Upstream LNG Technology
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Lecture – 49
Tutorial on hydrate removal

Welcome. After learning about the removal techniques for the gas hydrate, we shall be now looking into the estimation of the gas hydrate and various effects of the impurities on this gas hydrate formation.

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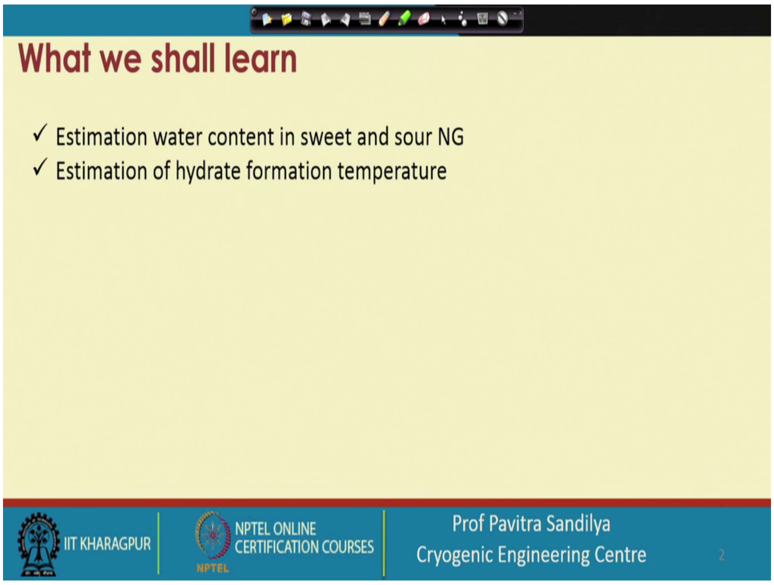

So, in this tutorial on the hydrate removal, we shall be learning about the estimation of the water content in sweet and sour natural gas, because water contain determine the extent or the possibility of the gas hydrate formation. And also we shall be estimating the hydrate formation temperature.

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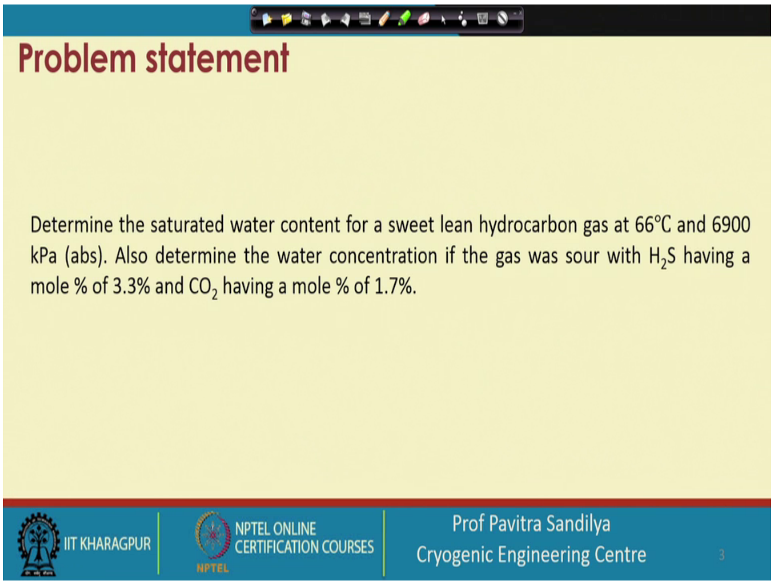

So, first let us look into the problem that in this problem, we will determine the saturated water content for a sweet lean hydrocarbon gas at 66 centigrade and at this particular pressure absolute. And also we have to determine the concentration of the water if the gas were sour with this is the H 2 S content and carbon dioxide content. So, this is with 3.3 H 2 S and 1.7 percent of carbon dioxide what would be the water content of the same gas that means, we find that without the presence of the carbon dioxide and H 2 S, we shall be having one type of water content and in their presence the water content will be different. And in our lecture, we learned that the presence of the carbon dioxide and this H 2 S general decrease as this water content.

