Upstream LNG Technology
Prof. Pavitra Sandilya
Department of Cryogenic Engineering Centre
Indian Institute of Technology, Kharagpur

Lecture – 01
Introduction

Welcome back. We are now in the introductory chapter for the Upstream LNG Technology, what we shall learn in this chapter.

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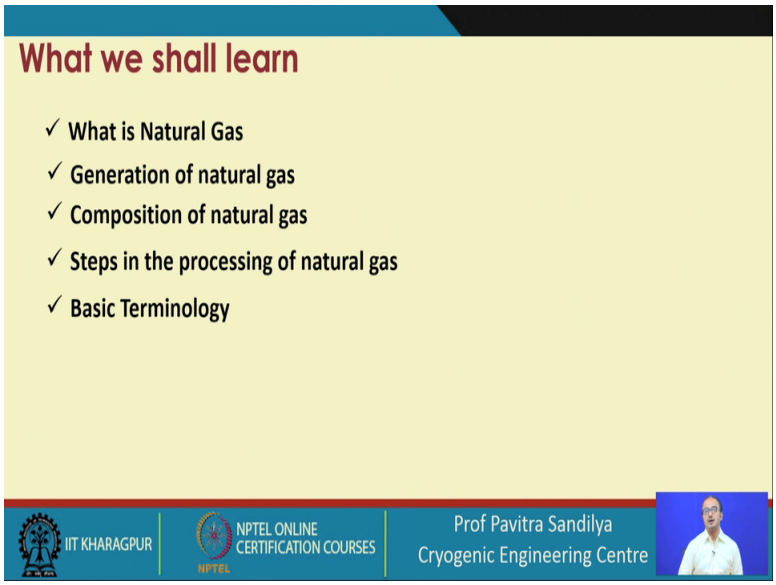

We will learn about what is natural gas, how we define this natural gas. Secondly, how this natural gas is produced in the nature. Thirdly, what are the compositions of natural gas? It will be followed by the various steps which are needed for processing of natural gas and this will be ending with some basic terminologies which we use in the petroleum and natural gas industries.

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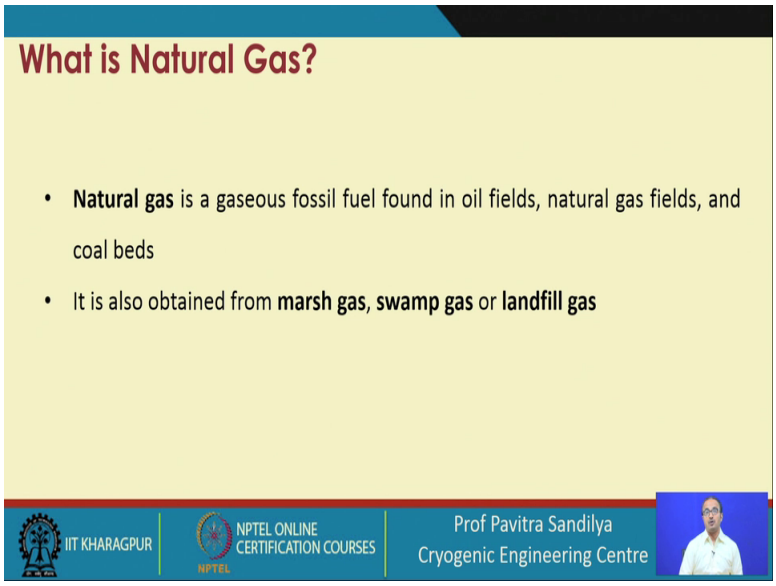

First query; what is natural gas? Natural gas is a gaseous fossil fuel which is found in various types of oil fields, natural gas fields and coal beds. In this case, you can note that oil fields and natural gas fields are generally located in the sea, there are a few in the land too, but coal bed is always in the landscapes, Natural gas as such is also obtained from various other land sources like marsh gas, wherever, we are finding some wetland because of the anaerobic oxidation, we get some kind of gases which are also called natural gas swamp gas or landfill gases.

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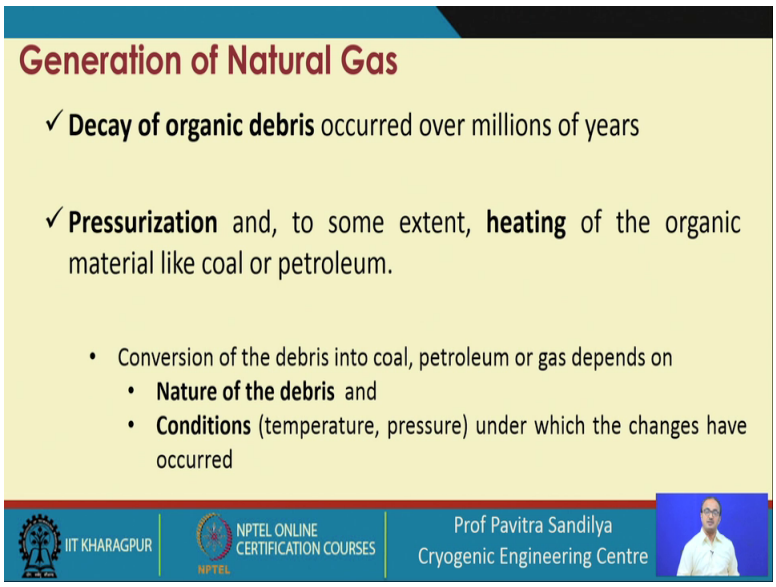

Let us now feel, how the natural gas is generated in the nature. It may have different sources, first of them is the decay of the organic debris which have been accumulating under the sea over a long period of time since, the birth of this earth. And under the sea, due to the large pressure and also some of the heat due to the geothermal energy, they convert the big molecules and break them up into smaller gas molecules basically, hydrocarbons which are taken out as natural gas.

