**Natural Gas Engineering**
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**Module No # 04**
**Lecture No # 13**
**Dehydration of Natural gas**

Hello everyone in today's lecture we will continue out discussion on natural gas processing so in today's topic we will cover dehydration of natural gas.

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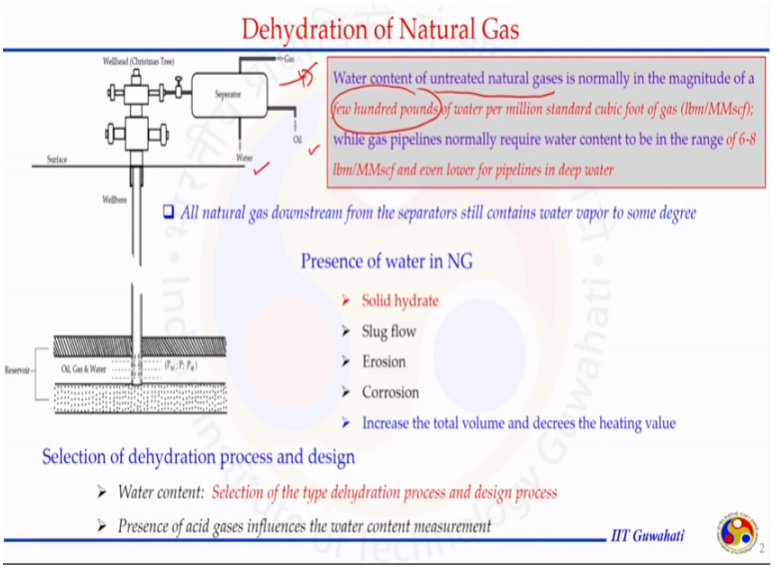


When we look our production system we see when the gas is reaching at the surface facilities it is meeting separator. The separator is going to separate the phases of the fluid that is getting produced based on the separator chosen two phase, three phase separator according to phases are being produced the water, gas and oil can be separated out. And after this when the gas which is supposed to be sent to transport by a pipe line the consumer to gas needs to meet certain specification of pipeline design.

And when we see that perspective the natural gas after the separator is supposed to be treated to remove the impurities present in the natural gas or some valuable will compound those are also present in the natural gas. And we had natural gas the water that is getting separated at the separator is just a free water depend on the composition of the natural gas like

hydrocarbon and non-hydrocarbon gases the solubility of water various that also depend on temperature and pressure condition.

So after the separator or the first unit that is phase by the natural gas produced from the natural reservoir is still carries significant amount of the water and that water needs to be removed the process of removing the water vapor from natural gas is called dehydration process the natural gas after the separate or the natural gas that is untreated carries few hundred pounds of water per million standard cubic feet of gas while the gas pipeline normally require water content to be in the range of 6 to 8 per lbm per MMscf.

That is where the water removal is required because the presence of water in natural gas gets several problem like the solid hydrate. If the water is present and by any mean the temperature and pressure of the natural gas at any point is falling in the range of hydrate formation the water that is present in the natural gas will form gas hydrate and it will plug the pipeline it will create several problem.

Not only hydrate formation the water which is soluble in the gas at a different temperature and pressure condition the solubility will get change. And it will come out from gas the phase to liquid phase when it is happening we are having two phase system water + gas and the slug flow will be present in the pipeline or in any flow system and that will create a problem.

When natural gas is having the acid gases and water is also present it creates a problem or the water creates a problem of erosion and corrosion. Not only the problem associate with the presence of the water in terms of erosion corrosion and phase changes the water that is present in the natural gas  if it is getting transported from one place to other place the more volume of the natural gas is getting transported which is having no additional energy content.

Water is not having any energy when we are transporting natural gas with the water means unnecessary we are transporting more amount of the volume. So even after the separator when we are having the natural gas that contains significant amount of the water and appropriate dehydration process should be chosen and designed to remove that water vapor

that is present in the natural gas and the selection of dehydration process and the design criteria depends on primarily two parts.

First is what is the amount of water the natural gas is carrying selection of the types of dehydration process and designing process will depend on that factor. Second is the presence of acid gases effluence the water content treatment. So if you are having a process that is chosen based on just water content but if acid gases are also present along with the water they will also influence not only the amount of the water content is measured they will also influence the process design and the overall process.

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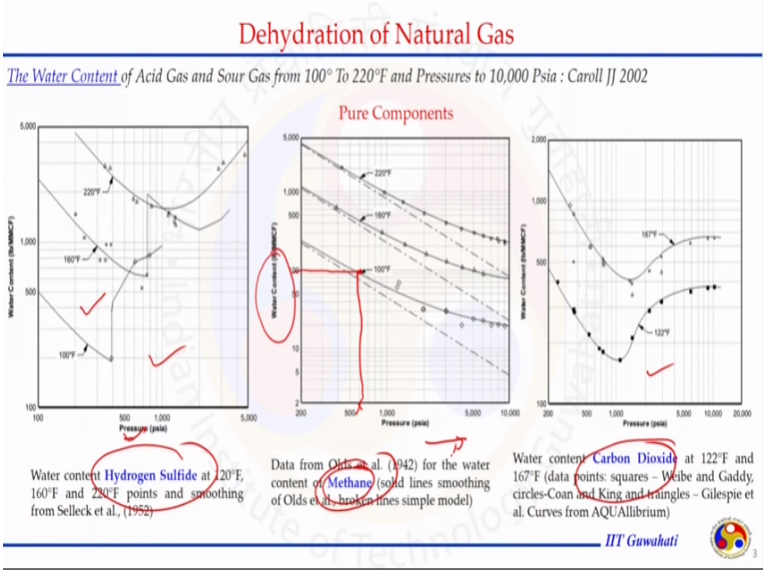


When we say natural gas is having hydro carbon and non-hydro carbon gases depend on the temperature and pressure condition the amount of water that is present in the natural gas depends on the composition of the natural gas also. So this slides shows here when we are having different gases like hydrogen sulfide methane and carbon dioxide in pure state.

The amount of the water they can content at a particular temperate and pressure we see the amount depends on the pressure as well as temperature. For example in hydro carbon gases like methane that is the major constituent of natural gas the amount of the water content at a particular temperature and pressure can be determined with the help of this chart that says at a particular pressure for example here and a temperature let us say 100 degree F this is the amount of the water content the natural gas or the methane can carry.

This chart also shows when we are changing the temperature and pressure the water content in the methane as well in the other non-hydro carbon gases also changes that says if we can change the operating temperature and pressure condition we can see how much water content can be accommodated by the natural gas or by it is constituent we had seen here for the pure component when it is a mixture behavior will be different.

But the trend will be same like overall when we are increasing the pressure the water content is decreasing and when we are reducing the temperature the water content is decreasing again.