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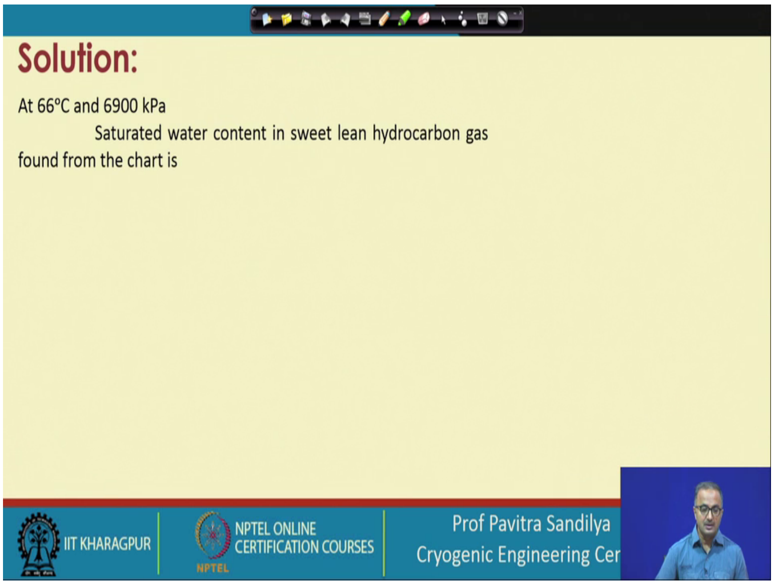

Now, let us look at this that here are the given situations. So, we shall be using the graphs which I showed in the lecture.

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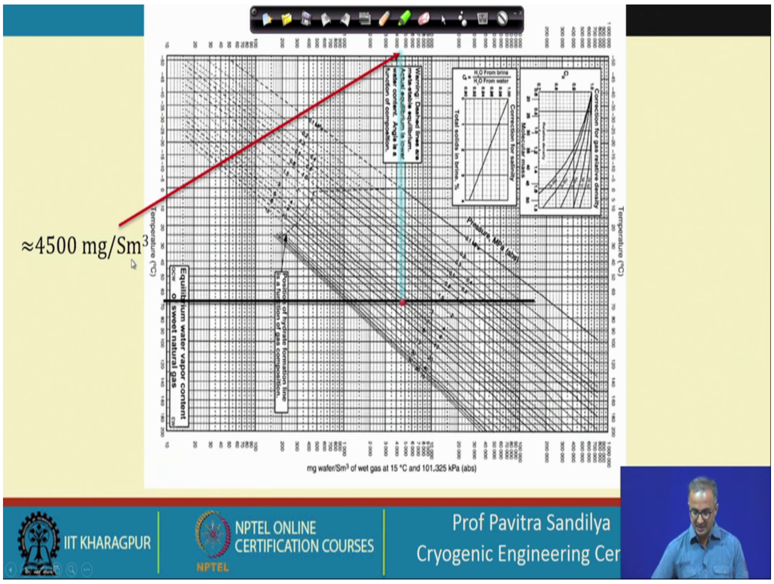

So, here we find that this graph we shall be using on this axis with the temperature; and on this axis we have the water content in terms of the milligram of water for standard cubic meter of the wet gas at 15 degree centigrade and about this 101 kilo Pascal that is about 1 atmosphere. Their various lines of constant pressure so and these are the corrections for the CO 2 and the brine. So, first what we shall do that we shall locate our temperature pressure. So, here we locate our temperature that is 66 degree centigrade and then we go to the pressure line. And we find that this is the particular point, where the given pressure and this temperature at coinciding. And at this point, now we can go to vertically up either on this axis or this axis.

So, find out the water content and this comes to about 4500, if you go to this we find is about between 4000 and 5000, this is about 4500 milligram per standard cubic meter of wet gas. So, this is how we find out the first part of the portion that (Refer Time: 03:18) clean gas non sour gas how we find out the water content.

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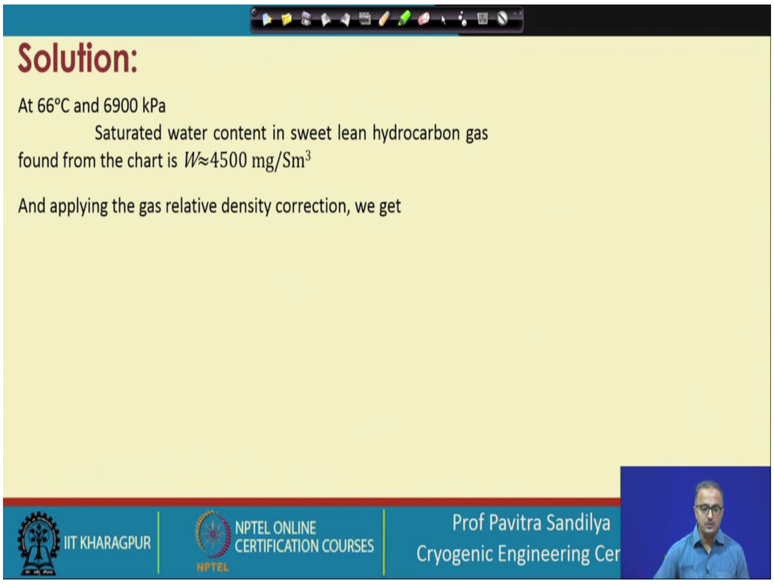

So, next we go for the correction for the relative density.