This conversion of this debris into the coal or natural gas depend on various factor; as we find that over the earth, there are natural gases and petroleum also which are of different qualities, they may have different compositions. And the reasons for these variations, in the compositions are the nature of the debris and the conditions under which this debris are being converted into petroleum or natural gas.

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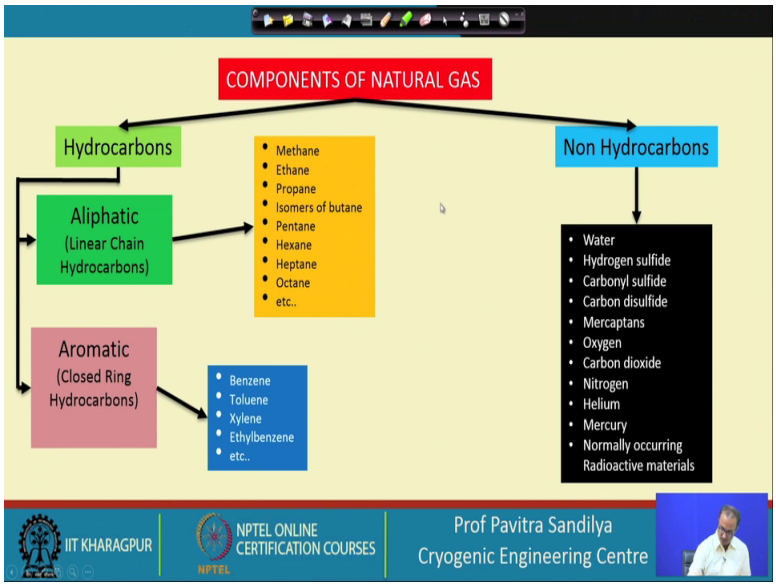

Let us now look into the word various components of natural gas. The natural gas has broadly 2 types of components, one are hydrocarbons and another group of components are non-hydrocarbons. Under hydrocarbons again we have 2 types. One is aliphatic hydrocarbons which you might be knowing represent the linear chain hydrocarbons; for example, I can have a linear chain like they may be consisting of (Refer Time: 04:30).

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The aliphatic hydrocarbons are linear chain hydrocarbons they may be alkane (Refer Time: 04:56).

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No no.

First we have to go through the (Refer Time: 05:10).

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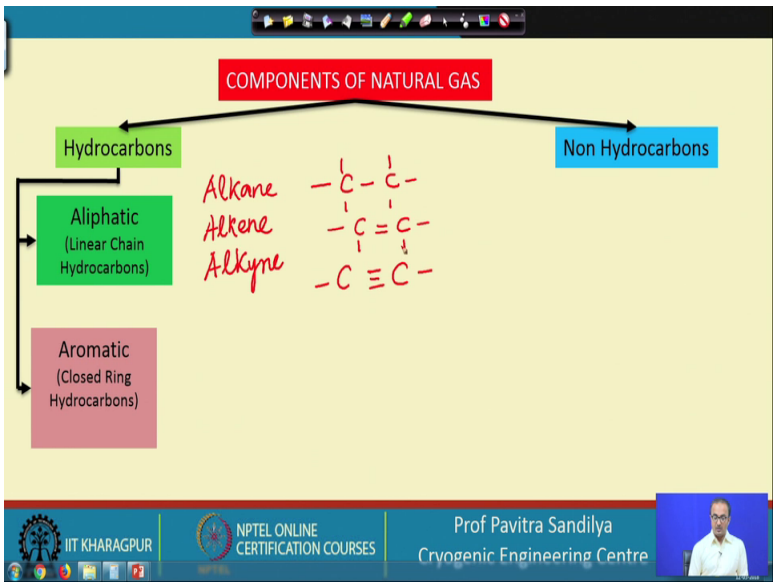

Aliphatic hydrocarbons are linear chain hydrocarbons and they may be alkane, alkene or alkyne and what are these? For example, alkane is saturated hydrocarbon with all single bonds. Alkenes are double bonded compounds and alkyne are triple bonded compounds and under this, we have again various types of hydrocarbons like methane, ethane, propane, butane, etcetera. And we have to understand that natural gas will contain only the lower hydrocarbons and not the higher ones which are present in the petroleum.

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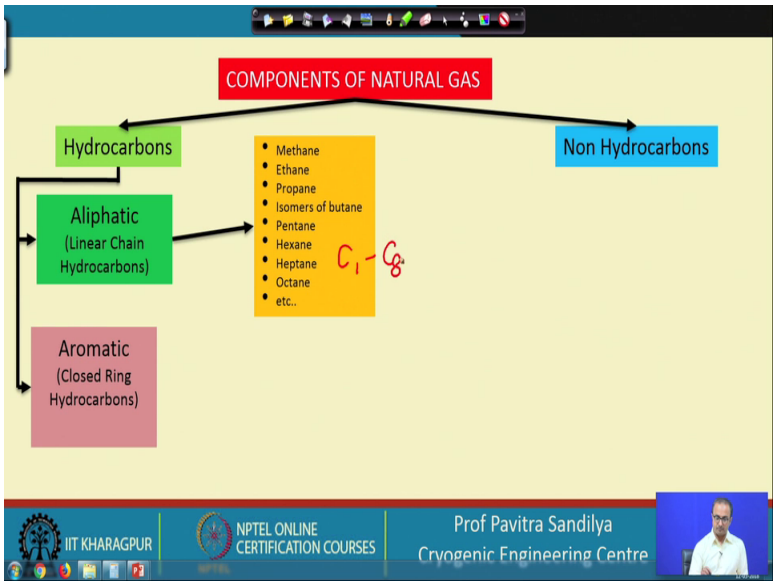

So, here generally we have from we call it C 1 to about C 8 hydrocarbons.

