroelasticity. What in general is 10:46AM
19 poroelasticity? 10:46AM

20 A Well, the theory of elasticity is the theory that studies 10:46AM
21 how solid bodies change their size and shape when they are acted 10:46AM
22 upon by various forces and stresses. 10:46AM

23 That might sound like the same definition I gave 10:46AM
24 before for mechanics, but elasticity would be sort of a subset 10:46AM
25 of mechanics that doesn't necessarily look at materials 10:46AM

1 breaking, but looks at their behavior prior to breaking, so to 10:47AM
2 speak. 10:47AM

3 Poroelasticity is the specific type of elasticity 10:47AM
4 that's relevant to porous materials. I wouldn't say in this 10:47AM
5 case it's a subset of elasticity. It's actually a somewhat more 10:47AM
6 complicated and generalized theory. Because in the theory of 10:47AM
7 poroelasticity, one has to account for the fact that materials 10:47AM
8 are porous and the fact that the fluid in the pores has a pore 10:47AM
9 pressure. 10:47AM

10 So it's sort of an extension of the classical 10:47AM
11 theory of elasticity to apply to porous materials such as 10:47AM
12 sandstones. 10:47AM

13 MR. FIELDS: Would you display D-23671. 10:47AM

14 BY MR. FIELDS: 10:47AM

15 Q In addition to your academic work, have you provided 10:47AM
16 consulting services on rock mechanics related issues in the 10:47AM
17 past? 10:47AM

18 A Yes. I've occasionally functioned as a consultant or expert 10:47AM
19 witness. 10:47AM

20 For example, a couple of examples here on the 10:48AM
21 screen. In the late 1980s, I served as a consultant and expert 10:48AM
22 witness on the topic of pore volume compressibility of 10:48AM
23 unconsolidated sands. That was done for the California Bureau 10:48AM
24 of State Lands as part of the Long Beach oil field reservoir 10:48AM
25 equity arbitration case. 10:48AM

1 I believe it was early 1990s, I was a consultant 10:48AM
2 on laboratory measurements of pore volume compressibility, and 10:48AM
3 interpretation of that data for a company called Terratek, which 10:48AM
4 is a very well-known rock mechanics testing company that's based 10:48AM
5 in Salt Lake City, Utah. 10:48AM

6 A few years ago I did some consulting work for a 10:48AM
7 company called Dove Energy where I was a consultant -- 10:48AM
8 specifically, where I analyzed data to determine pore volume 10:48AM
9 compressibility of various of their reservoirs in the Middle 10:48AM
10 East. 10:48AM

11 MR. FIELDS: Your Honor, at this point, BP and Anadarko 10:48AM
12 tender Professor Zimmerman as an expert in the area of rock 10:49AM
13 mechanics, including rock compressibility. 10:49AM

14 MR. GLADSTEIN: You Honor, Richard Gladstein for the 10:49AM
15 United States. 10:49AM

16 No objections, except to the extent of scope. We 10:49AM
17 would want his testimony to be consistent with your order, that 10:49AM
18 he's not allowed to testify as to any surrebuttal opinions, Your 10:49AM
19 Honor. 10:49AM

20 THE COURT: All right. I'll accept him as an expert. 10:49AM

21 BY MR. FIELDS: 10:49AM

22 Q Professor Zimmerman, did you write a report in this case in 10:49AM
23 which the report set forth your opinions as well as the reasons 10:49AM
24 for your opinions? 10:49AM

25 A Yes, I did. 10:49AM

1 MR. FIELDS: Would you please display TREX-11497.1. 10:49AM

2 BY MR. FIELDS: 10:49AM

3 Q Professor Zimmerman, is this the cover page from the report 10:49AM

4 that you prepared in this litigation? 10:49AM

5 A Yes, it is. 10:49AM

6 MR. FIELDS: Your Honor, we have offer Professor 10:49AM

7 Zimmerman's report, which is TREX-011497, into evidence. 10:49AM

8 THE COURT: All right. Any objection? 10:50AM

9 Without objection, it's admitted. 10:50AM

10 (Exhibit admitted.) 10:50AM

11 BY MR. FIELDS: 10:50AM

12 Q Look at D-23672. 10:50AM

13 At a very high level, would you please tell the 10:50AM

14 Court your opinions about the Macondo reservoir rock's 10:50AM

15 compressibility or level of compressibility. 10:50AM

16 A Well, the main conclusion of my report was that my estimate 10:50AM

17 of the average compressibility of the reservoir rocks in the 10:50AM

18 Macondo reservoir was 6.35 microsips. 10:50AM

19 Microsips is a unit that is used commonly in the 10:50AM

20 oil industry to quantify and measure the level of 10:50AM

21 compressibility. 10:50AM

22 This conclusion was based on my analysis, from 10:50AM

23 various pieces of data from the reports submitted by 10:50AM

24 Weatherford's Lab. In particular, this numerical value was 10:50AM

25 obtained from my analysis of the Weatherford Laboratory tests 10:50AM

1 done on measuring the uniaxial pore volume compressibility off 10:50AM
2 three cores from the Macondo reservoir. 10:51AM

3 These tests were, I believe, conducted using 10:51AM
4 standard rock mechanics testing procedures. My estimate of the 10:51AM
5 UPVC -- and I will abbreviate it as such occasionally in my 10:51AM
6 testimony -- my estimate of the UPVC value of 6.35 microsips was 10:51AM
7 also sort of bolstered and confirmed by my analysis of other 10:51AM
8 laboratory data measurements of different properties that are 10:51AM
9 closely related to pore volume compressibility of different 10:51AM
10 experiments that were conducted by Weatherford Laboratories. 10:51AM

11 Q Before getting into the details of your opinions, we've been 10:51AM
12 talking about this concept of compressibility. Can you explain 10:51AM
13 the concept of compressibility and how it relates to materials. 10:51AM

14 A Well, in the most general sense, the compressibility is the 10:51AM
15 parameter that quantifies how easy it is for a body to change 10:51AM
16 its size and shape When it's acted upon by pressures. 10:52AM

17 So, very specifically, the compressibility is 10:52AM
18 defined as the fractional change in the volume of a body divided 10:52AM
19 by the pressure that is applied to that body. 10:52AM

20 All materials are compressible to one degree or 10:52AM
21 another, even though it might not appear that way to the human 10:52AM
22 eye. So even a material such as steel, which we generally think 10:52AM
23 of as being very rigid, has a nonzero compressibility. It's 10:52AM
24 actually about 0.04 microsips. 10:52AM

25 At the other extreme, a loaf of bread, for 10:52AM

1 example, actually has a compressibility of roughly about a 10:52AM
2 million microsips. 10:52AM

3 So all materials are compressible to one degree or 10:52AM
4 another. Of course, my testimony in this case will focus on the 10:52AM
5 pore compressibility of the sandstones. 10:52AM

6 MR. FIELDS: Would you display D-24650. 10:52AM

7 BY MR. FIELDS: 10:52AM

8 Q We've repeatedly heard in this litigation and we heard 10:53AM
9 earlier from you about a term called microsip. So what is a 10:53AM
10 microsip? 10:53AM

11 A Well, like I said, since compressibility is defined as the 10:53AM
12 fractional change in volume divided by the implied pressure, it 10:53AM
13 has sort of units of one divided by pressure or one divided by 10:53AM
14 psi. 10:53AM

