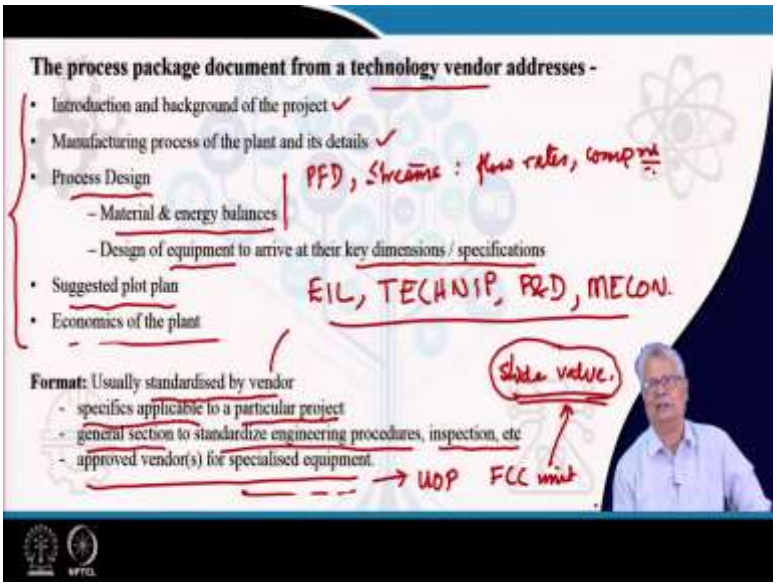
**Principles and Practices of Process Equipment and Plant Design**

**Prof. S. Ray**
**Prof. Gargi Das**
**Department of Chemical Engineering**
**Indian Institute of Technology, Kharagpur**

**Module - 05**
**Lecture - 63**
**Process Packages**

Good day to you all. So, today we are going to talk about Process Packages. In fact, we are coming to towards the end of the course. Beyond this you will have the design of a complete plant to be covered in very brief and before that let us have an idea what a complete process package looks like and what all components it should have.

(Refer Slide Time: 00:57)




To start with let us know a few things. The process package document comes from the technology vendor; that means, it is created by the vendor of technology. Suppose as a designer you are giving your design to someone else you are the vendor. So, but naturally if you are talking about any project document, it must start with an introduction and background of the project, that is the first thing that is required.

Now, if it is not too small a plant, even if it is, the manufacturing process of the plant and it is details are detailed in this. So, these two are basically something like preamble which will always be at the right beginning of your process package. You definitely have

to provide the details of the process, the process that is being designed and will be implemented by your client.

The fundamental thing in any process is basically the balances of material and energy. So, you will have the material balance mostly in the form of a process flow diagram with its streams marked on it. The stream details will be naturally that flow rates and compositions.

So, if you look at the PFD with the flow rates and composition of the streams marked on it you will understand what exactly is the flow between the different process units, different equipment and what exactly is a energy transfer involved in the entire process itself.

You definitely can have an idea that what is the amount of energy which is required for your process, which is a very very important parameter for your client to know because he is the one while he operates his plant has to get an arrange for it. Next comes the gross idea about the equipment, the equipment that are designed and in order to give the idea right at the beginning, the key dimensions and the specifications are to be provided in the process package.

Do not think that the process package which is given right at the beginning, it is basically the process technology package, is not the complete document with which the plant can be fabricated or can be built based on it itself. You, this is a starting document for making the detailed design.

Normally, with the technology that is provided to the client you are suppose to suggest a plot plan also. This could be a generalized plot plan for similar plants or in case you have the details about the location of the plant, you are may include a specific plot plant for this specific client also.

Normally, the economics of the plant is also decided along with the project evaluation in the process design that is basically the process technical process package. The after all it is a document. Normally these documents are standardized by the vendor. In India. Typically, the good vendors and the famous vendors are Engineers India Limited, you have a company called Technip. There is a unit called P and D, P and D. Then you have got Mecon. All these companies they have standardized these packages.

Now, it is obvious, the content which I have mentioned is present in this particular standardized document of the vendor, but in slightly different forms depending on the type of industry they serve. This format could be containing the specific specifics applicable to a particular project. It will definitely have a generalized section to standardize the engineering procedures and the practices and the inspection that has to be followed if such a plant has to be built.