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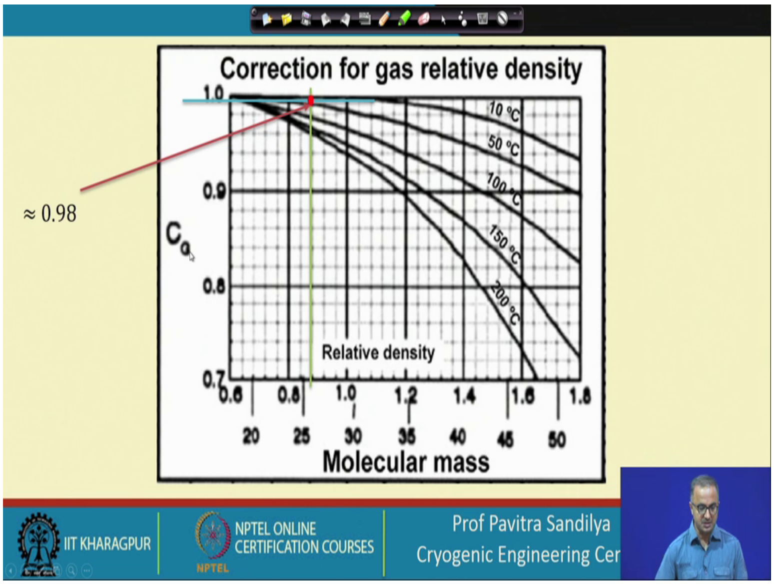

Here we have the graph. So, how we correct it? So, first is locate the relative density from this problem. And here we find the relative density was here and the temperature is 66. So, somewhere between the 10 degree and there is 50 degree line curves, we shall be locating the 69 this temperature and then we shall be reading out the value of this C Gs correction factor 0.98.

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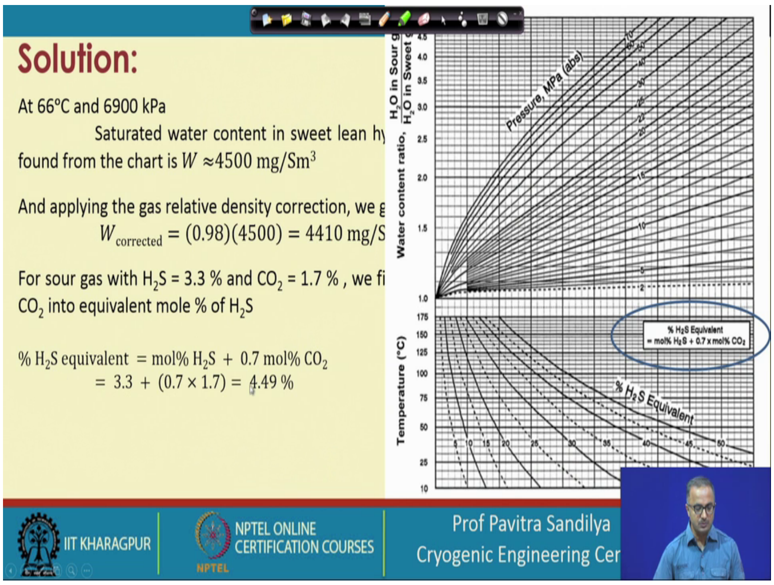

And then we shall be putting this correction factor with this one; and we shall be getting the value of this correction this water content. And we find the by this correction the water content has now decreased. Now, we go to the next part of the problem that is to find out the water content in the presence of the H 2 S and the CO 2.

Now, for this we shall be using these particular graphs. Now, in this graphs, you find that these graphs are given in terms of the pressure, temperature and the equivalent H 2 S content. Now, equivalent H 2 S content is given by this formula that is the mole percent of the H 2 S plus 0.7 into mole percent of carbon dioxide. So, first what we would do that we would be finding the equivalent H 2 S mole fraction and this comes to about 4.49 percent.