15 In order to not always talk about numbers with 10:53AM
16 large or small exponents, it's common to use the units of 10:53AM
17 microsips. Specifically, micro means 10 to the minus 6 power, 10:53AM
18 or one part in a million. So a microsip specifically is 10 to 10:53AM
19 the minus 6 power divided by psi. 10:53AM

20 So micro is just the typical scientific word for 10:53AM
21 10 to the minus 6 power. Sip, at one point someone tried to 10:53AM
22 cleverly come up with way of coming up with a word that 10:53AM
23 indicated one divided by psi, and that how became S-I-P. So 10:54AM
24 that's sort of the term that's used in the oil industry, 10:54AM
25 microsip. 10:54AM

1 But essentially it means 10 to the minus 6 per 10:54AM
2 psi. 10:54AM

3 MR. FIELDS: Let's display D-23674. 10:54AM

4 BY MR. FIELDS: 10:54AM

5 Q And, Professor Zimmerman, can you explain to us what this 10:54AM
6 diagram depicts? 10:54AM

7 A Well, on the left, there's sort of a picture of a sandstone. 10:54AM
8 And, that small region, sort of the outline in the yellow 10:54AM
9 square, is sort of blown up on the right. So one could imagine 10:54AM
10 that on the right represents that a small piece of that 10:54AM
11 sandstone viewed under a microscope on a very larger scale. 10:54AM

12 We see that the sandstone essentially consists of 10:54AM
13 two main components: It consists of minerals, and in this 10:54AM
14 particular image the mineral grains are indicated in that sort 10:54AM
15 of mottled brown coloring. I think one of the grains is 10:54AM
16 indicated by the arrow up on the -- in the upper left corner 10:55AM
17 there. 10:55AM

18 But also, the grains do not completely occupy all 10:55AM
19 of the space. There is void space or pore space between these 10:55AM
20 grains. Those pores are shown in the image in the darker brown 10:55AM
21 color in the reservoir. Those pores would be filled with some 10:55AM
22 mixture of hydrocarbons and water. 10:55AM

23 Q Now, let's specifically focus on the compressibility of 10:55AM
24 reservoir rocks such as sandstones. Can you take a look at 10:55AM
25 D-23719. 10:55AM

1 Now, when discussing how pressures cause volume 10:55AM
2 changes to porous materials like sandstones, what are the 10:55AM
3 different types of volumes that you would be looking at as a 10:55AM
4 scientist or as an engineer? 10:55AM

5 A Well, as this picture shows and I mentioned just previously, 10:55AM
6 the sandstone consists of a mixture of mineral grains and 10:55AM
7 fluid-filled pore space. 10:55AM

8 So, first we have something, pore volume -- and I 10:56AM
9 believe there probably should have been an arrow here pointing 10:56AM
10 from here to there showing that this sort of orange area 10:56AM
11 outlines one of the pores. 10:56AM

12 If you imagine the total sum of the volume of all 10:56AM
13 of these pores would be referred to as the pore volume of this 10:56AM
14 rock; the total volume occupied by the minerals would be 10:56AM
15 referred to as the mineral volume of the rock; and by 10:56AM
16 definition, the total overall volume which is referred to in 10:56AM
17 this context as the bulk volume, which would be the volume that 10:56AM
18 would be represented within this green boundary. That would be 10:56AM
19 the volume that one would measure on a core if you just measured 10:56AM
20 the length and diameter of the core. 10:56AM

21 That bulk volume consists of the sum of the pore 10:56AM
22 volume plus the mineral volume. 10:56AM

23 Q We've heard about pressures and compressibility. If you 10:56AM
24 look at D-23676, what type of pressure or pressures exist in and 10:56AM
25 around reservoir rock? 10:57AM

1 A This large square region represents sort of a blowup. So, 10:57AM
2 sort of under a microscope, so to speak, of a small piece of the 10:57AM
3 rock in a generic reservoir. That rock is acted upon in the 10:57AM
4 reservoir by different stresses or pressures. 10:57AM

5 I should point out that, for the context of what I 10:57AM
6 will be discussing today, there really isn't a distinction 10:57AM
7 between the word stresses and pressures. I might be using both 10:57AM
8 of those terms interchangeably. 10:57AM

9 So this rock is acted upon -- I'll mention first 10:57AM
10 this vertical stress or vertical pressure which is sometimes 10:57AM
11 called the overburden confining pressure. It's essentially due 10:57AM
12 to the weight of the rock that's lying above the reservoir. 10:57AM

13 So at that weight of all the rock lying above the 10:57AM
14 reservoir pushes down on the reservoir and exerts a pressure on 10:57AM
15 it in the vertical direction. 10:58AM

16 There are also stresses that act laterally or in 10:58AM
17 the horizontal direction. Those would be known as the lateral 10:58AM
18 confining pressures. In general, these two pressures are not 10:58AM
19 equal to each other in a reservoir. 10:58AM

20 Q Let's take a look at D-23675. What is the relationship or 10:58AM
21 the interaction between these confining pressures that you 10:58AM
22 previously identified and the pore pressure? 10:58AM

23 A Well, as I mentioned, there are confining pressures that act 10:58AM
24 both in the vertical and horizontal direction. 10:58AM

25 If somehow those confining pressures, for example, 10:58AM

1 would increase, that would have the effect of compressing the 10:58AM
2 pore and making it smaller. 10:58AM

3 But there's another factor that comes into play 10:58AM
4 with porous material such as sandstones. The fluid in the pore 10:58AM
5 space is pressurized, and that fluid is typically under some 10:58AM
6 high pressure. That pressure is known as the pore pressure or 10:58AM
7 the pore fluid pressure. 10:59AM

8 That pressure exerts a pressure outwards from the 10:59AM
9 pore space into the mineral grains. So, as we see from this 10:59AM
10 cartoon here, the pore pressure exerts forces in the outward 10:59AM
11 direction against the rock. 10:59AM

12 In some sense, it's clear that the pore pressures 10:59AM
13 and the confining pressures are acting in opposite directions 10:59AM
14 and have somewhat opposite affects on the pore volume. 10:59AM

15 Q Let's take a look at a three-slide set. Its D-23681, 10:59AM
16 D-23682, D-26383. 10:59AM

17 We've talked generally about compressibility; but, 10:59AM
18 in using these slides, can you tell us why pore volume 10:59AM
19 compressibility is an important parameter. 10:59AM

20 A Specifically, the pore volume compressibility quantifies how 10:59AM
21 much the pore volume will change when the pore pressure changes 10:59AM
22 or when the pore pressure depletes. 10:59AM

23 So if, for example, fluid depletes from this 11:00AM
24 reservoir either through production or through leakage, the 11:00AM
25 pressure in the -- the pore pressure in the reservoir would 11:00AM

1 decrease. If the pore pressure decreases, the pore volume will 11:00AM
2 decrease according to this pore volume compressible effect. 11:00AM

3 If the pore volume has decreased, there is 11:00AM
4 obviously less volume available in the reservoir for the fluids, 11:00AM
5 and those fluids that can no longer be stored in the reservoir 11:00AM
6 must leave through the well. 11:00AM

7 So the pore volume compressibility is a very 11:00AM
8 important parameter for quantifying how much fluid can be stored 11:00AM
9 in a reservoir or how much fluid is stored in a reservoir under 11:00AM
10 various conditions. 11:00AM