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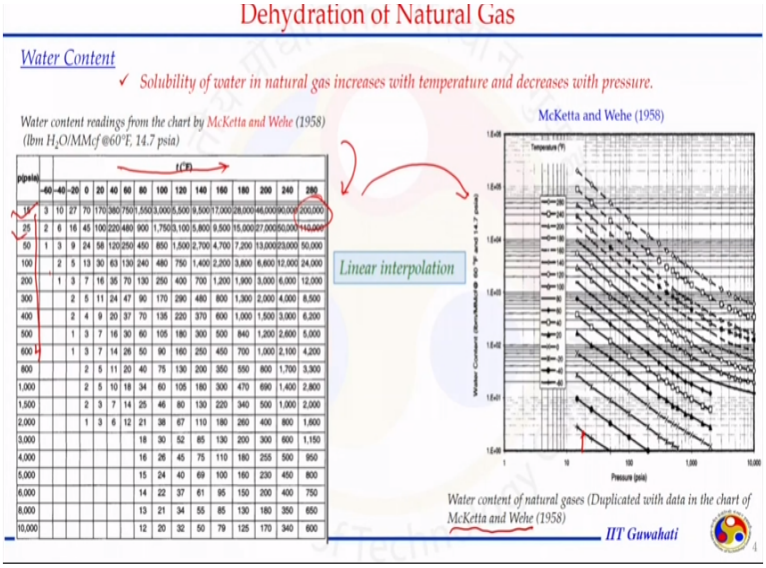


So the water content that is the solubility of water in natural gas increases with temperature and decreases with pressure that we had seen for the pure component here we can see for a mixture that is consider as a representation of the natural gas and from this Mcketta and Wehe method that is represented in a graph form that can also be represented in the table format that says at a particular pressure and a particular temperature what is the solubility of water or other way what maximum amount of the water can be present in the natural gas and that we can see from this table as we are increasing the pressure the amount of the water content is decreasing.

Similarly when we are increasing the temperature the amount of the water content is increasing the similar data has been shown in this graph also this is also from the Mcketta and Wehe.

When we are having condition at the intermediate location for example here it is showing for 15 25 Psia and if you want a 20 psi we can always do the interpolation to get the data at a position which is not given in the table.

Similar in the graph also we can read it that is more convenient way to get the data at a particular pressure and temperature both for a single component as well as a mixture means natural gas is showing with increase in temperature and decrease the pressure the solubility of water in natural gas increases.

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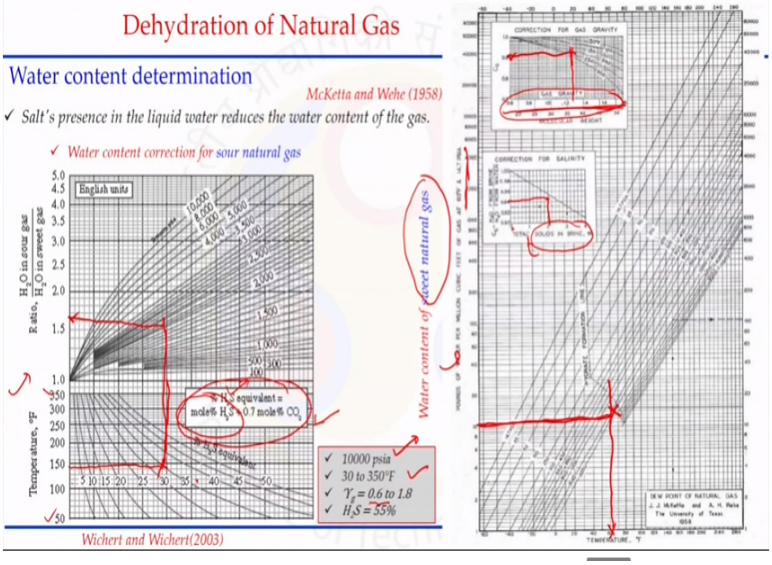


When it comes to determine how much water content is there either we can read certain publication chart data available in the literature where we can use the establish mathematical processor to calculate it here I am showing again from Meketta and Wehe graph that is for the sweet gas means which is not having any sore component in it like the H2S and SO2 primarily in the water content determination the salt presence in the liquid water also influence the water content calculation primarily the water content in a natural gas decreases when the salt is concentration is increasing.

So the salt present in the liquid water reduces the water content of the gas so from this slide we can see when we are having a natural gas let us consider the natural gas as a sweet gas and at a particular temperature and pressure data we can see the water content in the natural gas and we can see at what temperature and pressure the natural gas is we can read this chart and

can say for example we are having a gas at natural gas at 60F and certain pressure let us say that pressure is around 2000Psi this is at 2000 Psi line here this point we can read the amount of the water content by the natural gas at that condition.

The correction should be made primarily for the specific gravity because this data is considered specific gravity because this data is considered specific gravity as 0.6 and the specific gravity is different then we can use this inside chart that says at a particular specific gravity we can go vertically to a temperature condition at which the gas A is and going on the Y axis we can calculate the correction factor that should be included for the specific gravity means when the gas is not having specific gravity 0.6 we have to make the correction factor for that.

This is not only the composition of the natural gas that is in the form of a specific gravity what the salt concentration will also influence and for that we can see another inside chart that says solid in the brain solution if we can know we can go vertical and choose the point where it is striking this incline line and we can see the ratio of H2O from brain by H2O from water the correction factor that represent the H2O in the brain solution when the salt is present or the H2O in just pure mineral water or means the water which is not having significant salt concentration in it.

So while doing this we could calculate the water content of the sweet gas now if our gas is sore gas we have to make the correction factor again or we have to adopt the process at that can give us the water content when the sore gases are present in the natural gas for that purpose what we can do we can use this another chart that is given by (()) (13:16) in 2003 and using this chart we can see what is the percent of that acid gases or in the terms of H2S equivalent that accounts for both H2S and CO2 using this expression and once we know that percent we can see that percent and at what temperature our gas is.

So for example that percent is just 35 when and our gas is 150 degree Fahrenheit we can see we are here from here we can go vertically up and see the line of pressure let us say 2000 Psi and from here we can see on the Y axis we can calculate the ratio that say H2O in sore gas divided by H2O in sweet gas so from this chart in the right hand side we can get the H2O in

sweet gas condition and using the left and chart we can convert this to estimate the H2O in the sore gas.

All these is good or valid in the following conditions are met for example the pressure should be up to 10000 Psia the temperature should be 30 to 350 degree you can see from this chart where it is shown and gamma Z should be 0.6 to 1.8 the chart is given only for that range and H2S up to 55 % this is equivalent H2S in the natural gas. If that is matching we can use this chart to get the water content of the natural gas.

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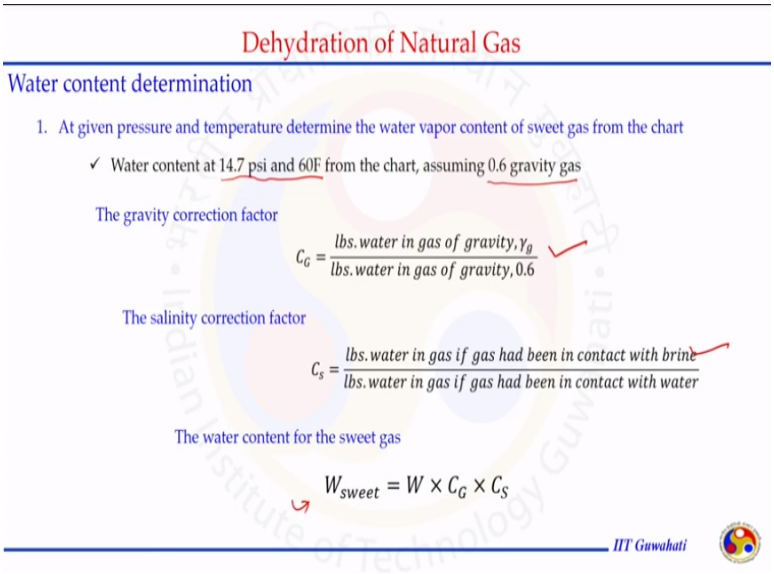


The same processor we can write in the mathematical way for example the water content at 14.7 psi and 60F from the chart assuming 0.6 gravity as we seen in the last slide from the left hand side chart or from the Mekette and Wehe chart we can apply the correction factor for these specific gravity, for the salinity and once we know both the correction factor we can calculate the water content assuming the gases just as sweet gas not having sore gases in it.

