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MR. WEBB: That is all.

MR. PORTER: Anyone else have a question? The witness may be excused.

MR. CAMPBELL: I have a little bit of re-direct, please. I would like, if the Commission please, to straighten up a few matters here that perhaps have left the record in doubt in a mathematical sense.

REDIRECT EXAMINATION

BY MR. CAMPBELL:

Q Mr. Keller, would you put those two things up on that board. Mr. Keller, in connection with your cross-examination by Mr. Hinkle, on one of the several hypothetical situations on which you have testified here, and also on a hypothetical question by Mr. Webb, you made some hasty calculations with reference to those situations.

Would you, by reference to the calculations you have put up there on the board, and referring first to Mr. Hinkle's hypothetical case of one well with a thousand pounds of pressure, and one well with five hundred pounds pressure, relate briefly to the Commission what your recalculations indicate as to that situation.

A Well, sir, I made some mistake in my calculations, both in respect to Mr. Hinkle's questions, and Mr. Webb's. I would like to correct them. I thought the easiest way to do so was to set them down in black and white where they are clearly shown. The

assumption under Mr. Hinkle's question was that we had two wells, equal in all respects, except that the pressures varied. Number 1 had a thousand pounds of pressure, Number 2 five hundred, and then the problem was to calculate the deliverability, and the reserve under that assumption.

Correcting that yesterday, I testified that the deliverability would vary as three to one. Comparing the two wells, on calculating it in the quiet of my room, I calculate 3.2 to 1, while the reserve would be in direct proportion, or 2 to 1.

In addition, I have calculated the allowable that would be assigned to two wells under the assumptions involved on the recommended basis, and on the present basis, and I find that the allowable of the Number 1 well would be 2.2, compared to 1 on the Number 2 well, under the recommended basis and, of course, 1 to 1 on the 100% acreage basis, since the assumption was that all other factors about the two wells were equal.

Of course, it is quite obvious, I think, that the ratio of the reserves, or the ratio of the allowable, under the recommended formula of 2.2 to 1, is much closer to the ratio of reserves to 2 to 1 than is the 1 to 1 basis calculated under the present allocation formula. Actually, the 75, 25 basis was within about 10% of being directly, of the allowable being directly prorational to reserves.

Q Now, with regard to the hypothetical case posed by Mr. Webb, I believe you, in your calculations, came up with a differential on the one thousand pound, two hundred pound cases of 67 to 1. Did you recalculate that?

A Yes, sir. I made a very large error in that calculation. As I recall, the assumption was similar to the one I just discussed, except that the pressures instead of being a thousand and five hundred, and with a thousand and two hundred in this case, all other factors about the two wells were equal, the question was, what was the relative reserves, and deliverability in the two wells under that example.

I testified that the ratio of reserve would be in proportion to the pressure, or 5 to 1, which is correct, and that the deliverability would be 67 to 1.

Now, I recalculated that, and that is in error. Actually, with an N-value of 1, the ratio of the deliverability would be 25 to 1, but using the 8/10th slope that I have recommended N-value it would be 13.2 to 1.

I have then made some calculations to show the effect of that disproportionately between reserves and deliverability on the allocation on the 75, 25 basis; the ratio of allowable would be 4.6 to 1 in favor of the thousand pound well on the 100% acreage basis, it would be 1 to 1 and, of course, it is obvious under the hypothesis

of these questions, that the 75, 25 which distributes 4.6 to 1, is much closer than the 5 to 1 reserve distribution than is the 1 to 1 basis here.

Although, I want to be sure that I am not creating a false impression that I'm claiming that the 75, 25 formula is near that percent in the Jalmat Field. It actually works out under this hypothetical situation to be a lot closer, I think, or somewhat closer probably than is reasonably possible in the field itself, although the formula that I have recommended is the best formula I have been able to devise to allocate allowables as near as possible to reserves in the Jalmat Field.

Q Now, in connection with the Jalmat Field, you testified on Cross-Examination that you have concluded from your studies in the Jalmat Field, that this formula would approach, at least, the protection of correlative rights, closer than the present formula, and you have also testified, I believe, in the Jalmat Field that there is a relationship of sorts between the deliverability and the gas reserves.

Would you please state generally and briefly, what studies you referred to in your answer to those questions. What type of studies?

A Yes, sir. I evaluated the reserves for all of the wells in the field for which I had pressure production trends that could be extrapolated in order to estimate reserves.

I found 265 wells with sufficient production history that I could estimate reserves on that basis. I had available back pressure tests on a little over 300 wells, where I had both the slope of the back pressure curve, and the open flow from which I could calculate the deliverability on the recommended basis of the flow against 80% of the shut-in pressure for each well.