11 Q Now, in your report you talk about two types of pore volume 11:00AM
12 compressibility. The first type you talk about is the 11:00AM
13 hydrostatic pore volume compressibility. The second type is 11:00AM
14 something called the uniaxial pore volume compressibility. 11:01AM

15 So, first of all, let's talk the hydrostatic pore 11:01AM
16 volume compressibility. What is that? 11:01AM

17 Perhaps we can pull up D-23677. 11:01AM

18 A The term hydrostatic is used in the field of rock mechanics 11:01AM
19 to refer to situations in which all of the confining pressures 11:01AM
20 are equal to each other. 11:01AM

21 So in this particular -- in the particular case of 11:01AM
22 hydrostatic, state of hydrostatic stress, that would be a 11:01AM
23 situation in which the vertical confining stress and the 11:01AM
24 horizontal confining stresses are equal. 11:01AM

25 So, in a hydrostatic compressibility test, one 11:01AM

1 would change those stresses by equal amounts. In such a test, 11:01AM
2 vertical stresses and the horizontal stresses are continuing to 11:01AM
3 change by equal amounts. 11:01AM

4 If one then measures how much the pore volume 11:01AM
5 changes during that test, one can calculate something called a 11:01AM
6 hydrostatic pore volume compressibility. 11:01AM

7 As I'll mention in a second, that's not exactly 11:02AM
8 the mode of deformation that takes place in a reservoir, but it 11:02AM
9 is sort of a starting point of the theory of porous materials 11:02AM
10 and pore compressibility. 11:02AM

11 Q Now, what is pore volume -- sorry -- what is uniaxial pore 11:02AM
12 volume compressibility? 11:02AM

13 A Well, when the rocks deform in the reservoir, they don't 11:02AM
14 deform under conditions where all of the stresses are changing 11:02AM
15 by equal amounts. 11:02AM

16 In general, they undergo a type of deformation 11:02AM
17 that's called uniaxial deformation, meaning that the rock 11:02AM
18 actually only compresses in the vertical direction. So, uni, 11:02AM
19 meaning one axis. The rock compresses along one axis; in this 11:02AM
20 case, a vertical axis. 11:02AM

21 MR. FIELDS: Can we pull up D-23678? 11:02AM

22 BY MR. FIELDS: 11:02AM

23 Q That might help. 11:02AM

24 A Yes. 11:02AM

25 So here we see an example of uniaxial 11:02AM

1 compressibility where the rock is compressing in a vertical 11:03AM
2 direction but is not compressing in the lateral direction. 11:03AM

3 Reason that this happens in the reservoir is that 11:03AM
4 the lateral size of the reservoir are bounded by essentially 11:03AM
5 almost infinite expanse of other rock which essentially prevents 11:03AM
6 the reservoir from expanding in the lateral direction. 11:03AM

7 That's not the case in the vertical direction 11:03AM
8 because the surface can subside. And so the rock is allowed to 11:03AM
9 compact or compress in the vertical direction. 11:03AM

10 So, specifically, to get back to your question, 11:03AM
11 uniaxial pore volume compressibility would be the 11:03AM
12 compressibility of the pore volume measured under a situation in 11:03AM
13 which the rock was deforming only in the vertical direction. 11:03AM

14 Q Now, Dr. Blunt has performed something called the material 11:03AM
15 balance analysis. For the material balance analysis, which type 11:03AM
16 of pore volume compressibility would be relevant, hydrostatic or 11:03AM
17 uniaxial? 11:03AM

18 A As I mentioned, in the reservoir, the rock deforms in the 11:04AM
19 uniaxial mode. And so the type of compressibility that would be 11:04AM
20 most relevant to a material balance calculation would be the 11:04AM
21 uniaxial pore volume compressibility. 11:04AM

22 Q Let's switch briefly to another topic. Let's talk about 11:04AM
23 rock consolidation. 11:04AM

24 As part of your work in this case, did you 11:04AM
25 consider the degree or level of consolidation of the Macondo 11:04AM

1 reservoir rock?

11:04AM

2 A Well, that's one of the issues that I thought about in the
3 process of preparing my report, in preparing my testimony, yes.

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11:04AM

4 Q Now, what is the concept of rock consolidation? What does
5 that mean? I think you have the core that Dr. Blunt used.

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6 That's D-23958.

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7 A I'll start by saying that sandstone, many millions of years
8 ago, began as essentially as a loose collection of sand grains.

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9 So sands in the reservoir start out as loose sand grains, as you
10 would see at the bottom of a beach or the bottom of a lake.

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11 Over geological time, over millions of years,
12 these sand grains get buried under more sand grains. They then
13 get compacted under increasingly higher pressures and also
14 higher temperatures. This process tends to cause the sand
15 grains to get compacted and consolidated together, and you can
16 think of it almost to some extent sort of welded together.

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17 So there's sort of a gradual process that goes on
18 over geological time that transforms the rock from its initial
19 state as a loose collection of unconsolidated sand grains to
20 something that more and more sort of we think of as a solid
21 body.

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22 That sort of process is the process of
23 consolidation, and it can proceed to varying degrees and varying
24 rates. Some sandstones are consolidated to the point where
25 there's hardly any porosity left at all, almost a solid body

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1 with 2 or 3 percent porosity. 11:06AM

2 So there's a spectrum of consolidation that 11:06AM
3 essentially refers to essentially how solidified the rock is. 11:06AM
4 To some extent, it also correlates with loss of porosity. So 11:06AM
5 unconsolidated sands would have a very high porosity, close to 11:06AM
6 40 percent; and, as the consolidation process proceeds, the 11:06AM
7 porosity generally decreases. 11:06AM

8 Q Now, did you arrive at any conclusions about the Macondo 11:06AM
9 sandstones' level of consolidation? 11:06AM

10 A Yes, I did. 11:06AM

11 Q And what is that? 11:06AM

12 A Well, I should point out that, as I said, in some sense, 11:06AM
13 there's a spectrum, as I've mentioned. But the main sort of 11:06AM
14 distinction that one can draw is between unconsolidated and 11:06AM
15 consolidated sandstones. It's a question of whether the sand 11:06AM
16 essentially functions as a loose collection of grains or whether 11:07AM
17 it has some sort of solidity to it, like this. This would be an 11:07AM
18 example of a consolidated sandstone. 11:07AM

19 Based on various pieces of data that I've seen 11:07AM
20 from the Weatehrford Laboratories, my conclusion is that the 11:07AM
21 Macondo rocks are what one would call weakly consolidated. They 11:07AM
22 are in the consolidated category. They are actually as 11:07AM
23 consolidated as this rock is. They're weakly, but they are 11:07AM
24 consolidated. They are consolidated. 11:07AM

25 Q Now, are you aware of literature that provides general 11:07AM

1 correlations between, for example, a rock's level of
2 consolidation and pore volume compressibility?

3 A There have been attempts in the past to sort of collect
4 large amounts of data on the pore volume compressibility of
5 different rocks, to plot those as a function of the porosity of
6 that rock, and to try to group them into different categories
7 such as consolidated or unconsolidated.

8 If one does that and if one looks at any of these
9 data sets, one sees a very large scatter. So it is true that
10 some people have tried to develop correlations. The correlation
11 co-efficients are usually very weak, by which I mean that
12 although it is always possible to draw some line through a data
13 set. In most cases, these data sets are really clouds of data
14 that have a huge range.