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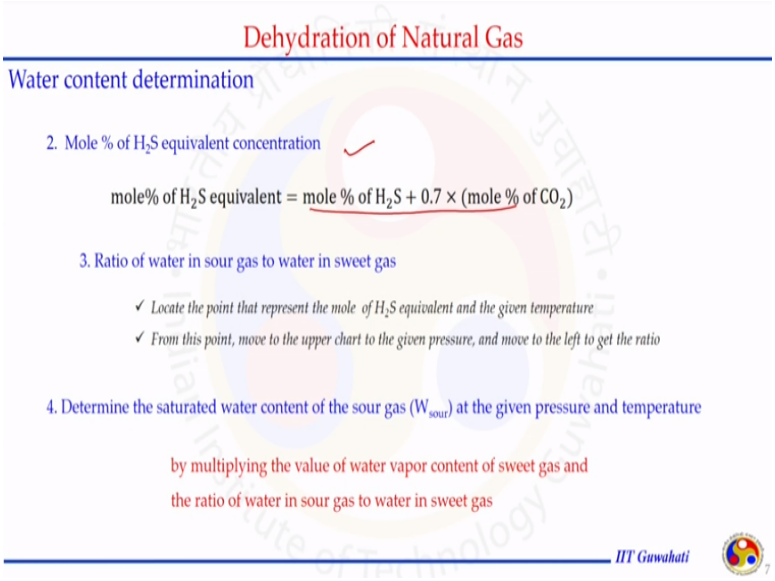


And for correction the sweet gas sour gas we can calculate the H2S equivalent in this formula going this into right hand chart we can calculate the point that represent the percent of S2S equivalent and the temperature going vertical on the upward chart we can calculate the ratio that shows the sour gas to sweet gas ratio and already we know water content in the sweet gas we can calculate the water content in the sour gas.

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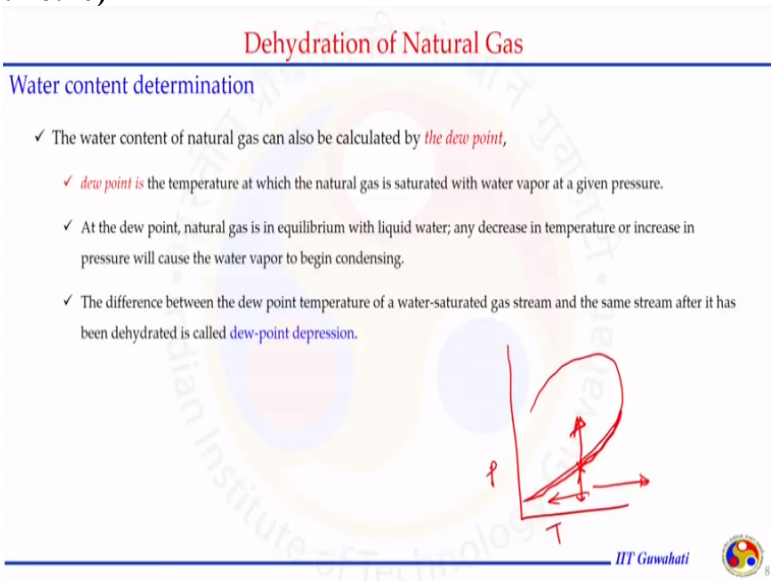


With this processor we are able to determine the water content in the sour gas there is another process to calculate the water content and that can be done by calculating the dew point. Dew point is the temperature at which the natural gas is saturated with water vapor at a

given pressure we understand from our phase diagram behavior if gas is a mixture it will give us the phase when we are talking about PT diagram.

And from this PT diagram we understand this is a dew point curve and when we are changing the pressure we are increasing the pressure this will go to liquid phase more than the gas phase and when we here we are having mostly the natural gas in the gaseous phase. Similarly if we are going at a high temperature we will go more towards the gas side and when we are reducing the temperature we will go or may enter again in the phase envelope and get the liquid.

So the same thing is applied when we are having the dew point calculation at a particular pressure if we are able to change the condition and find out difference between the dew point temperature of water saturated gas stream before the dehydration or after the dehydration we can calculate how much amount of the water content can be removed and the difference between the dew point temperature of a water saturated gas stream and the same stream after it has been dehydrated is called dew point depression. So the dew point depression can tell us how much water can be removed from the system.

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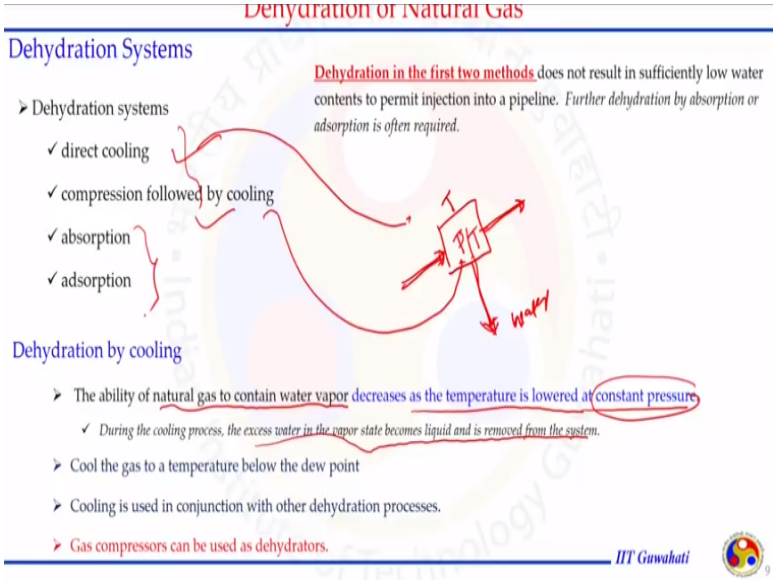


So there are ways there are processors that allow us to perform the dehydration of natural gas. So the dehydration system can be classified broadly in four major processors that is direct

cooling when we are having the natural gas if we cool it because of the difference of dew point condition the water component will get condense from the gas and we can separate it compression followed by cooling.

So for example when we are pressurizing the natural gas again we will go into the two phase natural gas system where the water molecules will come out from the gas phase under high pressure condition and by further cooling it we can get the water separated from the natural gas. But both direct cooling and compression followed by cooling like in this situation when we are having the inlet gas and outlet gas when we are changing either the temperature in the direct cooling or temperature pressure followed by temperature change in the compression followed by cooling processor the water content here will be different the water content here.