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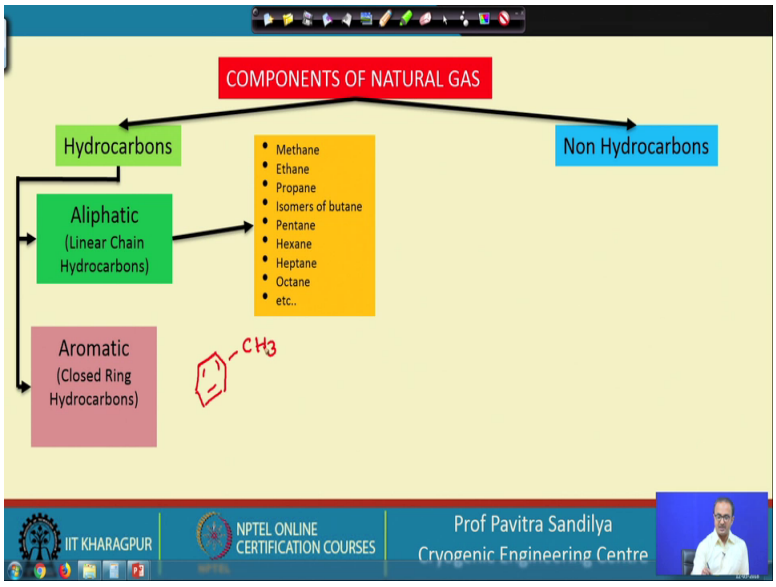

Next group of hydrocarbons which are present in natural gas are the aromatics and aromatics are closed ring hydrocarbons they are generally like some kind of ring structure. We have this; you know the famous benzene ring structure and along with benzene, we might be having some other alkyl group like toluene or xylene, etcetera. So, we have like benzene, toluene, xylene which are sometimes together known as BTX.

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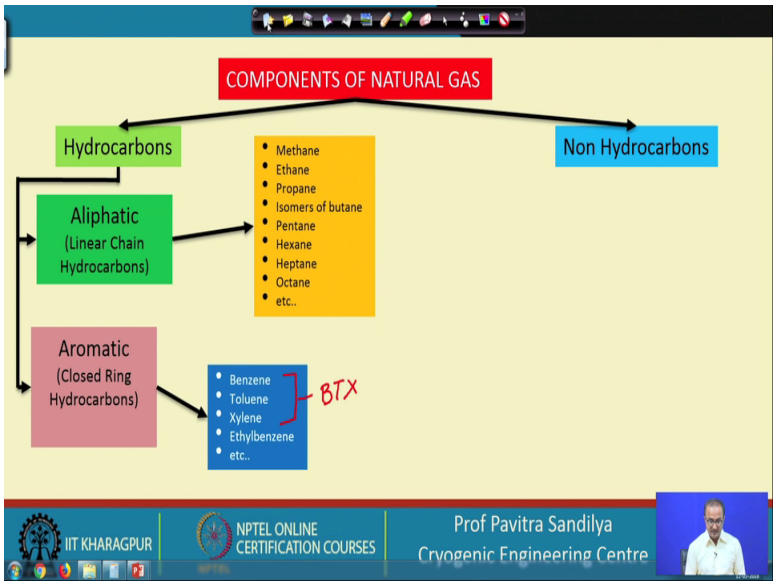

These 3 are sometimes given the term BTX and then we may be having ethylbenzene that is C 2 H 5 and C 6 H 5, after this hydrocarbon components, we have some non hydrocarbon components also. In this, we have water hydrogen sulfide carbonyl sulfide then carbon disulphide, mercaptans, oxygen, carbon dioxide, nitrogen, helium, mercury, normally occurring radioactive materials. This normal last one is sometimes in short is called norm.

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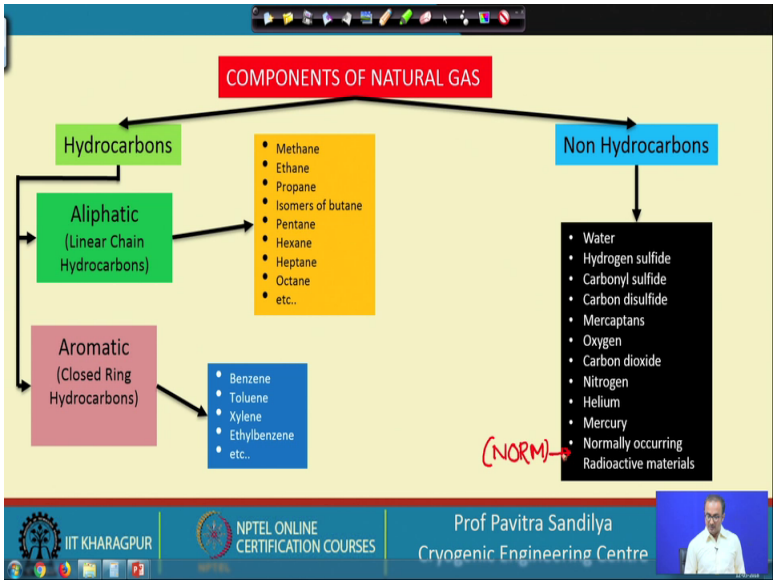

Here I may mention that the helium is produced from natural gas and helium is a very important gas because it is used in superconductivity.