I estimated the deliverability, or calculated it on that basis for approximately 300 wells.

Now, out of the 265 wells that I had reserve estimates on, and the 300 some odd wells that I had deliverability calculations on, there were about 226 wells that I had both deliverability results, and reserve estimates, and I have made comparisons between reserves and deliverability, employing that data.

Q Did you plot those on maps in the Jalmat Field?

A Yes, sir, I did plot that map.

Q Would you get out those plots, please.

MR. LAYTON WEBB: I would like the record to show which Mr. Webb's testimony he is disagreeing with.

(Marked Texas & Pacific's Exhibits 8 and 9, for identification.)

Q (By Mr. Campbell) Mr. Keller, I would refer you to what has been identified as Texas Pacific's Exhibit Number 8, and ask you to state to the Commission what that is.

A I have, on Exhibit Number 8, attempted to represent the

relative distribution of reserves in the Field, that I arrive at from the 265 wells that I was able to estimate reserves for by extrapolating pressure production information. The Exhibit Number 8 is a map of the Jalmat Gas Field area. I have taken the data on the 265 wells and arranged them in sequence of increasing reserves, that is, with the lowest reserves first, going up in ascending order of reserves to the highest.

I have then broken, or divided, those wells into four groups having an equal number of wells in quarters, so to speak. On that basis, I have found that the fourth of the wells having the poorest reserves all had reserves of less than 1.4 million, correction billion cubic feet per well. I have taken that poorest fourth and colored the acreage assigned to them on the map in dark blue; similarly for the second group of wells.

By that process, I found that the second best wells, the reserves vary from 1.4 billion per well, to 3.09, I have colored the acreage to these wells in light blue. The third group of wells being next to the best group, which have reserves ranging from 3.09 to 5.17, I have colored them in light red. For the best wells, which have reserves greater than 5.17 billion per well, I have colored this dark red.

The result is that the better than average reserve wells, the acreage assigned to them, is colored in red on the map. The best

half of the better half is in dark red, and the next to the best in light red. Conversely, with the less than average reserve wells are in blue, the poorest fourth of the wells being in dark blue, and the next to the poorest in light blue.

Q Will you refer to what has been identified as Texas Pacific's Exhibit Number 9, and state what that is, please, and explain it.

A Yes, sir. I have for each of the groups of wells, or each quarter, arranged in sequence of reserves, I have -- correction Exhibit Number 9 has been prepared by taking the 300 some odd wells that I have deliverabilities taken on, and arranging them in sequence of deliverability, starting with the lowest deliverability and going to the highest deliverability.

I have then divided those wells in fourths on a deliverability basis, and colored in the map on a deliverability map basis, in a similar fashion as I did on a reserve basis on Exhibit Number 8.

The result is that of those 300 wells, the wells that have less than average deliverability for the 300 are colored in blue; for the ones that have greater than average deliverability are in red. I have further broken down just as with reserves, the better wells into the dark red and light red quarters and the poor wells from a deliverability standpoint in a light blue and dark blue.

Q Now, based upon that study, what is your conclusion?

A Well, sir, as I tried to explain from Exhibit 7, it seemed

apparent to me that deliverability and reserves must be related in some fashion; that is, in general, the better the deliverability, the better the reserves, so I was attempting to testify that as applied to actual conditions in the Jalmat Field, and this was what I thought a reasonable method of analyzing to see if there was a correlation between the deliverability and reserves in general throughout the Field.

I found that there was a general correlation, and I believe it shows up in a comparison of the reserve distribution and the deliverability distribution illustrated in the manner I have just described on Exhibit Number 8, and 9.

For example, it will be noted that on Exhibit Number 8, in the vicinity of Township 23 South, Range 36 East, there is a large red area of high reserves which correlates roughly with a large red area on Exhibit Number 9 in the approximate same location, showing the area of high deliverability. Similarly, we will notice that there is a high reserve and deliverability area indicated by the red in the north end of the Field, that there is a fringe around the edge of this red area, designating the high reserve area; of blue colored wells showing lower than average reserves, which roughly corresponds to a fringe of lower deliverability wells on Exhibit Number 9.

There is also a rough correlation between the reserve distribu-

tion in the south 30 or 40 percent of the field. Most of the wells down there are poorer than average reservewise with a few scattered better than average wells designated by red.

The same thing is true from a deliverability standpoint in the south end; most of them are lower in deliverability, with a few scattered wells of high deliverability. To my mind, this just illustrates that if you will take the actual data in the Jalmat Field, it is still true that good wells are usually good deliverability-wise, and reserve-wise, and conversely.