And we will be able to get the water separated out from the natural gas in most of the cases it depends on the availability of until water vapor decrease as the temperature is lowered at a constant pressure that happens in the direct cooling processor. So in direct cooling processor we decrease the temperature at a constant pressure during the cooling processor the access water in the vapor state becomes liquid and it removed from the system that we can remove from here.

Cool the gas to temperature below the dew point will give us the more separation cooling is used in conjunction with other dehydration process like the compression process where compressing the natural gas will allow us to remove more water compared to just cooling process similar by performing the absorption and adsorption process allow with the cooling will provide us the better removal of water content on the natural gas.

So in that way we can consider the gas compressor as a dehydrator because during the compression stage we are going to increase the pressure and because of that the water will come out from the gas phase. In general it happens the dehydration process of direct cooling and compression followed by cooling are not enough to remove the desired quantity of the water from the natural gas and along with these two process it is often absorption and adsorption process are associated or are performed.

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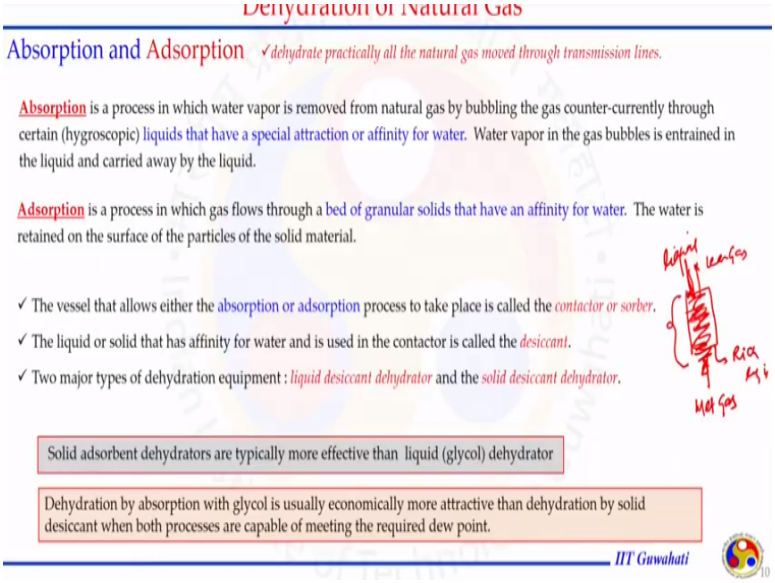


So what is absorption and adsorption process so they are the process to dehydrate natural gas up to certain level when it is matching the specification of pipeline transportation. And dehydration by absorption and adsorption practically remove the most of the water content present in the natural gas before it is going to pipeline or the transmission line. So the absorption is a process in which water vapor is removed from natural gas by bubbling the gas counter current through certain choice of the liquid those are having special affinity towards water and those liquid are able to separate the water component selectively from the natural gas.

Water vapor in the gas bubble entered in the liquid and carried away with the liquid out of the column where they are getting contacted. So in absorption process we sketch here we are saying counter current flow is happening so we are having natural gas or the wet gas, wet gas means the gas which is having the water is going to a absorption tower and from the top.

We are having the liquid or a selected liquid that is flowing downward gas is flowing upward they are getting contacted here in the absorber tower where there could be either the trace kind of arrangement or packed bed kind of arrangement and because of the contact here the gas becoming the lean gas means the water has been separated out and the liquid is becoming rich liquid means it is having now water with it.

In the adsorption process we are having the similar kind of the arrangement but the major difference between the absorption adsorption process is in absorption we are having the liquid that is having selectivity towards the water and able to separate the water from the gas while in the adsorption we are having the packing of the solid granular material or a bed of granular solid that is having affinity for water and water is separated out from the natural gas with the help of that solid packing.

So if we say the nomenclature for this absorption and adsorption process the vessels that allow either the absorption or adsorption process to take place is called the contactor or absorber. So this vessels or the tower is a contractor or absorber if we are talking about specific terminology in case of adsorption it is a absorber tower or in case of adsorption it is a adsorption tower. But in general terminology it is called as absorber or contractor.

The liquid or solid that has affinity for water and is use in the contractor is called the desiccant so when we are having the adsorption process the desiccant is liquid and when we are having the adsorption process the solid packing is a desiccant. The two major types of the dehydration process equipment based on the phases we are using like the liquid and gas we can say liquid desiccant dehydrator also we can call it as a adsorption process or solid desiccant dehydrator it means a it is a adsorption process.

When we compare both the solid adsorption dehydrator there are typically more attractive than liquid specially the liquid is chosen is glycol dehydrator and this is happen because the solid adsorbent are having more surface area because of the porous nature because of the forces or the capillary forces they applied on the fluid or the gas that is passing through it the solid absorber are more efficient and more effective.

While on the other hand when the dehydration by absorption using the glycol is considered it is more economical then the solid packing or the adsorption process when we are comparing the dew point means the amount of the water should be removed is same. If you want to reach the water content of the dry gas means after the dehydration process if we compare the dry gas in terms of water content and if it is same the absorption process is in glycol liquid is considered more economical.

We will see a major difference between the absorption and adsorption process in the subsequent slides.

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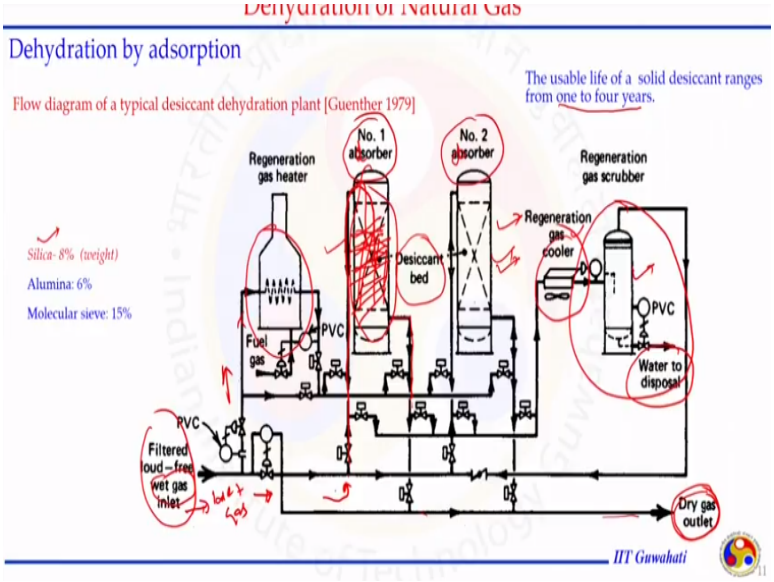


So this is the adsorption process the flow diagram shows all the equipment or the flow of gas through the symmetric diagram and in this symmetric diagram we can see there are centrally two towers there could be more than two towers we can say this is number 1 absorber or number 2 absorber that should be a actually absorber because we are having the solid packing here the process is called absorber.