In some cases you also have an approved vendor list for the specialized equipment. I will give you an example (Refer Time: 05:46) Universal Oil Product or UOP is a very famous company in the refining sector and they designed various plants including the fluidized bed catalytic cracker unit or the FCC unit. The FCC unit has got quite a few specialized equipment. One such equipment is the slide valve. There are few vendors in the world or few manufacturers in the world who make this slide valve.

So, quite naturally in the process package for the FCC unit, which is given by UOP. The prospective vendors who can supply you the slide valve is also mentioned. The basic design and the features of the slide valves to be used in this particular plant is also mentioned therein.

(Refer Slide Time: 06:44)


I have already said that the basis of detailed engineering of the plant is the process package; that means, now what I am saying is a new term which is the detailed engineering of the plant. Detailed engineering means it is basically after the stage the

equipment will be fabricated, delivered, erected, commissioned, operated and maintained. So, that would be the life cycle of your plant to start with.

So, detailed engineering of the plant starts with a process package which given by the technology vendor. Quite naturally the detailed engineering if you are talking of it must be having the sufficient information to start with the project description, then if it is a big plant block flow diagrams and all these we have discussed right at the beginning when we talked about various documents involved in design.

You will have the process flow diagram naturally with the stream flows and a compositions as well as the energy flow requirements over there, a process description of the different units, which are involved in your plant and you will certainly have the process and instrumentation diagram which will tell you what are the control loops and what are the process parameter indication loops; that means, again in industrial parlance you can look at it and find out what are the open loops and the closed loops involved in your plant.

The communication has to be in terms of drawings as well. The first thing that you have are the general arrangement drawings; that means, if it is a distillation column, what you will have is a gross dimension marked on a elevation drawing. A little bit details about the location of the nozzles possibly the elevations at which the trays will be fixed that will also be there, the height of the skirt support will also be there.

And naturally whatever is required to have an general idea will be there. Mind it GA drawings are not fabricational drawings. In fact, GA drawings are used in order to assemble things after they have been fabricated. Fabrication drawings are prepared separately.

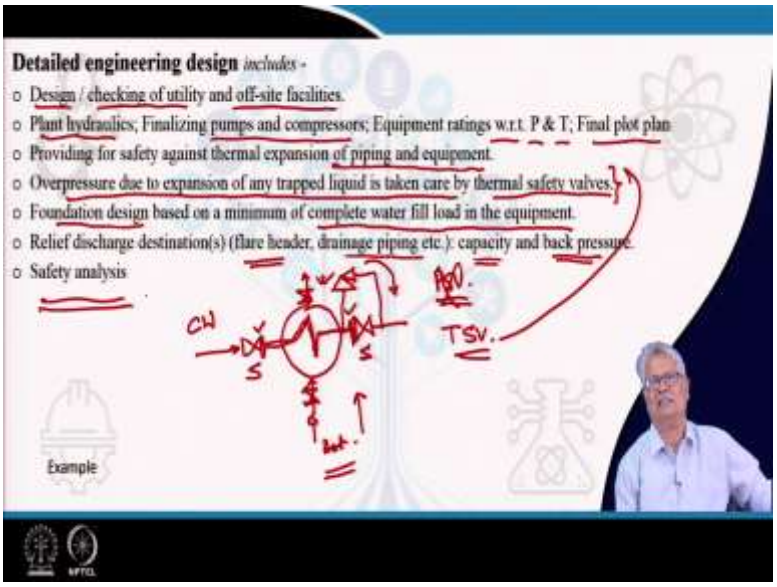
Now there may be requirement for communicating additional information through additional drawings depending on the complexity of the process and what exactly is to be communicated. Normally the instructions for layout, erection, equipment, installation and operational safety is also to be covered and it also includes the standards and the codes to be followed.

In fact, if you are talking about the Indian scenario, depending on the industry certain sections will definitely be Indian, but in case you are getting a technology from outside, a

foreign technology comes in, they will be specifying certain standards according to their country or their own requirement. Either the equivalent thing has to be given in BIS or directly something like ASME or something which is more accepted I mean which is quite accepted internationally will be used. The standards and the codes part is extremely important.

It is because if I buy particularly different specialized equipment from different countries or different manufacturers, they have to confirm to the same standard in order they can be connected; that means, the standards will specify not only the mechanical integrity, but it will also specify compatibility with respect to material, with respect to physical connections also. Now, the project specifications we have already said and these are the ones.