15 So I think your question was, can one develop
16 correlations? People have attempted to do that. But even those
17 people that have attempted to do that point out that they cannot
18 be used to predict for volume compressibility very accurately,
19 because the range of sort of outlying data is just much too
20 large.

21 Q As an expert in rock mechanics, what is your opinion about
22 the best way to determine the pore volume compressibility of
23 reservoir rock?

24 A Well, since pore volume compressibility will vary from one
25 reservoir to the next, and as I've just sort of mentioned or

1 implied, even if one looks at other rocks that have exactly the 11:09AM
2 same porosity as the rocks that you're interested in, that 11:09AM
3 information alone cannot really give you an accurate estimate of 11:09AM
4 the pore volume compressibility. 11:09AM

5 So the only reliable way or the most reliable way 11:09AM
6 to estimate the pore volume compressibility would be to take 11:09AM
7 cores from that reservoir, bring them to the laboratory, and 11:09AM
8 conduct pore volume compressibility measurements on those cores. 11:09AM

9 Q As part of your work in this case and in the formulation of 11:09AM
10 your opinions about the Macondo reservoir's pore volume 11:09AM
11 compressibility, did you evaluate data from lab measurements of 11:09AM
12 samples taken from the reservoir? 11:09AM

13 A Yes. I looked at several sets of data from measurements 11:09AM
14 made by Weatherford Laboratories and different cores taken from 11:10AM
15 the Macondo reservoir. 11:10AM

16 Q Let's turn to discuss the rock samples that were collected 11:10AM
17 from the Macondo well reservoir. What types of samples were 11:10AM
18 collected in the reservoir? 11:10AM

19 A The cores that were collected are something called rotary 11:10AM
20 sidewall cores. 11:10AM

21 MR. FIELDS: Would you please show D-23685. 11:10AM

22 BY MR. FIELDS: 11:10AM

23 Q Can you explain to the Court and us what a rotary sidewall 11:10AM
24 core is? 11:10AM

25 A Well, this slide shows a schematic diagram of the reservoir; 11:10AM

1 this white vertical column represents the borehole. In a rotary 11:10AM
2 cycle coring, a tool would be dropped down the borehole, and a 11:10AM
3 rotary device would be projected out laterally to the side of 11:11AM
4 that device. 11:11AM

5 It would drill by a rotary action drill into the 11:11AM
6 reservoir horizontally away from the well. Essentially, as we 11:11AM
7 see here in this schematic and in this what was an animation a 11:11AM
8 minute ago, as it rotates, essentially pulling out a small 11:11AM
9 cylindrical core out of the reservoir. 11:11AM

10 That coring bit would then be pulled back into the 11:11AM
11 coring device and eventually brought back up to the surface 11:11AM
12 where that core could be tested in the laboratory. 11:11AM

13 So, just to summarize, the rotary refers to the 11:11AM
14 fact that the coring is drilled out in a rotary drilling action. 11:11AM
15 Sidewall refers to the fact that the coring is taken from the 11:11AM
16 sidewall of the borehole, not from the borehole itself. 11:11AM

17 Q Are there other types of cores that can be extracted from a 11:11AM
18 reservoir? 11:11AM

19 A Yes, There are. 11:11AM

20 Q What are examples of other types of cores that can be 11:12AM
21 extracted or collected from the reservoir? 11:12AM

22 A There's something called a percussion sidewall core. That's 11:12AM
23 a core that was also be taken off to the side of the borehole. 11:12AM
24 That's done by sort of essentially shooting a hollow cylinder 11:12AM
25 into the reservoir that then essentially cuts out a cylindrical 11:12AM

1 core.

11:12AM

2 So it would be another way of obtaining a
3 cylindrical core from the sidewall of the reservoir, by
4 essentially a shooting action, not rotary action.

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5 There's also conventional cores. Conventional
6 cores are rock cores taken from the rock that used to occupy the
7 place that's now occupied by the borehole. So conventional
8 cores are taken -- in the case of a vertical well, such as one
9 at Macondo, the conventional core would be taken out vertically
10 out of the borehole.

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11 It would then be brought back to the surface to
12 the laboratory where a small plug would be taken out of it, and
13 then again one would take that small plug and do laboratory
14 tests on the plug.

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15 So, yes.

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16 Q Now, how many rotary sidewall core samples were collected
17 from the Macondo well reservoir?

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18 A I believe a total of 44 rotary sidewall corings were
19 collected from the Macondo reservoir.

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20 Q And, of those 44 cores that were collected from the
21 reservoir, how many of them were tested for rock properties that
22 you used in your work?

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23 A Well, a total of nine of them were tested for the type of
24 rock properties that I used in my analysis. In one of those
25 cases, specifically referring to the ultrasonic or the acoustic

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1 velocity tests, the data was only complete on two of those three 11:13AM
2 cores. 11:13AM

3 So I actually used data from nine different cores 11:13AM
4 in order to inform my opinion. 11:13AM

5 Q Well -- 11:14AM

6 A I'm sorry, I used eight different course. 11:14AM

7 Q So, with respect to the other 36 or so cores, why didn't you 11:14AM
8 use data from those cores? 11:14AM

9 A Well, in some of the cores, no tests at all were performed. 11:14AM
10 On other cores, tests were performed to measure different rock 11:14AM
11 properties that are not directly relevant to the issue of pore 11:14AM
12 volume compressibility. 11:14AM

13 So, for example, other cores were used to measure 11:14AM
14 permeability, or I believe electrical resistivity, and those 11:14AM
15 properties are not closely related to pore volume 11:14AM
16 compressibility. 11:14AM

17 So that data would not have been relevant to my 11:14AM
18 calculations or my determination. 11:14AM

19 MR. FIELDS: Would you please display D-23684. 11:14AM

20 BY MR. FIELDS: 11:14AM

21 Q Professor Zimmerman, what does D-23684 show? 11:14AM

22 A Well, this is a schematic diagram that shows the locations 11:15AM
23 where these eight cores were taken. These eight cores, 11:15AM
24 specifically referring to the eight cores, the data from which I 11:15AM
25 used to reach my conclusions about the uniaxial pore volume 11:15AM

1 compressibility.

11:15AM

2 So, in this image here, the reservoir sandstone
3 layers were D layer, E layer, and the F sandstone layer are
4 shown in this sort of darker brown color.

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5 Again, this vertical sort of grey region
6 schematically represents the borehole. These small white
7 numbers represent the depths at the top and the bottoms of the
8 different sandstone layers.

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9 These yellow numbers represent the depths at which
10 these particular cores were taken. So, for example, core 3-6R
11 was taken from the depth of 18,074.9 feet, et cetera.

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12 So we see these are the depths roughly to scale at
13 which these eight cores that I have referred to previously were
14 taken from the reservoir.

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15 Q You talked about rotary sidewall core samples. Were there
16 any conventional cores that were collected from the Macondo
17 reservoir?

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18 A No. As far as I understand, there were no conventional --
19 there was no conventional core retrieved from the Macondo
20 reservoir.

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21 Q Is it common to have compressibility testing performed on
22 rotary sidewall cores?

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23 A It is commonly done within the oil industry, yes. It's not
24 a rare or uncommon practice.