And we can say it is a absorber or contactor there could be multiple because in the case of absorption process when we are performing the adsorption process to remove the water from the natural gas over the time it is required to regenerate the solid packing. And when we are having just only one tower it will be a situation when we have to shut down the operation either clean the impurities those got stick to the solid packing or just replace the solid packing in both the cases we have to shut down the process that is why always there are multiple towers and one and two are in operation other or in the standby mode and or in the regeneration mode.

When we want to switch to other tower the previous tower that is got contaminated or that is where the solid packing is not more effective as the time passes so we have to use another

tower in the operation. If we look more closely here we can see the center part is here where the natural is travelling from here.

And before natural gas goes to dehydration operation it should pass through a filter or a separator depend on the composition natural gas is having if it is containing some solid particular if it is having some liquid compound those should be separated out before they are going adsorption process or the adsorption tower because those liquid will block the pose present in the solid packing and reduce the efficiency of the process.

So the gas is passing through filter process and you say this symmetric diagram include several other equipment other than the adsorption tower those are required we will see one by one so when the gas is passing through filter this is called the wet gas. So we are having the wet gas here, wet gas means it is having the water with it and the wet gas can either to this side or this side assuming the wet gas is going to the tower first and we are operating only one tower and when it is going from the top it will pass through this packing of this solid.

So in the tower gases pass from the top not from the bottom the reason passing from the top is we are not going to disturb the packing of the solids in the tower because of the high velocity of the gas that is why it is pass from the top and when it is pass from the top it will pass it will travel through this solid packing and that is solid packing could be because of the granular silica gel box side alumina or activated alumina or molecular is type of the material.

The silica is having preference over the others because of it can tolerate the significant percent of acid gases present in the natural gas before it is going to be in a falling situation and when it happens what will be the situation we are going to get the gas from the bottom part and when this gas is coming out from the bottom it may go till end and going to be a dry gas outlet and this will depend on what is the efficiency of this absorption process.

If it is able to remove most of the water present in the natural gas it is just a dry gas and it go to outlet. Here it is shown as desiccant bed where we are having the stand by desiccating tower or adsorption tower and in that case when this is in operation this is going to regeneration

process. In regeneration process what happens whatever the water molecules or the contamination in the natural gas those odor on the surface of the solid.

The solid should get free generated so the tower can be used for the next cycle and in that case we have to make the arrangement in such a manner a part of the gas is going through some heating process and the heated natural gas is passing through the second tower or the regeneration tower from bottom to top and we are able to remove all the impurities or able to regenerate the bed for the uses.

And when it is happening natural gas got heated and before it can sent to a separation process it has to go through a cooler if the natural gas is having more temperature or natural gas is at a higher temperature the amount of water content will be high which the separation will be difficult that is why the natural gas should be cooled down before it is going through the process of dehydration and that can be done using the cooler.

We are having one regeneration gas scrubber also when we are removing the contamination from the natural gas we have to have a separator from where we are able to get the water that is getting separated in the regeneration part should be able to collect at the end and this will be the water to dispose, if liquid content is also there in the natural gas that is also getting separated during this process we have to our this three phase gas scrubber that can provide the additional option for the liquid separation.

Otherwise if we look in this seed we are having we are having two towers multiple towers could be there with the desiccant bed packing the efficiency depend on the packing it is having there is a heater and cooler combination to heat the natural gas so the regeneration process can be effectively performed and then further cooling the natural gas so it go to dehydration process and at the end we are having a gas scrubber which is able to separate the water out from the regeneration gases.

In this process if we see the efficiency will depend on the amount of the natural gas that is getting dehydrated and the type of the packing it is having the usual life of the packing is around 1 to 4 years it depends on the contamination as well as the water content present in the natural gas that is going to the dehydration process.

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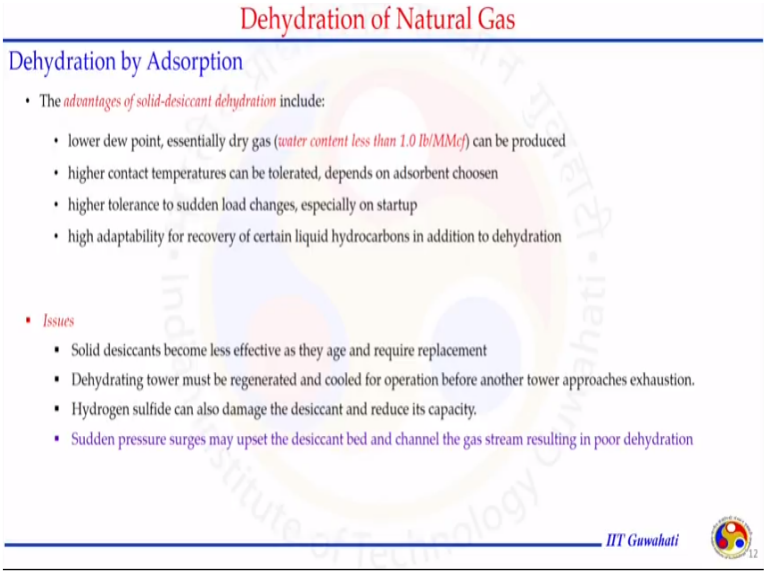


And if we see the advantage of adsorption process we can say lower dew point can be achieved and that means we can get the dry gas which is having very minimum amount of the water content and that could be up to less than 1.0 lb per MMscf. That is the advantage of using the solid desiccant again the affinity the impurities and the circulation rate will affect the process.

Higher contact temperature can be tolerated as we said we are supposed to cool the natural gas before it is going to the dehydration unit means the adjacent tower even the temperature of the natural gas is not that high because of the solid packing those are designed tolerate the higher temperature the higher temperature process can be tolerated but depend on again the adsorbent chosen.

Absorbent means the solid packing higher tolerance to sudden load change especially on startup so as we see the packing of the solid can disturb if we are having the high gas flow rate from the bottom we do not do that think similar if there is any sudden low change is happening the solid packing may disturb we may get the channel formation and in case of the solid desiccant we are having more tolerance for such kind of the chances and that helps us when we are starting up the process or during the startup of the plant .

High adoptability for recovery of certain liquid carbon in addition to dehydration process so this packing for example this silica granular silica gel packing that is having the acceptability or adoptability for the other contamination those could be higher hydrocarbon present or some solid particles in the natural gas those could also be separated out in the dehydration process.

Certain issues are there as with any other process so the issues with the adsorption dehydration process or solid desiccant becomes less effective as they age means over the time when they are getting use because of the contamination present in the natural gas because of the water is getting accumulated we are they are going through the regeneration process at a higher temperature the efficiency of those a solid desiccant it becomes less and after certain time user life 1o to 4 year the replacement is required it is a part of the process.

Dehydration tower must be regenerated as mentioned there should be standard adsorption tower which is under the regeneration mode or it is already regenerated it can used when the first hour is put under the shutdown mode and that is should be regenerated and cool for operation before another tower approaches exhaustion means when we need the second tower it must be ready otherwise the operation needs to be shut down.

Hydrogen sulfide can also damage the desiccant and reduce it capacity and that is the advantage of using this silica over the other desiccant because it has more tolerance from the H2S. Sudden pressure such may upset the desiccant bed and channel the gas stream resulting in poor dehydration process those should be taken care when we are going to design or going to use adsorption process for moving the moisture from the natural gas.