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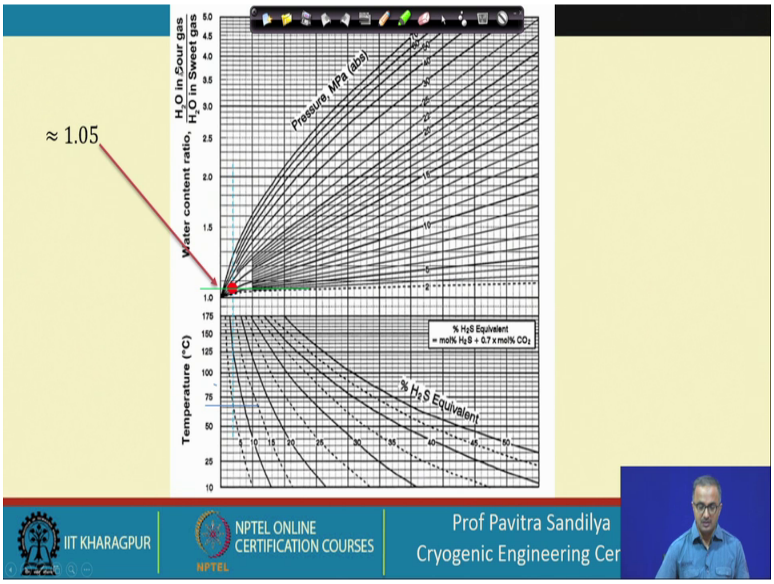

Now, to use these graphs what we do first you locate this 4.49 and we first locate the temperature here; and then we locate the 4.4 this is the various constant percent H 2 S equivalent, so 5, 10, 15 like this. So, what is 4.49 this is somewhere near this 5. And we have our temperature here. So, where ever their intersecting from this intersection point we move up to the given pressure; and from the given pressure we find that some where here we have the pressure located. And we go to the y axis to read out the water content ratio that is given by the water content in the sour gas to the water content in the sweet gas. So, we read out the ratio from this.

Now, please understand that for sake of understanding we have put very big dot here, but whenever you are solving such kind of problems you have to do it very fine pencil. So, that there is no smudging of the points. So, here somewhere here we shall be finding the what water content ratio this we read out this is about 1.05. So, what we have to do this, this particular ratio then multiplied by the water content in sweet gas we will give us the water content in the sour gas.

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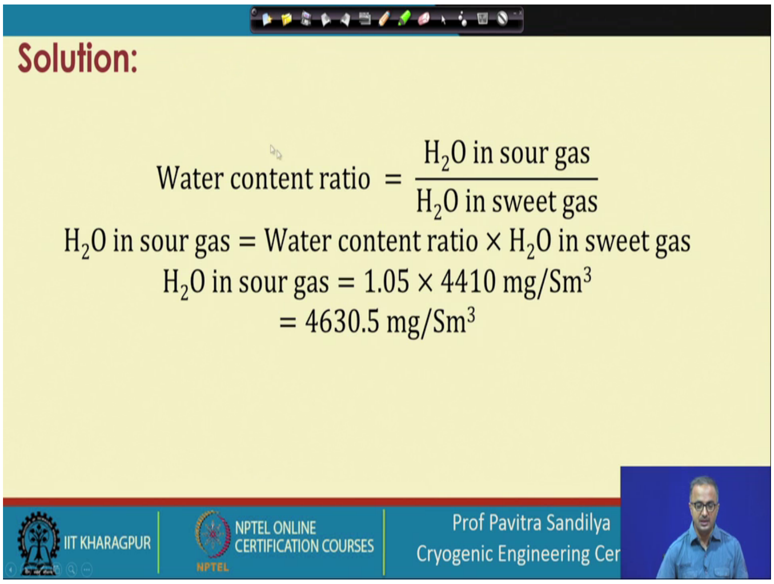

So, here it is the water content ratio is taken 1.05 and this is the one we have obtained for the sweet gas and this is how we find the water content in the sour gas. And as I told you that the sour gas contained sour gas water content is more than that for the sweet gas because of the presence of the H 2 S and the CO 2.

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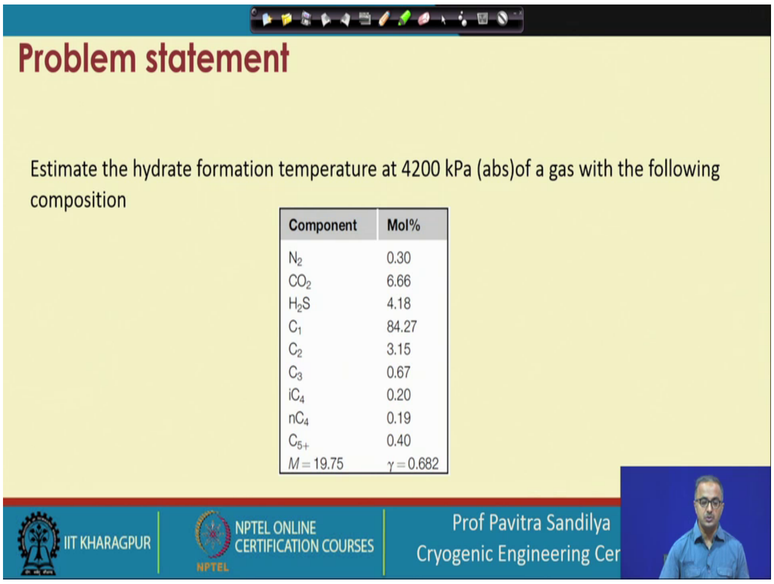

Next we come to another problem which concerns with the determination of the hydrate formation temperature for some given pressure and for this kind of a natural gas. In this case, we have been given the molecular weight here and the specific gravity of the natural gas with these are the mole fractions of the various components.