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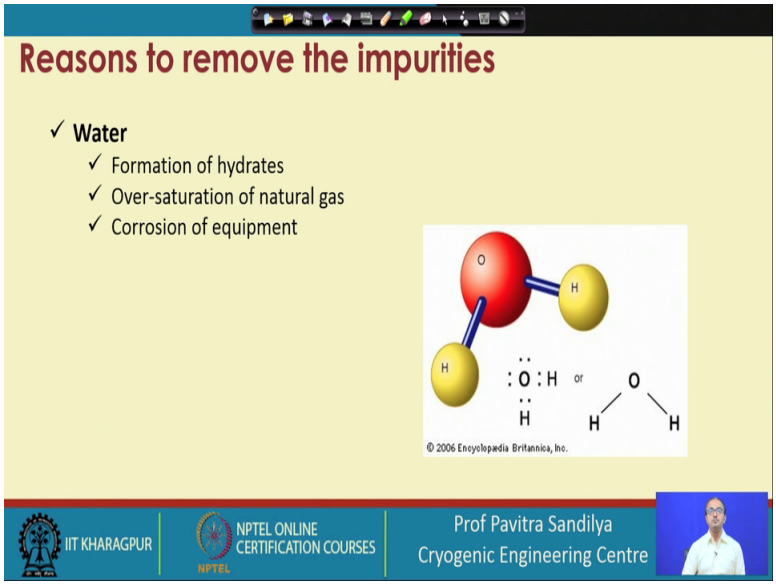

Why do we need to remove the impurities? Let us look one by one to the prominent impurities present in the natural gas, first water because natural gas is coming from under the sea. The presence of water causes various types of problem 1; problem is the formation of hydrates, we shall be learning about hydrates later, here I was just say that hydrates are some kind of compounds which are formed by inclusion of some gassed molecules in a cage of water.

In case of natural gas, the hydrates formed are from methane, maybe ethane, sometimes nitrogen, etcetera and when these hydrates are formed, they are like ice, they look similar to ice and what they will do? They will simply clog the pipelines or any other accessories. So, they need to be removed. What are need to be removed? So, that this hydrates are not formed. Secondly, the presence of water will cause over saturation of the natural gas which will lead to precipitation of some components in the natural gas and that will again precipitate in the various pipelines or the equipment.

And thirdly because natural gas has many other acid gases like H 2 S, Co 2, etcetera which will react with water and form some weak acids like carbonic acid, sulfuric acid, and they will be causing corrosion to the various pipelines and the equipment. So, that is why the water needs to be removed.

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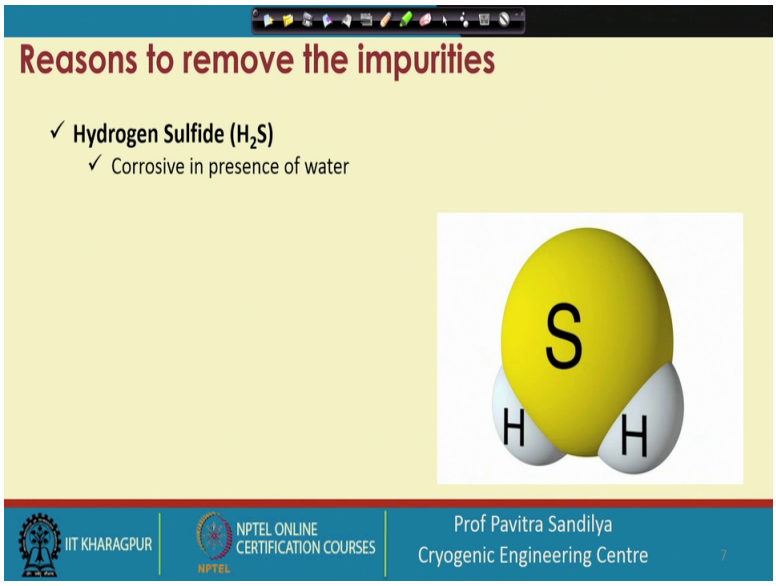

Next is hydrogen sulfide that is H 2 S, this H 2 S will react with water and form some acid that and will lead to corrosion.

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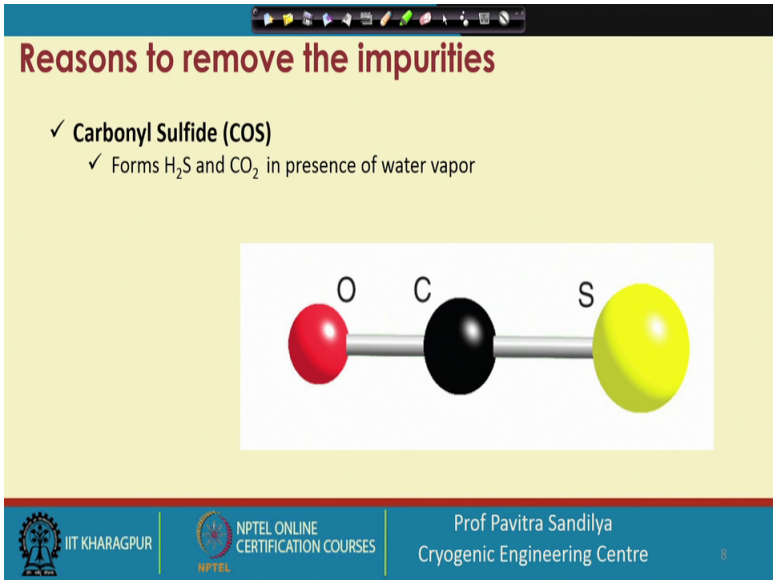

Thirdly, we have carbonyl sulfide that is COS which will form H 2 S and CO 2 in presence of water vapor at high temperature.