Specifically the pour size distribution in the desiccant they should not get block permanently or the regeneration step should be operated in such a manner when the effective surface area of the silica particles or any other solid desiccant can be recovered to its original state so the efficiency of the dehydration process can be maintained.

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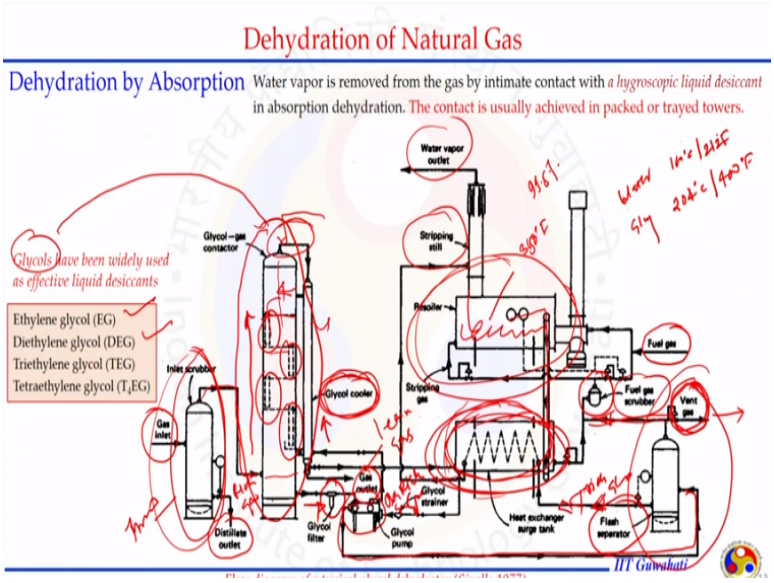


When we talk about another process that is badly used is the absorption process so the water vapor is removed from the gas by intimate contact with a hydroscopic liquid desiccant in absorption dehydration tower the contact is easily achieved in packed or tray column. So the absorption process we are having the solid packing here in this type of the process where we want the gas and liquid or getting contacted in the tower we should have a some arrangement where the contact time can be increased that can be done by creating a packing with the inert material or arranging the trace in the column.

That we can see here so this is the glycol gas conductor mostly there could be several solvent view for such purpose but the glycol has ben widely used as effective liquid desiccant and the four types of the glycols like the ethylene glycol easy di-ethylene glycol DEG tri-ethylene glycol and tetra-ethylene glycol or the combination of them can be used to perform the absorption dehydration process.

So this sheet is shown for the glycols that could be either of them or the combination of them or the glycol gas contacted tower shown here that says we are having the packing inside of it this shows for the tray type of the arrangement when we are having the trace and allowing the fluid to travel from a certain section of this trade tower and from bottom to top there is a significant room or the volume available to get efficient contact between the gas and liquid.

And the liquid which is chosen is again having some hydroscopic means specific affinity to water and it will be able to absorb the water from the natural gas and when it is happening again the similar kind of the terminology we can follow so the gas that is wet gas means it is rich in water is being sent to this absorption process before it goes to absorption tower again if it is carrying some impurities like the liquid hydrocarbon solid particles and others those should be separated out with the help of some inlet scrubber it is like a separator.

So the gas or the wet gas inlet is here we are going to get the distillate outlet in this separator and if we are having oil and water free water I mean to say then we have use a three phase separator here and after that when this is happening the gas from this scrubber or separator is going to flow from bottom to top in this absorption tower and this liquid desiccant is flowing from top to bottom and that is where the counter current flow is happening in this tower and gas and liquid are the contact because of the packing and because of the tray arrangement the contact time can be adjusted to have the more efficiency of the process.

So the glycol that is coming to the system we can say coming through this line glycol cooler we can see the glycol that is getting regenerated or means getting purified before it is sent to the tower and where we are having this contact and the bottom part we can say we are going to get the lean gas here it was the rich gas that was sent to the absorber and what about the glycol or the solvent desiccant so this solvent desiccant that was sent here is lean and from the bottom we are going to get the solvent which is rich glycol means rich glycol means it is having more water.

And when this rich glycol is coming may not having only the water but some impurities those are transferred from gas to glycol and that is where first thing should go through some filter arrangements. So this is the place from where the glycol is or rich glycol is getting out of the tower it should go through from filter unit where any impurities those enter into the glycol should separate out because it is going again to a pump and any impurities may damage the pump.

And after the pump it is sent to a flush separator and this flush separator is able to separate out the gases those may have transferred from the natural gas to glycol and the remaining glycol

will go to further unit and this bend gas that may be methane or some other hydrocarbon gases may be used for energy requirement or may be just went out and discharge so the glycol that is here which is carrying the water it is a rich glycol and this rich glycol is going to a heat exchanger and after that it will go to a re boiler section.

And in this re boiler section the glycol will get separated out from the water and the re boiler operation is easy in case of the glycol solvent because of the boiling point difference water is having boiling point is around 100 degree Celsius we can say it is 212 Fahrenheit and glycol is having around 204 degree Celsius means 400 degree Fahrenheit. So because of significant different in the boiling point we can easily separate or boil of the water from the glycerol.

And in that case early boiler is required in the energy for the re boiler can be provided either from the external fuel gas or the gas that is produced in the flesh separator. So a part of that can also be used to energy required for the boiler before it is going to burn in the boiler it has to pass through the scrubber to take out any impurities in the gas and when this separation is happening we can say this is stripping is still a long tower because of the self-reflex.

The water will go out because of the low boiling point just 100 degree Celsius and the glycol will fall down here and get accumulated in this freezer and from where because of the arrangement it will go to heat exchanger place get heated it will transfer the heat to the glycol that is passing here one is flowing here in the shell another is in the tube and the arrangement can be done on the heat transfer calculation which one should go to shell side which one should go to tube side and we are not discussing the heat exchanger in detail.

But the arrangement is done in such a manner so the glycol that is here reduce the temperature little bit but transferring the heat to this glycol the rich glycol that is going to this flush separator. So the lean glycol and rich glycol are exchanging the energy and further here it is coming to this section where the glycol cooler which is having the natural gas or the dry gas is passing through it in the shell side or in the tube side we are having the glycol that is hard that is further getting cool down and when it is happening then it is going to tower at a desired temperature it needs.

And in this process over all we can say we are having the inlet scrubber here we are having one scrubber at the end also we are able to separate the rich glycol and the gas if any present and in between we are having one absorption tower are re- boiler where we are concentrate ethylene glycol by removing the water vapor and we can re circulate the glycol here so the efficiency of this process compared to adsorption process where we are having the solid.

First thing is it does not need to shut down the process or additional tower the regeneration is done in terms of re-concentrating the glycol. If any losses of the glycol may happen because we are exposing the glycol to high temperature makeup of the glycol is easy compared to solid dehydration process where we have to change the packing of certain time. And in this process the re-boiler is operated around 350 degree Fahrenheit and we are able to re-concentrate glycol up to 99.5 % or better.