(Refer Slide Time: 11:03)




When I say detailed engineering design, the detailed engineering design would include fundamentally the design of the main process, certainly it will also include the checking of the utility and the offsite facilities. If you are giving you are getting a technology from somewhere, it has to be in synchronous, in synchronization with the other facilities which may be either existing or which will be added later on. One such thing is the set of utility and its requirement and offsite facilities.

Typically I will put it like this. If I having a particular technology which ask for a water supply at a temperature of 25 degree centigrade and you do not have an utility which

supplies water cooling water at 25 degree centigrade, either that utility has to be managed and has to be provided or the design has to be modified in some way.

So, quite naturally for detailed an engineering design procedures, you require a sufficient information of what may be available as utility as well as in offsite facilities. Next comes in your detailed engineering the plant hydraulics. This is something which we have talked about; that means, in detail engineering stage you finalize the pumps and compressors, their specifications and their drivers.

The equipment rating with respect to pressure and temperature are also finalized. The final plot plan is covered in your detailed engineering document. Now, you have to provide safety against expansion of the piping and equipment. This is something very important in process plants because your installation temperature could be the ambient.

But its operating temperature could be much higher or much lower in cryogenic plants which definitely requires that there has to be provisions for either expansion or contraction of these equipment, which may required certain overpressure release, sometimes space, sometimes anchoring and things like that.

Over pressure due to expansion of any trapped liquid is taken care of by thermal safety valve. This is something which we have talked about when we talked about heat exchangers. I will just give you an example. I have here a shell and tube exchanger and what I have here are two gate valves which are isolation valves. Now, the shell side possibly is the hot fluid. This is the hot fluid and this is say cooling water coming in and a hot fluid gets cooled here and leaves here.

You have isolation valves here as well. Now, what happens is if this is shut, this is shut; that means, there no cooling water flow and you by some wrong operation you started hot stream first, what is going to happen; the liquid between this point and this point that is going to expand. Immediately what we will find that the gasket which is there in the flange here they will start leaking, because that is usually the weakest point in your piping system.

So, that this if your gasket failure does not happen, if it happens you are saved, you have saved your equipment and if it does not happen then possibly you are going to have tube failures. So, what is done is you provide here a pressure safety valve across one of these

valves so that the overpressure here gets released downstream. Now, this is a pressure safety valve no doubt, but it protects against the overpressure under thermal expansion. So, this is called a Thermal Safety Valve or a TSV. So, this is what is meant by this.

You will also notice the next item the foundation design is finalized in the detailed design stage and the minimum load that has to be carried by the foundation is a complete water field load in the equipment. For example, if you are talking about a distillation column which normally will be having lot of vapours vapour inside and some amount of liquid.

The foundation load is designed not only on the weight of the metal and the weight of the liquid which is which it is supposed to carry even under emergencies. It is considered with fully filled with water. This is something very often and perhaps many do not, I will say appreciate it because it increases the foundation load bearing requirement often to quite a few times.

Particularly for hydrocarbon columns, you should not consider the hydrocarbon filling of the entire column because hydrocarbons have density less than water and what happens is during initial stages immediately after your erection the entire column is filled up with water and water washed.

So, in any case at least once in its lifetime it will be filled with water and it cannot, it must have the mechanical integrity to withstand that. So, note one thing, the foundation design is based on the minimum complete water fill. Now, comes the consideration for the safety which relates to the relief discharge destinations.

The relief is against over pressure and here when I am talking about the destination, it has to be a safe disposal. In some cases if it is a benign discharge maybe a little bit of steam and all it could be discharged to the environment or the ambient. But it has to be located such that it does not pose any threat to the working personnel around.

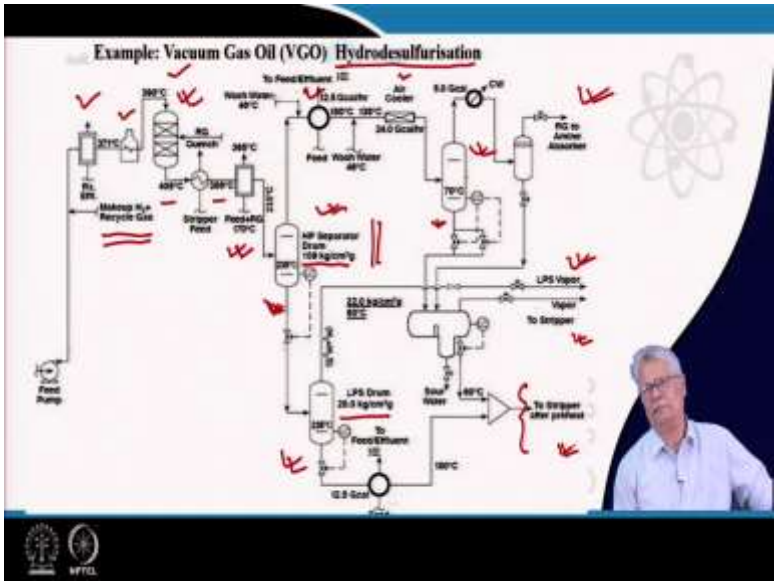
If it is a hydrocarbon or if it is a toxic vapour, it has to be discharged to a flare header. You definitely have to check that any such discharge is discharge safely. Sometimes safeties are also discharged into drains for example, the pump discharge safety will be draining will be discharging either to it is suction or it will be drained if it is a benign liquid like water.