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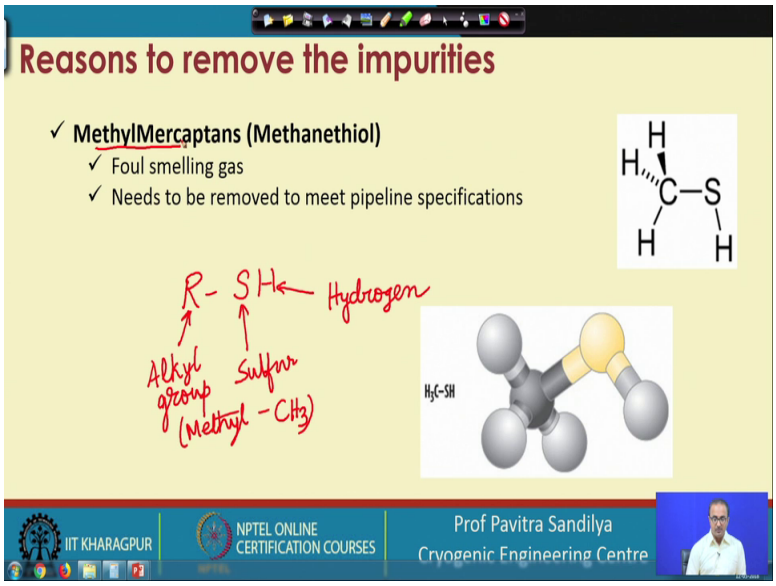

You have some other sulfur compounds like Mercaptans; mercaptans in general are represented by this formula this R stands for some alkyl group, S is for sulfur and H for hydrogen. So, in case of natural gas, we have the alkyl group as methyl group that is CH 3. So, this methyl group forms mercaptans and this is called methyl mercaptan.

This mercaptans as such are not harmful because they will not be producing any kind of acid, but they are undesirable because they impart some pungent foul smell to the natural gas and naturally when we are using such kind of gases for our consumption at home or somewhere we do not want the gas to be smelling bad. So, these methyl mercaptans are removed from the natural gas.

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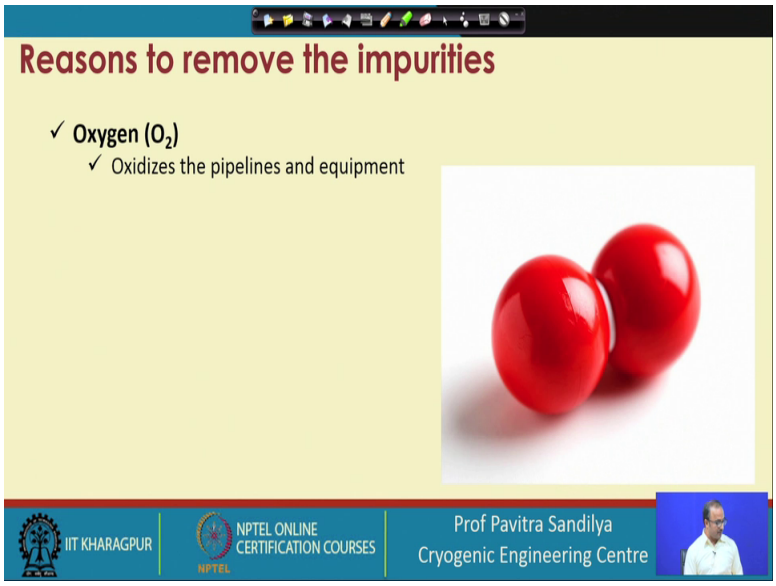

Next, we have oxygen as another impurity and we know because oxygen is a very reactive gas, it can react with various types of components in the natural gas. It can oxidize the various components and they can form different types of impurities with may precipitate or it may also cause some damage to the equipment by corrosion.

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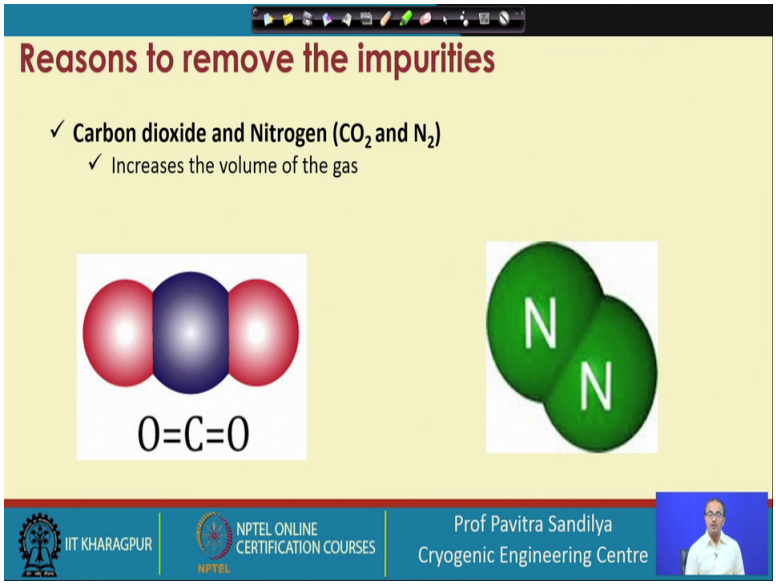

Next group of impurities are carbon dioxide and nitrogen; carbon dioxide is an acid gas which will be making carbonic acid in presence of water. Whereas, nitrogen as such is an

inert gas under normal conditions, but the presence of nitrogen will increase the volume of the natural gas the and that is not desirable when we are storing the natural gas.