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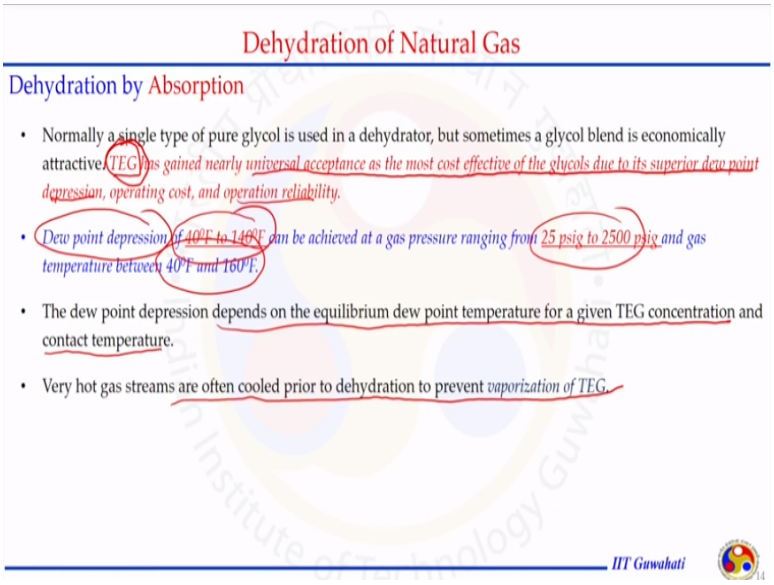


The losses can be managed by making up the glycol to this process we can use either a single type of the pure glycol or we can go with a combination but from the studies conducted TEG as gained nearly universal acceptance as the most cost effective of glycol due to its superior dew point depression, operating cost, and operation reliability. The dew point depression can be achieved up to 40 degree F to 140 degree F significant water removal can be performed with the help of TEG and in the pressure range of 25 psig to 2500 psig and gas temperature 100 to 160 degree Fahrenheit.

So this can be operated we cannot expose to a high temperature because in that case the degradation of glycol may happens when the glycol is getting degraded certain chemicals may get formed and those will contaminate the entire operation. So we should not exceed or we should not expose to a very high temperature condition but within this operation condition we can achieve significant dew point depression.

The dew point depression depends on the equilibrium dew point temperature for given TEG concentration and contact temperature. So at what temperature the natural is getting in contact depends on the TEG concentration and that temperature the water removal can be achieve and the water removal will also be represented in the form of dew point depression.

So if we understand at what temperature and pressure the gas is at one point and at what condition or the other point if we can calculate the dew point at this condition and the new condition we can calculate the amount of water is removed from the natural gas very hot gas stream are often cool prior to dehydration prevent vaporing TEG in that case we will lose the solvent or the liquid desiccant that I should say at tri glyceride in our in this case and if the vaporization of the glycol is happening we have as add as a makeup from the outside and that will include addition cost to the process.

So if we compare as mentioned previously if we compare the adsorption process with the absorption process we can see the adsorption process can be more effective because the solid packing does we can go from 1 year to 4 years and the selectively of that packing towards water molecules allow us to perform the efficient process in terms of water removing. But if the water removal is same in both the process this process is more economical because only thing we have to add the makeup glycol not replacing the entire packing as in the case of the solid dehydration process.

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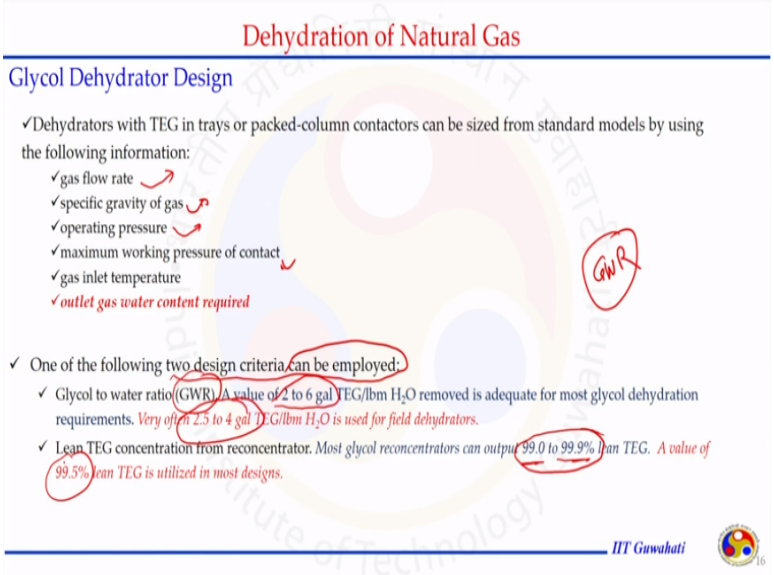


So if we specifically talk about the absorption advantage so the glycol dehydrator considering glycol as liquid desiccant to perform the absorption process it offer several advantage like the low initial equipment cost low pressure drop across absorption tower make up requirement may be added readily easily for the glycol that may get vaporize over the time if the temperature is high or it may lost little bit in flesh separator or somewhere the plant may be used satisfactory in the presence of material that would cause falling of some solid absorbent.

As mentioned the solid absorbent or solid desiccant make get fall because of some contamination those are going to clock the force it means going to reduce the effective surface area of the solid desiccant available. So if those kind of the chemical or substances are present in the natural gas it is better option to use the absorption process compared to adsorption process. Glycol dehydrator also present several operating problem like the adsorption process or like any other process when we are talking about the advantages there are certain issues also with any operation.

So for the glycol dehydrator if the suspended matters like the dirt scale formation iron oxide present they may contaminate the glycol solution and if it is happening the efficiency of the process will go down more care needs to be done in terms of the putting the glycol filter the pump that may get damage because of the impurities present flush separator when we are

considering only the gas is going on the bend and rich glycol is going through this a re-boiler and heat exchanger then the re-boiler step.

So every place if the impurities are present the efficiency may a down we have to be more careful in taking the more accent to separate out these impurities. Overheating of solution may produce both low and high boiling decomposition product. So for example if we are having the TEG the composition of TEG may produce different compounds and those are going to take a part in the absorption process and the process will be become less efficient when both oxygen and hydrogen sulfide are present corrosion may become a problem that is universal problem when we are having the water and went hydrogen sulfide together the problem of corrosion will be there.

Highly mineralize water with inlet gas may over the long time period crystallize and fill the re-boiler with solid salt. So if the water that is present which is having also some significant minerals present in it that is getting separated with the glycol going through the flush separator then going to heat exchanger then finally re-boiler when the water is getting out because of the evaporation process those mineral will remains in the glycol phase and if that the case they may create a problem.

To start a plant all trays must be filled with glycol before good contact of gas and liquid can be expected. So this is the operation problem that happens with any type of the gas liquid contact in a tray packed or column packed tower that will be also be in the case of dehydration absorption process. Sudden surge is should be avoided as mentioned in the adsorption process also in the starting and setting down a plant or otherwise large carry over losses of solution may occur during the process.

So we compare absorption and adsorption process certain features are same and certain advantage are offered by the absorption process and certain advantage offered by the absorption process. When we talk about the design aspects we can discuss the absorption process for its design application.