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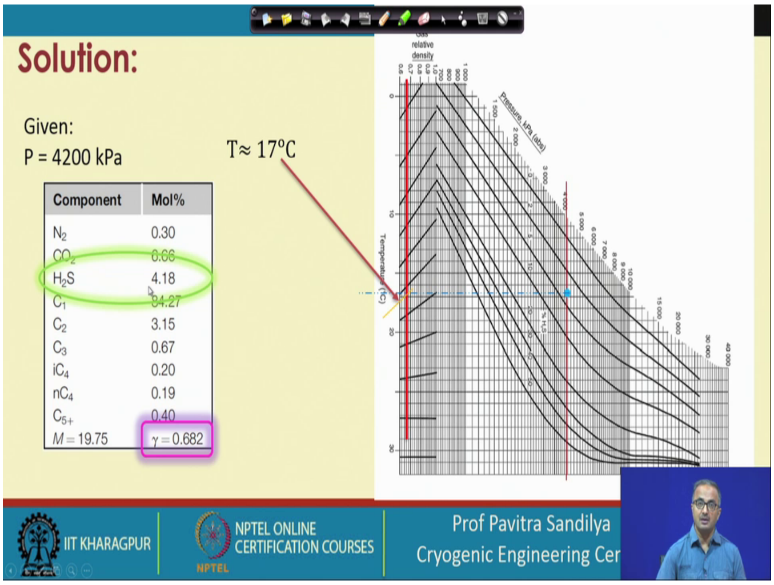

Now, what we do for this we have to use this particular chart here. In this chart, we find that we are given the temperature as these slant lines; and the relative densities are given can be taken from this vertical lines and these are the various pressures. Now, what we do that from the given value this data for first we locate the this line for the various types of this percentage H 2 S; and here this 4.18 is the H 2 S percent.

So, we locate somewhere we will have to locate this 4.118 and this is the pressure is 4200. So, this is 4000 and 5000, so this is the pressure line. And these whenever the pressure line is it is a dissecting exact same 4.18. So, what we need to do between 2 and 4 we have to interpolate to figure out where 4.18 lies; and this is the some point where this is 4.18.

So, from this intersection of this H 2 S curve and the pressure line what we do we go to the horizontally to find out the temperature here. And these temperature and also we have to also go for the specific gravity that is given has 0.682. So, we find the temperature and this particular section. And now we know that this slant lines are the temperature lines. So, we have to figure out some approximately though we find this lines are not exactly parallel. For sake of approximation, we make an a parallel line corresponding to this line which is nearest to it and then we extend it up to the temperature line.

Now, from this we can find out the value of the temperature about 17 degree centigrade. Please understand suppose this where line in the at this nearby this particular thing then we should draw the line parallel to this particular plot. So, but suppose it is in between these two, then you made taken average by taking a line parallel to this one and then you can take another than parallel to this one. And you will get two different temperatures. And you may take the average of the two temperatures to gauge the temperature for this particular hydrate formation.

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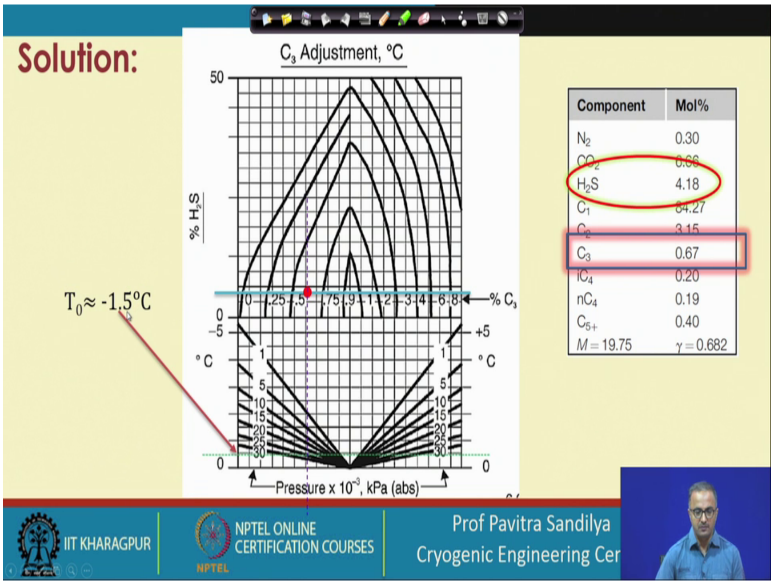