It is very important to note the capacity of the discharge system which receives the supply during the discharge itself. Another thing the discharge is against a back pressure. So, if your back pressure goes up, the safety over pressure under which it the safety valve operates will also go up and this may be a threat to your equipment.

So, you have to ensure such a design of your relief discharge destination which will have a fairly constant back pressure and if it is not, you have to use special type of relief discharge valves. A safety analysis is always essential during detailed engineering design.

So, these are the points which are to be taken care of in detailed engineering design. And during this design the information, which has been made available to you from the technical process package is essential, if and that is the starting basis for your detailed engineering.

(Refer Slide Time: 19:29)




I have a plant example here. It is a plant of which is of hydrodesulfurisation. Hydrodesulfurisation means using hydrogen you are removing the sulphur which is present in the hydrocarbon, which is the vacuum gas oil here, typically the vacuum gas oil will be having about 1 percent around 1 percent by weight of sulphur and it has to be brought down to it acceptable level. So, that it can be used as a component of diesel.

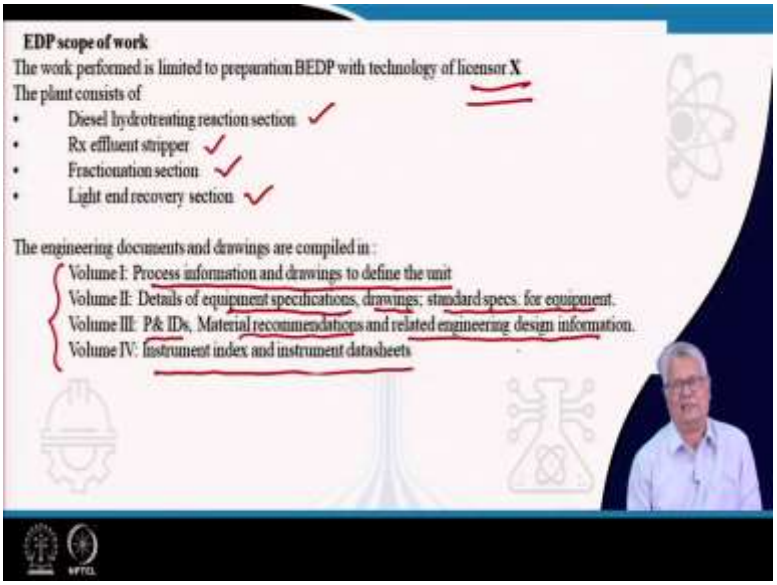
Let us look at the plant. Here you have a hydrodesulfurizer reactor. The bottom material comes out and quite naturally what you have here is it is preheated to a temperature of 390 degree centigrade. You have preheat exchangers followed by a furnace. You have the makeup and recycle gas hydrogen mixed with the feed. It is a solid catalyzed gas liquid reaction.

Now, what you have here is something like this beyond that you cool it from 405 to a lower temperature. Beyond that you have a plate and you have a plate type exchanger. Then it goes to a high pressure separator. The pressure is pretty high. In the high pressure separating drum it flashes the hydrogen which is unutilized and a little amount of lighter hydrocarbon which has formed, comes out, it goes out, it condenses here in the two heat exchangers and then what happens is it comes to another separator.

The sulphur which gets removed forms hydrogen sulphide and finally, it goes here for recovery of H2S from that of gas. The liquid is always coming from the bottom of these. So, this is also a bottom arrangement and it goes to a low pressure separator drum which is again a flash. Here the flashing happens at 20 kg whereas, the upper drum or the high pressure drum it happens at 109 kg pressure.