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25 Q Now, if we take a look at D-23686. We'll talk about some of

11:16AM

1 these tests in some detail; but, in general, what type of 11:16AM
2 laboratory tests did you evaluate or did you review in reaching 11:16AM
3 your opinions in this case? 11:16AM

4 A The primary test that I relied upon was something called the 11:16AM
5 uniaxial compression test. The three different cores were 11:17AM
6 subjected to that test, and I used the data on the three cores 11:17AM
7 in the uniaxial compression test to arrive at my conclusion of 11:17AM
8 6.35 microsips as my estimate of the uniaxial pore volume 11:17AM
9 compressibility of the Macondo reservoir. 11:17AM

10 I also looked at data from two other tests. One 11:17AM
11 was called the hydrostatic staircase porosity test, which is a 11:17AM
12 test in which porosity was measured as a function in changes in 11:17AM
13 hydrostatic pressure. 11:17AM

14 I also looked at some data from ultrasonic 11:17AM
15 velocity tests, which are tests in which the speeds of the two 11:17AM
16 different types of ultrasonic waves, the Q wave and the S wave, 11:17AM
17 were measured in the laboratory. 11:17AM

18 So I used data from these two latter tests as sort 11:17AM
19 of a consistency check and a way of ascertaining whether or not 11:17AM
20 there seemed to be anything anomalous or peculiar about the 11:17AM
21 numbers that came out from the uniaxial compression test. 11:18AM

22 Q Let's first focus on the uniaxial compression test. Is that 11:18AM
23 the test -- you were here when the video of Ms. Loos was played. 11:18AM
24 Is that the test that she was talking about? 11:18AM

25 A Yes. I believe it was, yes. 11:18AM

1 Q So let's talk about the uniaxial compression test. If you'd 11:18AM
2 pull up D-23720, which is a basic demonstrative, to help us 11:18AM
3 understand the fundamentals of this test. Can you sort of walk 11:18AM
4 us through how this test works in general. 11:18AM

5 A In the uniaxial compression test, the schematic shows a 11:18AM
6 cylindrical core that would be in the rock testing machine. The 11:18AM
7 top and the bottom, you have these generally steel platens that 11:18AM
8 apply the axial pressure or the axial stress. 11:18AM

9 There's also, although it's not shown here, 11:18AM
10 generally a fluid outside of the rock that applies the lateral 11:18AM
11 horizontal confining pressures. Schematically, there are 11:19AM
12 pressure gauges here. So this pressure gauge in the middle 11:19AM
13 represents sort of a measurement of the pore pressure or the 11:19AM
14 pressure of the fluid inside the pore space of the rock. 11:19AM

15 This pressure gauge represents the pressure of the 11:19AM
16 overburden, vertical overburden pressure. 11:19AM

17 And this pressure gauge represents the pressure of 11:19AM
18 the lateral confining pressure. 11:19AM

19 During the uniaxial tests, the overburden pressure 11:19AM
20 is maintained constant. As I mentioned earlier, that pressure 11:19AM
21 is essentially due to the weight of the rock that lies above the 11:19AM
22 reservoir, and that does not change during the depletion of the 11:19AM
23 reservoir. 11:19AM

24 What does in the first instance change is the pore 11:19AM
25 pressure. So, in these tests, the pore pressure would be 11:19AM

1 decreased at a certain rate to represent depletion of the 11:19AM
2 reservoir due to fluids leaving the reservoir. 11:19AM

3 The key point about these uniaxial compression 11:19AM
4 tests is that, in order to maintain the state of uniaxial 11:20AM
5 deformation, the lateral confining pressure is constantly 11:20AM
6 adjusted so as to prevent the rock from expanding or compressing 11:20AM
7 in the lateral direction. 11:20AM

8 So I think, if the animation can begin now, one 11:20AM
9 sees that the overburden pressure should stay the same. Pore 11:20AM
10 pressure decreases much and the lateral confining pressure 11:20AM
11 decreases. They don't decrease at this same rate. 11:20AM

12 The lateral confining pressure decreases -- in the 11:20AM
13 laboratory, it is purposefully decreased at exactly the right 11:20AM
14 rate to maintain state of uniaxial deformation. 11:20AM

15 So I think, in the test conducted by Weatherford, 11:20AM
16 the pore pressure was deleted down to a pore pressure of 3800 11:20AM
17 psi, which I believe was initially expected to be the final sort 11:20AM
18 of -- the final pressure at the end of the depletion life of 11:20AM
19 this reservoir. And the lateral confining pressure decreased 11:20AM
20 down this value. 11:21AM

21 So, during these tests -- should I continue? 11:21AM

22 Q Yes. 11:21AM

23 A -- what is actually measured is the compression, the bulk 11:21AM
24 compression of the core. In other words, what's actually 11:21AM
25 measured is how much this core gets shorter. Again, it's not a 11:21AM

1 large amount, so it's hard to really envision visually that 11:21AM
2 during this test the core will get shorter. That is what is 11:21AM
3 measured. So, in a sense, one is actually measuring the bulk 11:21AM
4 volume compressibility. 11:21AM

5 One then converts that to the pore volume 11:21AM
6 compressibility using known and well accepted mathematical 11:21AM
7 relations. 11:21AM

8 Q And how many cores did Weatherford Laboratories test for 11:21AM
9 uniaxial compressibility? 11:21AM

10 A Three different cores were tested for uniaxial pore volume 11:21AM
11 compressibility. 11:21AM

12 MR. FIELDS: Can we display TREX-9067.2.1. 11:21AM

13 BY MR. FIELDS: 11:21AM

14 Q Dr. Zimmerman, is this some of the raw data from the 11:22AM
15 Weatherford uniaxial compression test results that you 11:22AM
16 relied upon in determining your estimate of the reservoir's 11:22AM
17 uniaxial pore volume compressibility? 11:22AM

18 A Yes, it is. This is the data from sample from 3-6R. And 11:22AM
19 one sees, for example, the columns representing time, 11:22AM
20 representing the axial stress, which I've been referring to as 11:22AM
21 the axial overburden stress or overburden pressure. 11:22AM

22 This column presents the pore pressure. 11:22AM

23 And this column represents this lateral confining 11:22AM
24 pressure that we were discussing earlier. 11:22AM

25 Q I think you mentioned this in response to my earlier 11:22AM

1 question, but just to be clear, did the Weatherford uniaxial 11:22AM
2 compression test actually measure uniaxial pore volume 11:22AM
3 compressibility? 11:22AM

4 A Well, no. They directly measured the bulk volume 11:22AM
5 compressibility, yes. 11:23AM

6 MR. FIELDS: Now, will you please display D-24651. 11:23AM

7 BY MR. FIELDS: 11:23AM

8 Q Since we were interested in this case in the uniaxial pore 11:23AM
9 volume compressibility, will you tell the Court how you went 11:23AM
10 about calculating UPVC based on the Weatherford lab tests based 11:23AM
11 on the three core samples. 11:23AM

12 A Well, as I just mentioned, the test directly measures the 11:23AM
13 change in bulk volume or the compressibility of the bulk volume 11:23AM
14 of the rock. 11:23AM

15 As I'd mentioned earlier, the bulk volume of the 11:23AM
16 rock essentially has two components. It has the component of 11:23AM
17 the mineral grains or the sand grains, but also the pore space 11:23AM
18 component. 11:23AM

19 We are interested only in the compressibility of 11:23AM
20 the pore space. They have directly measured the overall total 11:23AM
21 compressibility, so one must subtract out or somehow account for 11:23AM
22 the compression that took place within the sand grains 11:23AM
23 themselves. 11:23AM