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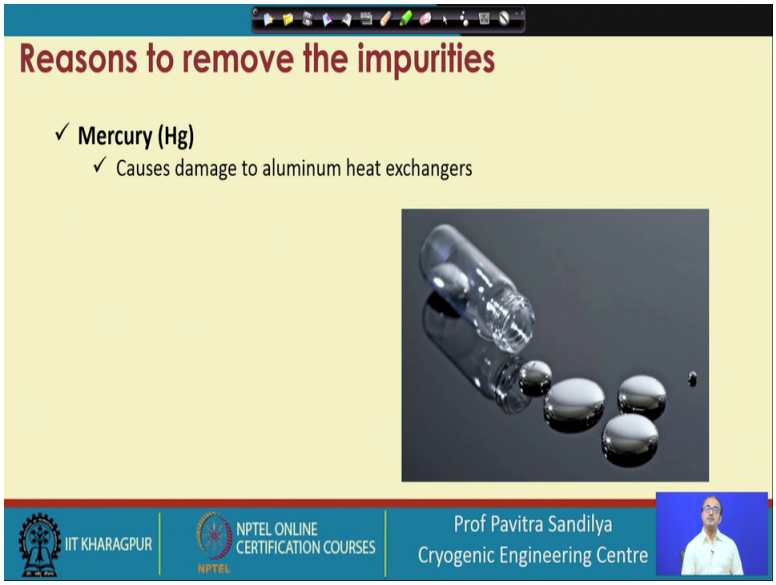

Another impurity is mercury; mercury, we all know is not environmental friendly and it is not good for our health other than that mercury can damage the heat exchangers which are made from aluminum.

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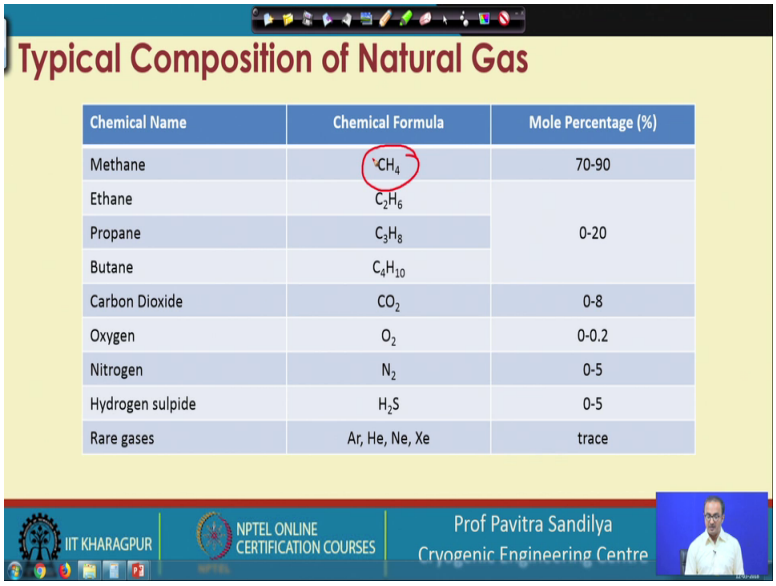

Chemical Name	Chemical Formula	Mole Percentage (%)
Methane	CH_4	70-90
Ethane	C_2H_6	0-20
Propane	C_3H_8	
Butane	C_4H_{10}	
Carbon Dioxide	CO_2	0-8
Oxygen	O_2	0-0.2
Nitrogen	N_2	0-5
Hydrogen sulpide	H_2S	0-5
Rare gases	Ar, He, Ne, Xe	trace

Now, we come to the typical composition of natural gas in this, we see that the natural gas is mainly methane largely methane if you contrast this with the other natural gas, we

have that is LPG which we use at your home that is most to the pentane and butane, other than methane, we also have the other hydrocarbons like ethane, propane, butane and non hydrocarbons like carbon dioxide oxygen nitrogen H 2 S and some rare gases like argon, helium, neon, xenon, etcetera.

This composition may vary from reservoir to reservoir and depending on the relative compositions, the techniques of separation and purification of natural gas will differ. So, it is important for us to know the composition of the natural gas, before we decide the type of separation and purification methods we are going to adopt.

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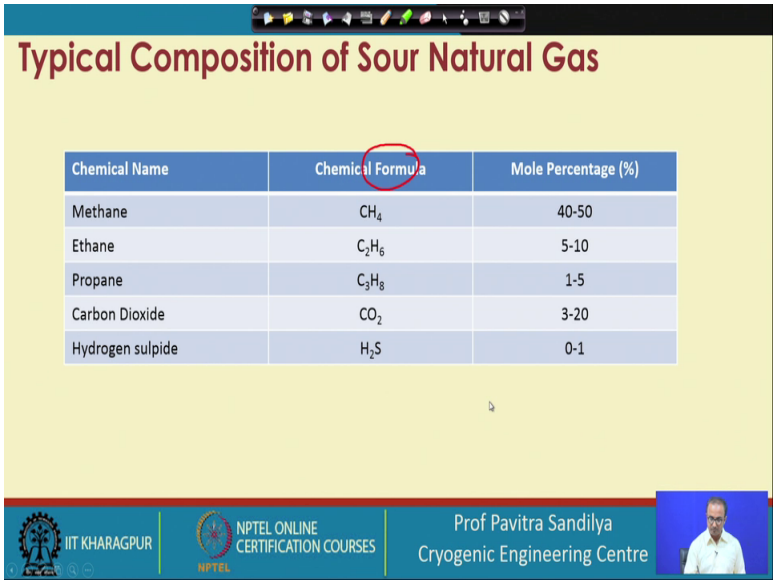