So the glycol dehydrator design depends on certain effectors that determine what size of the tower should be what should be diameter what should be capacity of the associate devices

like this separator at the inlet flush separator re- boiler duty heat exchanger dimension, glycol cooler all depends on the glass flow rate that is going to be dehydrated the composition of the gases or in terms of the specific gravity of gas at what pressure the gas is going to be treated and the maximum working pressure of contacts.

So we are making the gas liquid contact in the tower at what pressure that is happening gas inlet temperature at what temperature the gas is entering to the absorption plant and outlet gets water content required. That is the most important one the outlet gas water content and that means the dew point depression what dew point depression should be achieved and up to what level the dry gas after the dehydration process should be made dry means the less water content determine the specification or the design aspects of the absorption process.

Certain criteria are mentioned here so at least of the following tool design criteria should be or must be employed when we are talking about the process or absorption process that is the design meeting one of the criteria or not if not certain measure should be taken to make this process more effective, more efficient more economical. So for example the glycol to water ratio.

So when we say this much percent of the water content is present in the natural gas we want to reach to certain percent of the water content by removing the water from the natural gas how much amount of the glycol circulation should be employed to achieve that target and it is said the GWR glycol to water ratio there should be in the ratio of 2 to 6. So 2 to 6 gallon TEG per lbm or H2O.

This should be in the range of 2.5 to 4 for the field dehydrator operations so the GWR becomes important otherwise we are having more circulation of G compared to the water we are moving the pumping cost the size of the equipment going to deal with the glycol like the flush separator re-boiler all things will adopt the cost to the process lean TEG concentration when we are talking about re concentrating or recycling the TEG back to the absorption tower we should design the process that is meeting the recovery or re-concentration in the range of 99.0 to 99.9 % lean TEG.

Lean TEG means the water is not there or value of 99.5% lean TEG is utilizing most design so design of entire absorption dehydration process should be done we are able to recover 99.5% glycol of the TEG from the process sending it for the recycling purpose. So when we talk in detail of the design parameter for the absorption dehydration process we are not discussing about mechanical aspect but what should be size of the equipment that is going to be used to achieve the desired dew point depression.

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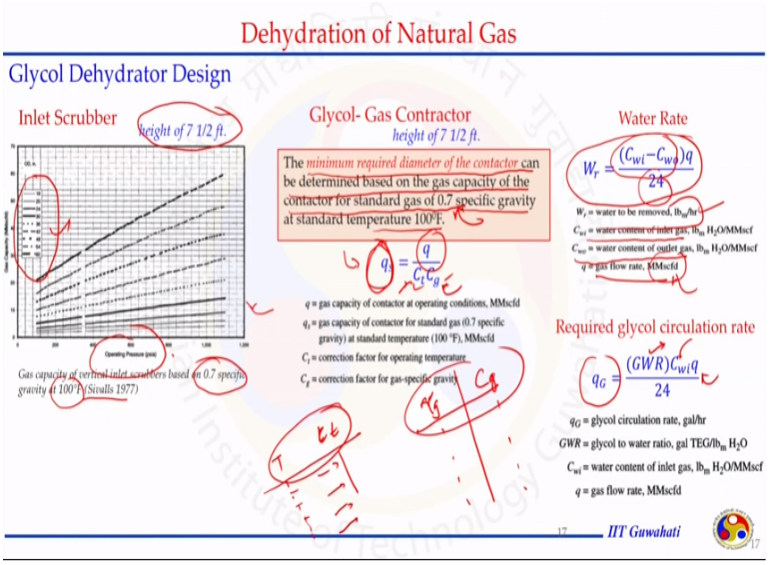


So if we talk the first unit that is installed in the dehydration absorption plant is the inlet scrubber mostly it is at the height of seven and half feet for the diameter it depends on the gas that is going to pass through it and the operating pressure it is getting operated based on that we can choose the diameter of the inlet scrubber. It is similar to separator the separator where we are having the separator pressure at which it is going to be operated and that amount of the natural gas it is going to deal with the diameter should be chosen.

We already know the height or we already fix the height seven and half feet and the volume required to accommodate that gas will be calculated and the diameter can be calculated from this chart given by (()) (01:01:41) this is given at a particular specific gravity and temperature different chart may be obtained for the different conditions.

Second unit that is important is glycol gas contractor again the standard height consider for this absorption tower which is having the tray and the packed bed to provide the more contactor

for the gas and liquid for that the minimum required diameter of the contactor can be determined based on the gas capacity of the contractor and standard gas 0.7 specific gravity at this temperature.

So similar what we are having here but in this case we are not having the standard gas or the gas with the 0.7 specific gravity we are having the different temperature also. So the correction for the temperature and the specific gravity should be included to calculate the gas capacity at the operating condition and the correction depends on the type of the gas contactor we are using it is a packed bed or it is a trade.

There are several tables reported in the literature the temperature CT seating can be done depending on the temperature it is getting operated. So we are having the timetable where the several temperature data are there and accordingly the correction for the temperature can be included in the expression. Similar for the specific gravity also what gravity we are having for a gas we are dealing with the correct factor are available in the form of table in the literature.

But again different correction factor will be applied for different arrangement for example tray or the packed one. Knowing the correction factor knowing the standard condition and 0.7 specific gravity gas at 100 degree F we can calculate the amount of the gas that is going to be deal by a gas contactor the height is already fixed we can calculate the diameter. Important parameter is how much water has been removed from this tower or absorption process can be calculated by this expression that says Cwi – Cwo multiply by the Q that is the gas flow rate.

Cwi is water content at initial gas that is the wet gas and Cwo water content of the outlet gas that is the dry gas if we take the different of that multiply by the gas flow rate divided by 24 that is just for the conversion to unit because the water removal is calculated in terms of hours while the gas flow rate in terms of the per day we can calculate the amount of water that could be removed from this process.

And to remove that water how much glycol circulation rate should be we can calculate knowing the GWR if multiply GWR with this Cwi initial water content of the wet gas multiply by the

gas flow rate we can get the glycol circulation rate to achieve the water content required in the dry gas or desired dew point depression.

Other things those are involved in the absorption dehydration process like the flush tank which is separating the rich glycol from the gases if any the dimension can also be calculated from the literature by knowing the amount of the glycol that is going to be deal by that flush separator. Similarly we can do for the re boiler duty how much energy should be supplied to re boiler if this much amount of the water and glycol is going to be separated at the re boiler condition and what should be the volume going to behave like a storage and from where the lean glycol is going to transfer to heat exchanger device and further it from the cooler it is going to absorption tower.

So in this lecture we had understood the several dehydration process starting with the cooling compression followed by cooling both depends on changing the temperature and pressure condition and the water or the dew point of the natural gas will get change and accordingly the water can be separated out from the natural gas. For that we understood the adsorption process that based on the solid packing in the column and in detail we understood the adsorption process.

And altogether we can say by performing the absorption and adsorption process most of the water present in the natural gas can be dehydrated and we can get very minute amount of the water present in the natural gas that is passing out of the dehydration plant. There are processors where the CO2 H2S can also be separated out along with the water but those process face the problem depend on the type of the process chosen we will discuss the sweetening processes removal of H2S and CO2 in the next lecture with this I would like to end my lecture here thank you very much for watching the video we will meet in the next lecture thank you.