Q You can come on back down here now, please. You have stated numerous times that that relationship is not an exact relationship, have you not?

A Yes, sir.

Q First, will you state what your study reflected with regard to the ranges of difference in reserves and in deliverability in this field?

A Yes, sir. Let me say this, that as I previously testified, there were 226 wells that I had both deliverability and reserve data on the same wells, so the comparisons that I am about to give you are confined to those 226.

I find that the reserves per acre varied 90-fold among those 226 wells, for my minimum of 8/10ths to a maximum of 91 million per acre. Now, that reserve per acre figure is arrived at by taking

the estimated well reserves from the pressure production extrapolation and divided by the assigned acreage. The deliverability for those same wells varied from less than a hundred thousand per day to as much as about 19.4 million per day. That's a variation of 194.

Now, if we eliminate the extremes, both from a reserve and deliverability standpoint, and take - eliminate the lower 10% and the upper 10%, and just consider the 80% of the wells representing the bulk of them in the middle, then the reserves per acre vary from 5.6 to 48.1, or a variance of about 8.6-fold. The deliverabilities on that same basis of comparisons vary from 360 thousand cubic feet per day, to 6.4 million per day, or a variation of 18-fold.

Q Does that wide variation indicate further to you that the allocation of allowables on the basis of 100% acreage does not serve to protect correlative rights?

A Yes, sir, it very definitely does, because regardless, under the present allocation formula, the acreage that has a reserve of 73 million per acre gets the same allowable as the one that has less than one million per acre, so you have got a 73-fold variation, extreme variation, correction, 91 extreme variation in reserves, but the allowables are 1 to 1 per acre.

(Marked Texas Pacific's Exhibit Number 10, for identification.)

Q (By Mr. Campbell) Now, Mr. Keller, you have constantly

stated here that your testimony as to the relationship between deliverability and reserve is not as to an exact ratio or portion. I refer you to what has been identified as Texas Pacific's Exhibit Number 10, and ask you to state what that is, and what it illustrates.

A Exhibit Number 10 is a graph on which I have plotted the deliverability in terms of M.C.F. per day, against reserves, in terms of millions of cubic feet per acre, calculated as I have previously explained for the data from the 226 wells on which I have both reserve and deliverability estimates.

Q What does that reflect?

A Well, sir, it reflects that there is a general trend or statistical trend relationship between reserves and deliverability. It reflects what I have attempted several times to explain today that they are not in direct proportion to each other, but there is a very definite statistical trend, which says in general that increased reserves are accompanied by increased deliverabilities, and conversely. Not that one is the cause of the other, it is not a cause and effect relationship; it is just a general trend relationship, and it's illustrated by this trend in the grouping of the points.

To illustrate that trend a little more definitely, I have drawn a heavy dashed black line at this position on Exhibit Number 10, which is the Median of the data shown on this graph. It was

arrived at in this fashion: You will recall I arranged the data in reserve order sequence, starting with the lowest to the higher, and divided them into four groups of equal number of wells. I have plotted the average deliverability against the average reserves per acre, resulting from that arrangement, and division into quarters, into red triangles, and have drawn, as you see, and it is a very definite straight line trend of that average data.

I have then taken the same group of wells, arranged them in an increasing deliverability sequence, spaces, taken average reserves and average deliverability after breaking up into those four groups, and plotted that average data that is, deliverability and reserves in general.

You will see that they both show a relationship, the average data does run in a little different direction; it's on that basis that I have attempted to average the trend of all of the data with the dark blue line shown at this position on Exhibit 10.

Q Did this further substantiate your position that deliverability entering into the allocation formula in some manner will serve to protect correlative rights more than the present formula?

A Yes, sir, because it tends to distribute allowables in conformance with a general relationship between reserves and deliverability. The present formula assumes that the reserves per acre throughout the Field are constant. My data shows that the variation

in reserves per acre is up as much as 90-fold, so it seems quite obvious to me that the inclusion of the deliverability formula would tend to protect correlative rights more than straight acreage.

(Marked Texas Pacific's Exhibit Number 11, for identification.)

Q (By Mr. Campbell) Now, Mr. Keller, you have referred in your answer on cross-examination to the situation as to the Jalmat Field, particularly bearing out your proposal as to that Field. Have you made any comparison between these wells in the Field divided into fourths, as to reserves and the allowable under the present and the proposed formula?

A Yes, sir.

Q I refer you to what has been identified as Texas Pacific's Exhibit Number 11, and ask you to state what that is, and explain it, please.

A Yes, sir. I took the 226 wells on which I had both reserve and deliverability data, and as I previously explained, arranged them in sequence of increasing reserves and divided them into four groups, with an equal number of wells, and which I have designated as 1, 2, 3, and 4 on Exhibit Number 11.