24 As it turns out for this particular type of rock, 11:23AM
25 very much the largest amount of compression occurs in the pore 11:24AM

1 space, but there is a small amount of compression that actually 11:24AM
2 occurs in the sand grains. That is a term that's easy to 11:24AM
3 account for on mathematically known equations. 11:24AM

4 That's sort of a correction, if you will, that one 11:24AM
5 needs to do to convert the raw data measured by Weatherford into 11:24AM
6 a uniaxial pore volume compressibility. 11:24AM

7 Q Are there formulas that you used in order to convert the 11:24AM
8 results of the Weatherford lab test results to uniaxial pore 11:24AM
9 volume compressibility values? 11:24AM

10 A Yes. There are known formulas which appear, for example, in 11:24AM
11 some of my published papers. It appears also in certain 11:24AM
12 well-known textbooks on petroleum-related rock mechanics, yes. 11:24AM

13 So I used known equations. I didn't used ad hoc 11:24AM
14 equations that were devised special for this purpose, no. 11:25AM

15 MR. FIELDS: If you could put that back up. 11:25AM

16 BY MR. FIELDS: 11:25AM

17 Q So there were three core samples, and each the core samples 11:25AM
18 had a different level of pore volume compressibility. How did 11:25AM
19 you take that information to come up with your estimate of the 11:25AM
20 reservoir's pore volume compressibility? 11:25AM

21 A Well, yes, there were three core samples. The cores were 11:25AM
22 3-6R, 3-16R, and 3-22R. As one can see on this panel in the 11:25AM
23 middle of the slide, each one had a somewhat different pore 11:25AM
24 volume compressibility as measured from the laboratory data. 11:25AM

25 Those three values were 8.57, 4.34, and 6.14 in 11:25AM

1 units of microsips. Pore volume compressibility is essentially 11:25AM
2 an additive property, so the proper way to average them is just 11:25AM
3 to take a simple arithmetic average, which I did using the only 11:25AM
4 three data values that available to me from these three cores, 11:26AM
5 and that leads to an average value of 6.35 microsips. 11:26AM

6 Q Now, if you look at it, and it may be hard to see, but for 11:26AM
7 example, if we look at D-24651 and we look at this little chart 11:26AM
8 for core 3-22R, it appears that at different pressure values the 11:26AM
9 level of compressibility of the rock changes. 11:26AM

10 Is that the case? 11:26AM

11 A Yes. As is typically the case for a sandstone or a 11:26AM
12 reservoir, particularly sandstones, the compressibility isn't 11:26AM
13 just a single number. It varies with the level of stress. So 11:26AM
14 at different stresses one would have a different level of 11:26AM
15 compressibility. 11:26AM

16 The value that I calculated here was my estimate 11:26AM
17 of the average value over the pressure range from 11800 psi down 11:26AM
18 to 10400 psi, which I understand to be pressures at the 11:26AM
19 beginning and the end of the leakage period. 11:27AM

20 Q Now, the tests that were performed by Weatherford used a 11:27AM
21 pressure range from 11800 to down around 3800 psi? 11:27AM

22 A Yes. The tests went down to a much lower pressure. I 11:27AM
23 assume that would have been the pressure that initially the 11:27AM
24 operators were expecting to complete the reservoir down to that 11:27AM
25 lower pressure of 3800. 11:27AM

1 I looked at the data at lower pore pressures, 11:27AM
2 again, just as sort of a consistency check to convince myself 11:27AM
3 that the numbers seemed to be reasonable. Had I used those 11:27AM
4 numbers in my pore volume compressibility calculation, I would 11:27AM
5 have actually got a lower pore volume compressibility, because 11:27AM
6 pore volume compressibility tends to decrease during depletion. 11:27AM

7 I didn't use pressures below 10400 psi, because 11:27AM
8 they are not relevant to the compressibility that existed in the 11:27AM
9 reservoir during the period when fluid was leaking from the 11:28AM
10 reservoir. 11:28AM

11 Q In your analysis of the data, did you include all of the 11:28AM
12 measured values from 11800 down to 10400? 11:28AM

13 A No. I actually, as can be seen -- well, one could see it if 11:28AM
14 one had very good vision here -- but can be seen very clearly in 11:28AM
15 one of the graphs in my report. 11:28AM

16 The initial part of this test, when depletion 11:28AM
17 began, there were actually lower values of pore volume 11:28AM
18 compressibility, and the raw data themselves show a trend where 11:28AM
19 initially the pore volume compressibility was low and started to 11:28AM
20 increase before leveling off and then essentially slowly 11:28AM
21 decreasing. 11:28AM

22 Typically we both expect from data and from lots 11:28AM
23 of theoretical considerations that the pore volume 11:28AM
24 compressibility would, if any anything, decrease as a function 11:28AM
25 as depletion occurs. Essentially because, as depletion occurs, 11:29AM

1 cracks get close in the rock and grain boundaries in the rock 11:29AM
2 get pressed more tightly together. 11:29AM

3 So anyway, to make a long story short, to my mind, 11:29AM
4 this initial period of a couple hundred psi where the pore 11:29AM
5 volume compressibility actually looked very low and was 11:29AM
6 increasing, I interpreted that as an experimental artifact. I 11:29AM
7 think that's very commonly done. It's been known for decades 11:29AM
8 that one often has what are generically referred to as 11:29AM
9 experimental artifacts at the beginning of a compressibility 11:29AM
10 test. 11:29AM

11 It's generally thought to be related to friction 11:29AM
12 between the rock and the platens. So those data points actually 11:29AM
13 indicated lower values, and I think -- 11:29AM

14 Q What would have happened if you had actually included the 11:29AM
15 data points from that couple hundred psi range? What impact 11:29AM
16 would that have on the pore volume compressibility estimate? 11:29AM

17 A If I had included that, I would have gotten a much lower 11:30AM
18 value. In fact, I think certainly with my glasses I can see 11:30AM
19 that this number here is actually 3.73. 11:30AM

20 So there were some data points that actually 11:30AM
21 showed much lower values. As I said, my feeling very strongly 11:30AM
22 is that I did not believe that these accurately reflected what 11:30AM
23 was going on in the reservoir, so I neglected the first few data 11:30AM
24 points corresponding to the first couple of hundred psi. 11:30AM

25 Removing those data points, the entire curve from 11:30AM

1 then down on to 3800 looked like a compressibility curve that I 11:30AM
2 would expect based on my experience. 11:30AM

3 Q So, based on your evaluation of the data from Weatherford 11:30AM
4 Laboratories' uniaxial compression test, what is your estimation 11:30AM
5 of the reservoir's pore volume compressibility? 11:30AM

6 A Based on my analysis of this data and as reported in my 11:30AM
7 report, my estimate was 6.35 microsips. 11:30AM

8 Q Now, as part of your work in this case, did you review the 11:31AM
9 Weatherford compression test procedures? 11:31AM

10 A Yes, I did. I did read -- those procedures and protocols 11:31AM
11 were described in the Weatherford report, and I did read them. 11:31AM

12 Q And do you believe that the procedures that were performed 11:31AM
13 by Weatherford were appropriate? 11:31AM

14 A Yes, I do. 11:31AM

15 Q You're aware that there is some criticism that Weatherford 11:31AM
16 ran the test at room temperature rather than at reservoir 11:31AM
17 temperature? Are you aware of that criticism? 11:31AM