Now, to give the correction for the presence of the H 2 S, what we do for the presence of the C 3 component H 2 S, what we do. Now, first we locate this H 2 S that is 4.18 and then percentage C 3 that is a propane is given as 0.67 mole percent that is from here be somewhere between 0.5 and 0.75, we will some of somewhere by interpolation locate this 0.67. And wherever it is intersecting from that point we come down and here we have the various pressures given. So, from these pressures wherever this particular vertical line is intersecting the given pressure from that we read out the temperature correction on the y-axis. And this comes to about minus 1.5 degree centigrade.

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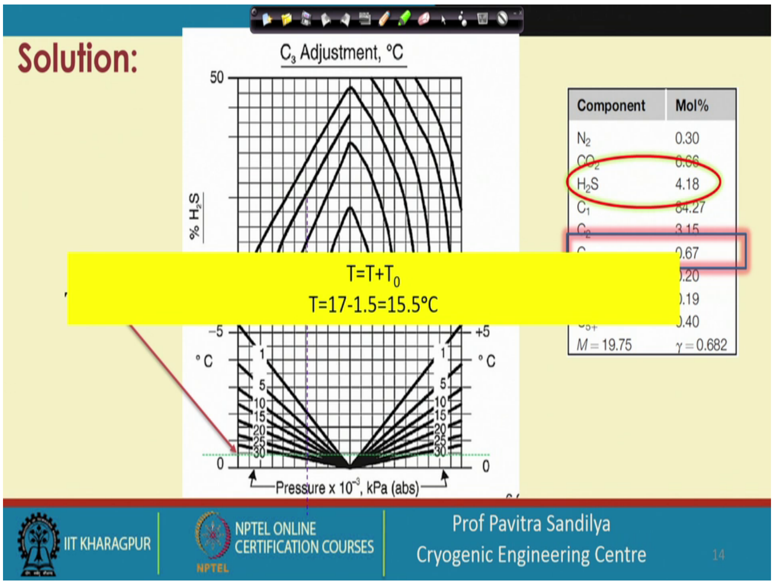

And now what we do from the 17 degrees formation temperature, we deduct this 1.5 and we find that the hydrate formation temperature in presence of the H 2 S and the propane content is coming to 15.5 degree centigrade, so that is how we are able to adjust for the presence of the C 3 component and the H 2 S for the hydrate formation temperature. Now, what we find the presence of this impurities decrease the formation temperature of the gas hydrate.

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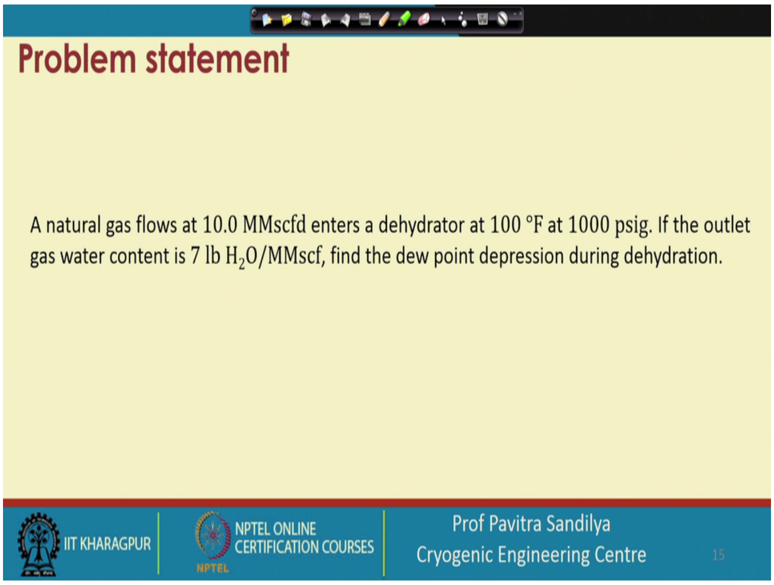

Next we shall take up another problem. In this problem, we are going to find out the dew point depression due to the change in the water content of the natural gas. So, the problem is like this that we have a natural gas which flows at this particular flow rate through a dehydrator at this 1000 psig pressure and at 100 degree Fahrenheit. And the outlet water content of the natural gas is given as the 7 pound of water per million standard cubic feet.