The number of wells in each group is also shown on Exhibit Number 4, under each of the bars on the bar-graph. There were 57 in the number 1 group, 56, 57 and 56 which is as near as you can divide 226 into four equal groups.

Then I have taken and calculated the average reserves per acre for each group, which I have designated by a red bar on Exhibit Number 11, which ties into the scale on the left hand side of Exhibit Number 1, for example, considering group number 1, the red bar reaching up to this portion correlating over to the scale, shows that the average reserve per acre for that first group of wells is approximately 6.4 million cubic feet per acre.

Going on up to the best group of wells, the highest group of wells, the average reserves per acre for that group is 46.8 million cubic feet per acre. Now, for each of the groups, I have also calculated the average deliverability which I have illustrated by the green bar. The lowest group, the average deliverability is 1.027 million cubic feet per day; for the best group is about 4 million 577 cubic feet per day.

It will be noticed that when we divide the wells in this fashion, that it is just as one would expect, that in general the average, the fourth of the wells with the lowest reserves also have the lowest average deliverability, and that the two increase in the same direction, although not at the same rate, to where the highest reserve wells also have the highest deliverability, and as you recall, we also found out that they were distributed areally in that same type of relationship. Then I have, in addition, I have shown the relative allowable that each of these groups would receive under the recom-

mended formula, and under the present allocation formula.

Q What is the result of that?

A The result of that is shown for the 100% acreage formula now in effect is shown by the heavy dashed line running horizontally across Exhibit Number 11.

Now, I might explain that this relative allowable as between groups, is relative on an acreage basis, to the average allowable for all four groups, so since 100% acreage treats each acre uniformly, and the relative allowable in terms of allowable per acre, the relative allowable for each group is the same. It's constant, that is, depicted by this horizontal line that the distributional allowable on the average to these groups would be constant on the present formula.

I have calculated the relative allowable per acre by the way that is tied about the scale on the right hand side of the Exhibit 11 for the recommended formula. As shown, that formula results in assigning the group with the lowest reserves, and the lowest deliverability, the lowest allowable, which on the relative allowable scale is approximately 8.56% of the average per acre allowable for all four groups.

It also results in assigning the best wells reserve-wise and also which happen to be the best wells deliverability-wise, a higher than average allowable. In other words, the allowable distribution

as illustrated on Exhibit Number 11, more nearly follows the distribution of reserves under the 75,25 formula, than it does the distribution of reserves under 100% acreage, using all the data, data I have available to me on the actual reserves and deliverability in the Jalmat Field.

To my mind, it very definitely shows that the recommended formula will tend to distribute on the average the allowables more nearly in proportion to the reserves than does the 100% acreage formula. Actually, it might be criticised in that it doesn't go far enough in that direction. For example, considering the lowest reserve group with the highest reserve group, we find that the ratio of average reserves per acre, that is from 46.8 to 6.4, is about 7.3 to 1.

The ratio of the deliverabilities is less than that on the average. It's from 4577 to 1027, or 4.5 to 1. The allowable varies from the best group of wells from a relative allowable of 1.59 to about .564, or a variation of 2.8 to 1.

So in summary, the reserves, the average reserves for these groups varies about 7.3 to 1. The deliverability about 4.5 to 1, and the allowable under the recommended formula about 2.8 to 1, while on the 100% acreage, it would vary as 1 to 1, the allowable would.

MR. CAMPBELL: I would like to offer Texas Pacific's

Exhibits 8, 9, 10, and 11 into evidence.

MR. PORTER: Without objection, they will be admitted.

MR. CAMPBELL: That's all of the questions I have of this witness on Re-direct examination.

MR. PORTER: At this time, the hearing will recess until 1:30.

AFTERNOON SESSION - FRIDAY, NOVEMBER 15, 1957, 1:30 p.m.

MR. PORTER: The meeting will come to order, please. Mr. Campbell, I believe you have one more question?

RE-DIRECT EXAMINATION
Continued

BY MR. CAMPBELL:

Q The question has arisen, Mr. Keller, as to the point, if the Commission should see fit to include deliverability in the allocation formula for the Jalmat Field, what present basis would you use in arriving at the deliverability in the formula?

A Well, sir, I would recommend that each well in the Field be tested in accordance with the testing regulations included in the directive of the Commission dated March 15, 1954, and that the deliverability obtained from that text be corrected to the flow against 80% of each well's shut-in pressure, taken in conjunction with that test in accordance with the equations included in that March 15, 1954 directive.

MR. CAMPBELL: That's all.

MR. PORTER: Does anyone have a question of the witness?

Mr. Utz.