18 MR. GLADSTEIN: Objection, Your Honor. This gets into 11:31AM
19 the surrebuttal. There was a list of ten areas that was a 11:31AM
20 deposition exhibit, and one of those areas, No. 6, is 11:31AM
21 temperature effect. 11:31AM

22 MR. FIELDS: Your Honor, a couple of things, if I may 11:31AM
23 be heard. 11:31AM

24 There are a couple of ways to approach this, 11:31AM
25 including his prior experience. I think the biggest issue that 11:32AM

1 we raised with Judge Shushan and we raised with Your Honor, is 11:32AM
2 one of the issues in this case was the pore volume 11:32AM
3 compressibility of this reservoir. 11:32AM

4 THE COURT: Wait. Simple question: Is this part of 11:32AM
5 his rebuttal report, what you're asking now? 11:32AM

6 MR. FIELDS: As far as whether or not the temperature 11:32AM
7 was taken into consideration, that is not in his original 11:32AM
8 report. 11:32AM

9 THE COURT: Okay. So I sustain the objection. 11:32AM

10 FIELDS: Your Honor, can we be heard on this issue? 11:32AM

11 THE COURT: You just were. 11:32AM

12 BY MR. FIELDS: 11:32AM

13 Q During the uniaxial compression test, what type of fluid did 11:32AM
14 Weatherford Laboratories use to fill the core sample's pores? 11:32AM

15 A They have used kerosene. 11:32AM

16 Q In your experience, have you seen kerosene used as a 11:32AM
17 saturant to fill the pores of rock samples tested for 11:33AM
18 compressibility? 11:33AM

19 MR. GLADSTEIN: Your Honor, I believe, again, this is 11:33AM
20 beyond his initial report. He's responding here to a criticism 11:33AM
21 that was raised by our rebuttal experts, which was that they 11:33AM
22 did, the test with kerosene, instead of in situ conditions of 11:33AM
23 brine. 11:33AM

24 MR. FIELDS: Your Honor, the question I want to ask him 11:33AM
25 is mbased on his experience, has he seen kerosene used? Has he 11:33AM

1 seen brine used? That's what I'd like to ask him. 11:33AM

2 THE COURT: But you can't get around the rebuttal issue 11:33AM
3 by saying I'm going to ask him, the witness, based on his 11:33AM
4 experience. 11:33AM

5 I sustain the objection. 11:33AM

6 MR. GLADSTEIN: Thank you, Your Honor. 11:33AM

7 MR. FIELDS: At some point, Your Honor, would we be 11:33AM
8 able to make an offer of proof for the record? 11:33AM

9 THE COURT: Sure. Sure. 11:33AM

10 MR. FIELDS: I'd like to ask a question, Your Honor, 11:33AM
11 which is: Do any of the criticisms he's heard change his 11:34AM
12 opinions about the level of compressibility of the reservoir. 11:34AM
13 Yes or no answer. 11:34AM

14 MR. GLADSTEIN: Objection, Your Honor. 11:34AM

15 THE COURT: Sustain the objection. 11:34AM

16 BY Mr. FIELDS: 11:34AM

17 Q You've talked about the results of the uniaxial compression 11:34AM
18 test data by itself in giving you the estimate of 6.35 11:34AM
19 microsips. 11:34AM

20 Why did you look at data from the two other tests 11:34AM
21 if you already came up with the 6.35? 11:34AM

22 A There were two other tests. As I mentioned, they were the 11:34AM
23 hydrostatic stair-step porosity test, and the ultrasonic 11:34AM
24 velocity test. These two tests measure properties that are 11:34AM
25 closely related to pore volume compressibility. I looked at 11:34AM

1 this data to try to basically provide bolstering evidence. 11:34AM

2 I didn't use this data directly as part of my 11:34AM
3 quantitative numerical calculation of the UPVC, but I used it to 11:35AM
4 convince myself whether or not the data from the UPV tests 11:35AM
5 seemed to be reasonable and plausible. So to check whether or 11:35AM
6 not it was roughly in agreement with the values that one would 11:35AM
7 obtain from these other two tests. 11:35AM

8 Q Just before we move on to the other tests, do you agree that 11:35AM
9 the method used by Weatherford and the procedures that were used 11:35AM
10 by Weatherford were standard and accepted or standard and 11:35AM
11 accepted approaches to measuring uniaxial pore volume 11:35AM
12 compressibility? 11:35AM

13 A Yes, I do. I have reviewed their procedures. I was fully 11:35AM
14 aware at the time of writing my report what procedures they 11:35AM
15 used, what pore fluids they used, and I determined that that was 11:35AM
16 an appropriate and proper and accepted procedure. 11:35AM

17 Q Let's turn to the second test that you analyzed in arriving 11:36AM
18 at your opinions in this case regarding the reservoir's pore 11:36AM
19 volume compressibility. That's the hydrostatic stair-step test. 11:36AM
20 How many samples were tested in that particular test? 11:36AM

21 A Three different core samples were tested in the hydrostatic 11:36AM
22 stair-step porosity test, and those were different core samples 11:36AM
23 than the three that were tested in the uniaxial pore 11:36AM
24 compressibility test. 11:36AM

25 Q And who performed the hydrostatic stair-step test on these 11:36AM

1 three different core samples? 11:36AM

2 A These tests were also performed by Weatherford Laboratories 11:36AM
3 in Texas. 11:36AM

4 MR. FIELDS: Would you please display D-23721. 11:36AM

5 BY MR. FIELDS: 11:36AM

6 Q Can you use this demonstrative exhibit to sort of explain to 11:36AM
7 the Court what a hydrostatic stair-step porosity test is and how 11:36AM
8 it works. 11:37AM

9 A Well, this slide shows two different images. The image on 11:37AM
10 the left is intended to represent the beginning of the test. As 11:37AM
11 I mentioned earlier, a hydrostatic state of stress is a 11:37AM
12 situation in which the vertical overburden stress and the 11:37AM
13 lateral horizontal confining stress are equal. 11:37AM

14 These three gauges, again, represent the vertical 11:37AM
15 stress, the lateral horizontal confining stress, and the pore 11:37AM
16 pressure. 11:37AM

17 In this particular test, the pore pressure was 11:37AM
18 held constant and the lateral confining pressure and the 11:37AM
19 vertical overburden pressure were increased at exactly the same 11:37AM
20 rate to represent the hydrostatic state of stress. 11:37AM

21 On the right, this represents the result of one of 11:37AM
22 these steps. So this was done in a stair-step manner by 11:37AM
23 increasing the hydrostatic confining pressure by a fairly large 11:37AM
24 amount, I think increments of 500 or 1000 psi. So the external 11:38AM
25 confining pressure would be increased. What was measured was 11:38AM

1 the porosity of the core. 11:38AM

2 So what was directly measured is the change in the 11:38AM
3 porosity of the core as a function of the change in the 11:38AM
4 hydrostatic stress. I believe they carried out about eight 11:38AM
5 stages in the stair-step to both decrease and then increase -- 11:38AM
6 increasing the pressures. 11:38AM

7 Q So, with respect to D-23721, this is just a representation 11:38AM
8 of one of the steps that would have been carried out as part of 11:38AM
9 several steps? 11:38AM