Now, here you have to see that the natural gas is getting dehydrated and we assume that this 100 degree Fahrenheit is the dew point at which the dehydration is taking place; and due to dehydration the amount of water reduces to this value. So, we need to find out that what would be the reduction or the decrease in the dew point, because as we know that with the change in the water content the dew point of the natural gas also changes; and as it as water content decreases so is the dew point.

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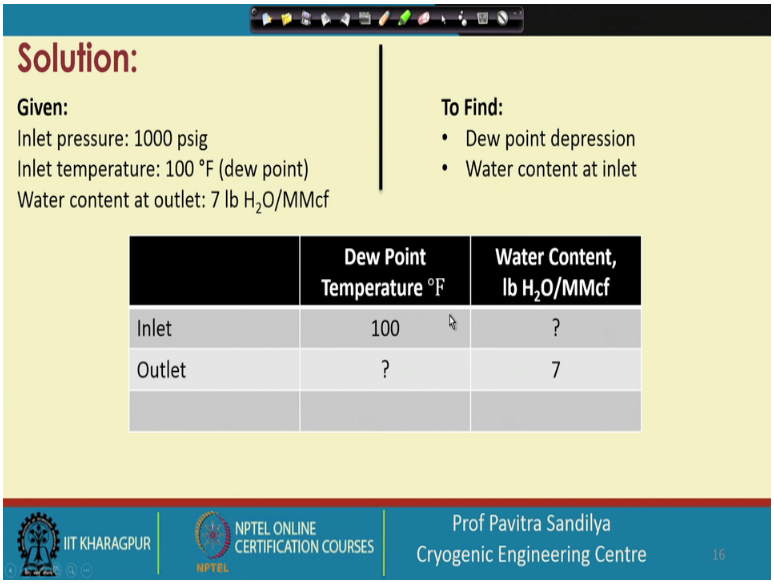

Now, here comes the solution that we are given all this data. And we have to find out the dew point depression; and along with that we can also find out the water content at the inlet. So, now we arrange all the given data and waters to be found out in this fashion.

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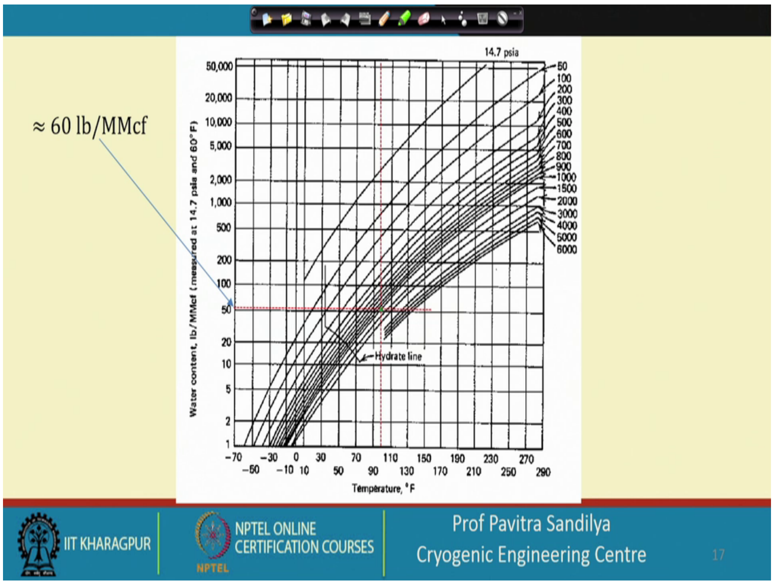

And we take a note of this particular plot which has been given for the water content. Here we find on the x-axis we have the temperatures in both in terms of the Fahrenheit and degree centigrade. And here on the y-axis we are given the water content in terms of the pounds per million cubic feet at 14.7 poi and psig and 60 degree Fahrenheit these are the standard conditions. And these are the various pressure lines. And here we find this is the hydrate line. So, this particular figure we also saw earlier.

Now, first we do what we do that according to our problem we first figure out put the 100 degree Fahrenheit from this x-axis and make a vertical to the given pressure of 1000 psig. And then what we do that here we locate at this 1000 psig line we locate this particular point and then from here we go to the horizontal line and go to the y-axis. And here we read out the value of the water content which is about 60 pound per million cubic feet of the natural gas so, that is how we find out the water content in the inlet natural gas.