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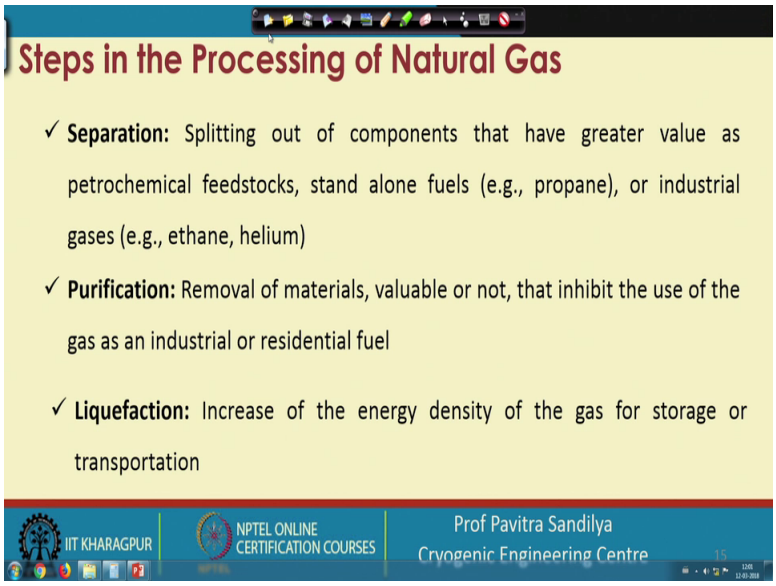

Now, we come to the various steps which are there in processing of natural gas, first is the separation; separation means that we are trying to take out those components which are present at in larger quantities. And in this separation processes, we also produce some kind of petroleum feedstocks and other industrial gases like ethane and helium, next is the purification step. In this in this case, we removed those components which are not present in large quantity when I say large quantity, it is heuristically, those components which have less than about 10 mass percent, in the natural gas, we shall learn about these mole for percent and mass percent later.

The last process for the upstream LNG system is the liquefaction, in this, the natural gas is liquefied for 2 reasons. Firstly, by liquefying it, we can store a given mass of the natural gas in a smaller volume and secondary by doing. So, we increase the energy density of the gas the energy density is defined as the calorific value of the natural gas per unit volume of the gas stored.

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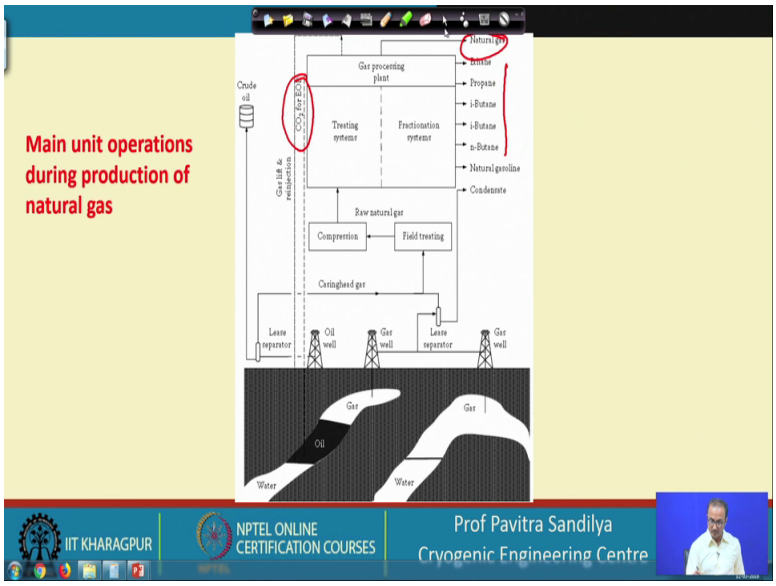

Now, in this figure, we are showing the main unit operations which are there for the production of the natural gas. First, we see here the oil field from which we are getting natural gas, we find that in the typical oil field, the gas exists over the petroleum oil and beneath the oil, we have some water. And in some oil fields, we do not have much of petroleum, we have only gas and water and this is the reason that when we are trying to extract the natural gas, we find the amount of water in the natural gas will be quite high.

Now, this natural gas come through some oil well gas well and then they are field treated to remove some of the debris or some of slurries and some muds and they are compressed and then sent for the processing unit in which we have various types of treating systems about which we shall be learning in the course. And in this case one important thing is that removal of CO 2, this CO 2 is removed and may be utilized for the extraction of the oil itself by the methods which in short is called EOR; carbon dioxide may be used to extract the oil again by what we call EOR that is enhanced oil recovery. And then we have the natural gas coming out after the processing and in this case, we are finding that various components other than the methane are also obtained.