10 A That's right. The second panel represents sort of the first 11:38AM
11 step, if you will, where the pressures were increased a little 11:38AM
12 bit, the rock compresses, the porosity would be measured, and 11:38AM
13 this process is repeated, you know, by a certain number of 11:38AM
14 times. 11:38AM

15 Q What type of information does the hydrostatic stair-step 11:38AM
16 test give you about a sample's uniaxial pore volume 11:39AM
17 compressibility? 11:39AM

18 A Well, in the most direct sense, this test tells you how the 11:39AM
19 porosity changes. If there are well-known equations, such as 11:39AM
20 appear in my book *Compressibility of Sandstones*, that will 11:39AM
21 relate the change in porosity as a function of stress to 11:39AM
22 hydrostatic pore volume compressibility. 11:39AM

23 So one can use those known equations to convert 11:39AM
24 this raw data into a hydrostatic pore volume compressibility. 11:39AM
25 One can then use other known equations that can be found in 11:39AM

1 various scientific papers and books to convert the hydrostatic 11:39AM
2 pore volume compressibility to a uniaxial pore volume 11:39AM
3 compressibility. 11:39AM

4 Q Let's take a look at D-23701. 11:39AM

5 Can you explain to the Court how you went about 11:39AM
6 converting the measured data from Weatherford, from the 11:39AM
7 hydrostatic stair-step test, to a UPVC value? 11:40AM

8 A Well, this first column here shows what's called a 11:40AM
9 differential pressure, which in this context refers to the 11:40AM
10 difference between the confining pressure and the pore pressure. 11:40AM

11 As I said, the tests were conducted at various 11:40AM
12 discrete values of this differential pressure. The second 11:40AM
13 column shows the hydrostatic pore volume compressibility, and I 11:40AM
14 directly compute from that porosity as a function of pressure 11:40AM
15 data. 11:40AM

16 So the second column shows two different volumes 11:40AM
17 of 13.3 microsips at a differential pressure of 1600 psi; 7.96 11:40AM
18 microsips and a differential pressure of 3000 psi. So one then 11:40AM
19 needs to convert that into uniaxial pore volume compressibility. 11:40AM

20 I should point out that the rule of thumb in the 11:40AM
21 industry is generally that that conversion is accomplished by 11:40AM
22 multiplying of a factor of about .5 or .6. 11:41AM

23 I used what I believed to be a more precise 11:41AM
24 convection, which I said is from an equation that can be found 11:41AM
25 in numerous scientific papers and books. The result of that 11:41AM

1 conversion is shown in these two columns here. 11:41AM

2 There is one more point that needs to be 11:41AM
3 mentioned. In order to carry out this conversion, one needs to 11:41AM
4 know the numerical values of several different parameters, one 11:41AM
5 of which is the porosity and one is something called the Poisson 11:41AM
6 ratio. The Poisson ratio, there were two pieces of laboratory 11:41AM
7 data from Weatherford Laboratories on the Poisson ratio on two 11:41AM
8 different cores. The Poisson ratio measured by Weatherford 11:41AM
9 Laboratory was 0.13 and 0.18. Based on those data and my 11:41AM
10 experience and knowledge of sandstone compressibility and 11:41AM
11 sandstone stone mechanical properties, I did my calculations 11:42AM
12 using a somewhat broader range of 0.1 and 0.2 Poisson ratio, 11:42AM
13 which I felt represented sort of a range that I might reasonably 11:42AM
14 expect to find in such a sandstone. 11:42AM

15 When doing that calculation for the Poisson ratio, 11:42AM
16 is it's actually represented by a Greek letter, but it looks in 11:42AM
17 this font very much like a V. 11:42AM

18 Using the Poisson ratio of .1 and .2, I came up 11:42AM
19 with either these values or those values in the third and fourth 11:42AM
20 column. 11:42AM

21 The last part of the calculation is as follows. 11:42AM
22 As I mentioned before and as is clear from this table, pore 11:42AM
23 volume compressibility varies as a function of pressure. We are 11:42AM
24 really interested in the pore volume compressibility at the 11:42AM
25 average differential pressure that existed in the Macondo 11:42AM

1 reservoir during the period of the spill and the leakage. 11:42AM

2 That value was 2372 psi. And so, since the tests 11:42AM
3 only give us values at 16000 and 3000, the last step in this 11:43AM
4 calculation is essentially to interpolate between the values at 11:43AM
5 1600 and the values at 3000 to find the values at 2372. 11:43AM

6 As you see, even looking at this fairly wide range 11:43AM
7 of potential values of Poisson ratio, this method leads to a 11:43AM
8 prediction of about a UPVC value of roughly 5 microsips. 11:43AM

9 I interpreted that as being sufficiently close to 11:43AM
10 my previously estimated value that was estimated from the direct 11:43AM
11 measurements, which was 6.35. 11:43AM

12 My conclusion from this was there was nothing at 11:43AM
13 all from this data to leads me to think that there was anything 11:43AM
14 grossly erroneous or incorrect about the values that I 11:43AM
15 calculated previously. 11:43AM

16 Q So, just to be clear, when evaluating the data from the 11:43AM
17 hydrostatic stair-step test, what was your estimate of the 11:44AM
18 reservoir's uniaxial pore volume compressibility? 11:44AM

19 A My estimate on this test alone would imply a value somewhere 11:44AM
20 between 4.56 and 5.47. 11:44AM

21 Q And how did that assist you in determining or evaluating 11:44AM
22 what was an appropriate estimate of the reservoir's uniaxial 11:44AM
23 pore volume compressibility? 11:44AM

24 A Well, as I said, what my conclusion was, that this value was 11:44AM
25 sufficiently close to the value I'd calculated previously, 11:44AM

1 bearing in mind that this data was taken was based on -- this 11:44AM
2 calculation was based on data from three different cores. 11:44AM

3 We know there's going to be slight variations of 11:44AM
4 compressibility from one core to the next, even within the same 11:44AM
5 reservoir. So the main thing that I used this data for was as 11:44AM
6 evidence that helped convince me or substantiated in my mind 11:44AM
7 that there was nothing out of the ordinary about or improper or 11:45AM
8 nothing about the value of 6.35 that one obtains from the 11:45AM
9 uniaxial tests that would seem to be on the surface incorrect or 11:45AM
10 erroneous or startling. 11:45AM

11 Q Let's turn to the acoustic velocity test. 11:45AM

12 THE COURT: Mr. Fields, let me just ask you where you 11:45AM
13 are in your exam. How much more do you think you have, time 11:45AM
14 wise? 11:45AM

15 MR. FIELDS: Your Honor, I probably have about another 11:45AM
16 25 minutes or so. 11:45AM

17 THE COURT: All right. You're moving to another topic 11:45AM
18 now; right? 11:45AM

19 MR. FIELDS: Yes, Your Honor. 11:45AM

20 THE COURT: Okay. Let's go ahead and we're going to 11:45AM
21 recess a little bit early for lunch. We'll come back at -- 11:45AM
22 let's take a little bit longer lunch than normal. Come back at 11:45AM
23 1:15. 11:45AM

24 (11:45 a.m., proceedings concluded.) 11:52AM
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CERTIFICATE

I, Susan A. Zielie, Official Court Reporter, do hereby
certify that the foregoing transcript is correct.

/S/ SUSAN A. ZIELIE, FCRR

Susan A. Zielie, FCRR

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