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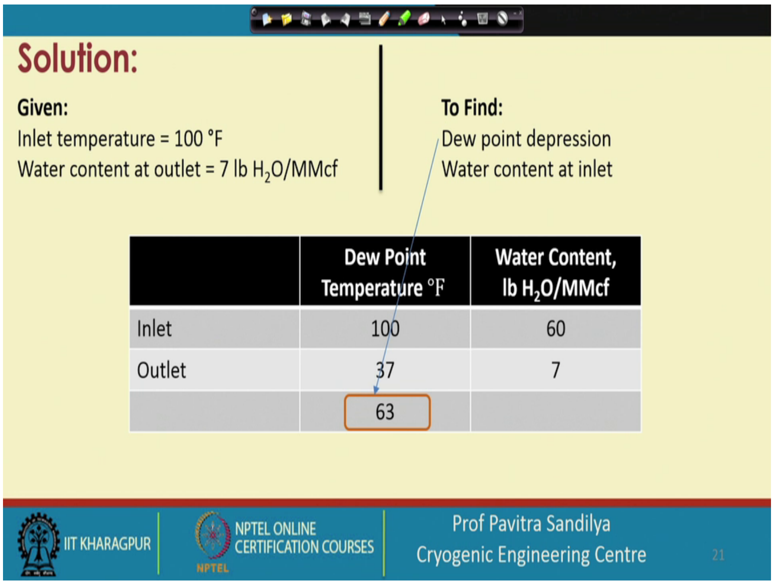

So, here we put the value as 60. Now, to go for the dew point temperature, now what we have to do, we will use the same graph now, with the water content as 7. So, again we go to this graph, and locate 7 on the y-axis and make an horizontal line which passes through the wherever it intersects the 100 psig design, there we drop the vertical line. And we find this is the temperature of the natural gas at the outlet.

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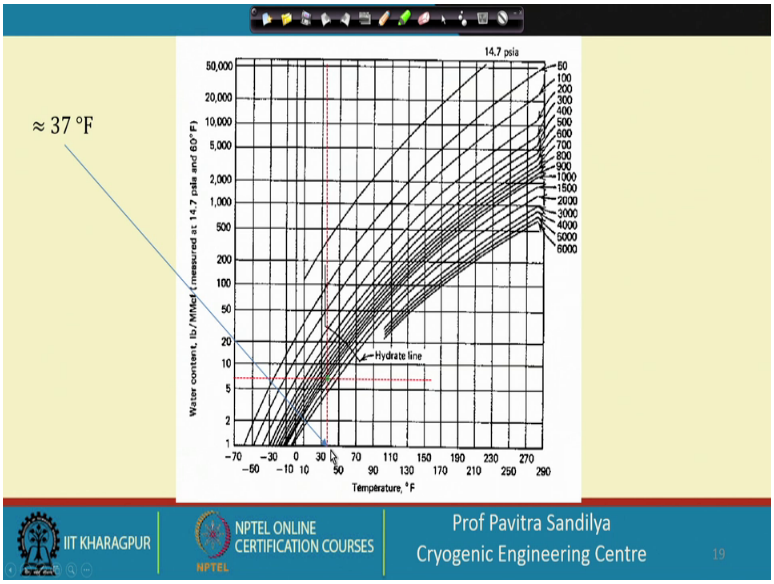

And now this particular temperature is about 37 degree Fahrenheit. So, here we write that 37 degree and this particular value 63 is the depression or the decrease in the dew point of natural gas due to a decrease in the water content.

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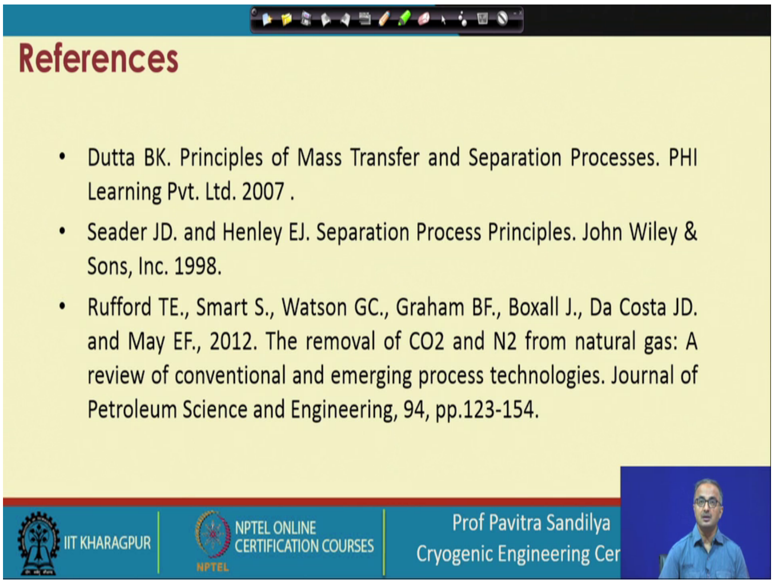

And these are the some of the references from which you can know more about the hydrates and this topic.

Thank you.