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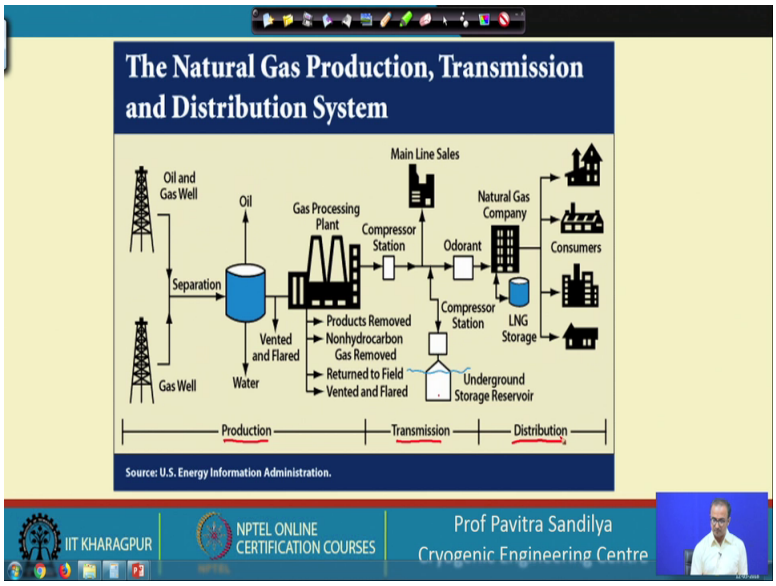

And in this figure which has been taken from the us energy information administration, here, we see that what all processes are needed to get the natural gas in the usable form to the consumers from the natural gas well. Here, we find that after we take the natural gas from the gas well, it is undergoing separation and we are removing the various oils and water and some of the gases are vented and flared and then they are taken to the gas processing plant.

And in this, we are removing the various types of impurities and then it is going to compression by compression, we are reducing the volume. After compression, it may be taken for sales or it is for further, it may be some odorant may be given to test its leakage problem and then it will be liquefied and put as LNG storage or it may also be put under the ground for storage and whatever form we store it as then ultimately it will be going to the consumers. So, broadly this whole system can be divided into 3 parts first is the production second is transmission and lastly that is the distribution.

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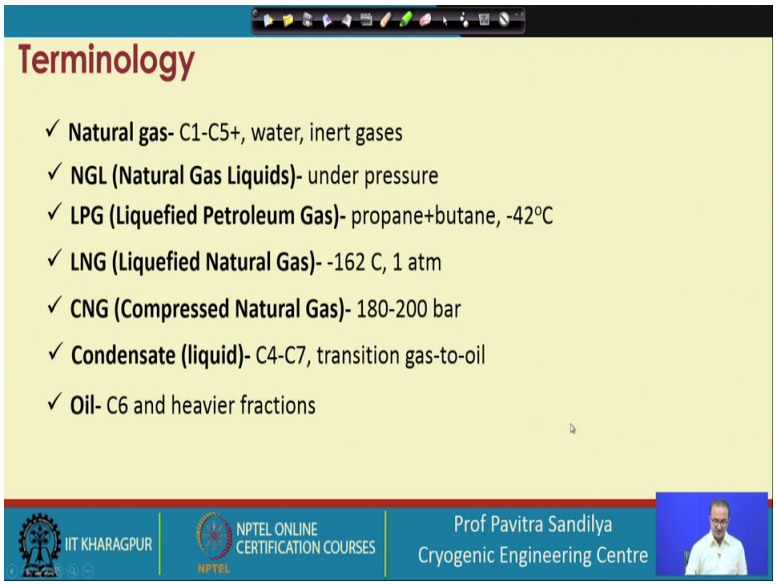

Let us now end this chapter by knowing some of the terminologies which are used in the natural gas and petroleum industries first is natural gas which consist of some water inert gases and some lowered hydrocarbons. Secondly, we have natural gas liquids which are formed under pressure thirdly we have LPG that is liquefied petroleum gas which is basically propane and butane and we use it at our home.

Next is liquefied natural gas that is LNG and you can note the temperatures of LPG and LNG; LNG is at very low temperature then we have compressed natural gas and this is at very high pressure of the order of about 200 bars, then we have condensed liquid which consists of hydrocarbons which are bit of higher molecular weight than natural gas and they are basically the C 4 and C 7 fractions that in butane up to heptane and lastly, we have the heavier oil fractions.

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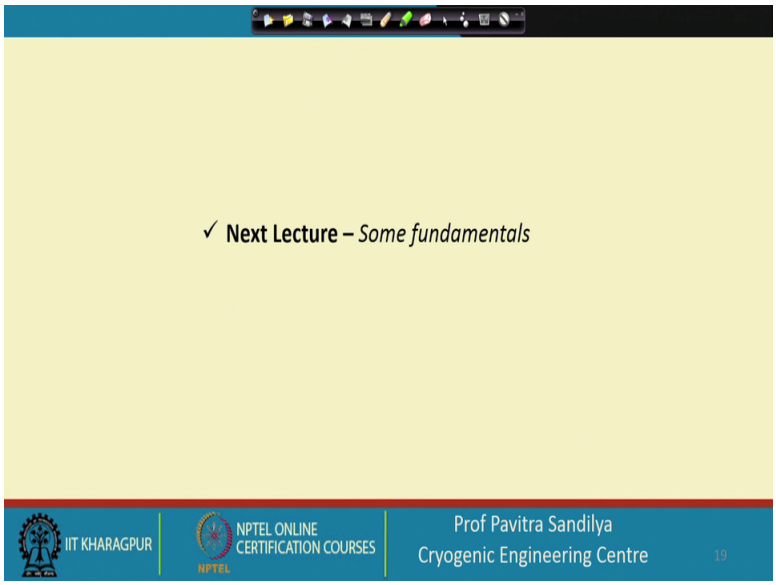

With this, we come to the introductory lecture on natural gas in the future lectures; we shall be talking of some more fundamentals.

Thank you.