Here again some more amount of vapour which is from the low pressure separator comes out and here we have the vapour which is finally going to the stripper and your bottom product here is finally to be stripped and it goes to another section. After preheating its basically go going to a stripper, which is nothing but a column and naturally in order to facilitates stripping you add heat; that means, you preheat it.

(Refer Slide Time: 22:27)

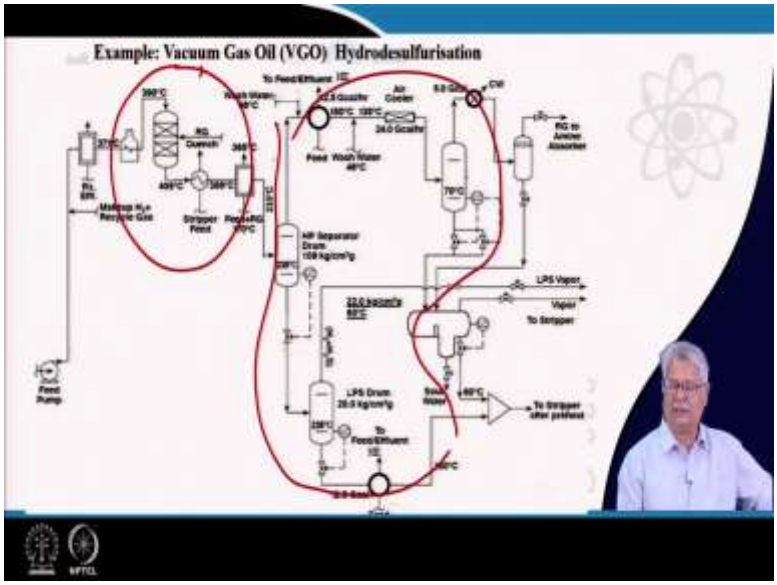



Now, the scope of work if you look at, the work performed is limited to the preparation of BDP with technology of the licensure. In fact, this is a correct this is an existing plant and I am not going to give you the details of this I cannot in fact. The plant consists of the diesel hydro treating reaction sector section, which is basically the reactor I talked about.

Then you have the reactor effluent stripper, the fractionation section which we have not included and a light and recovery section. The document is pretty large. In fact, it consists of first the process information and drawings to define the unit. It is something like a preamble. Then it details the equipment specification.

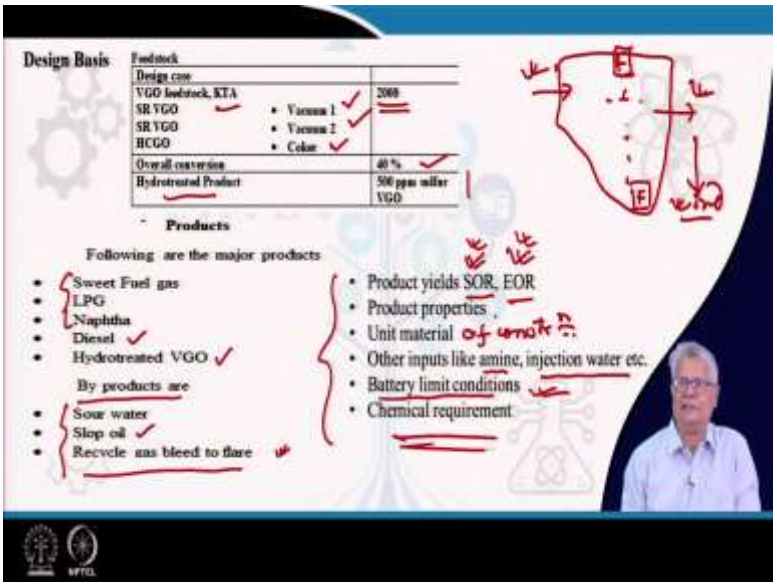
Again these are gross specifications. The gross drawings of showing the dimensions, standard specifications for the equipment if any, the individual P in P and IDs, the material recommendations and the related engineering design information. It does give the instrument index and the instrument data sheets.

(Refer Slide Time: 23:51)




It is the same diagram which is here and we can identify very well this is your reactor section and these are your separator section and we do not have the fractionated here shown.

(Refer Slide Time: 24:08)




The design basis if you look at it is VGO feedstock. It is kiloton per annum KTA. There are 2 vacuum gasoil streams which is coming from vacuum unit 1 and vacuum unit 2 and also you have a stream which comes from Coker, which is the heavy Coker gas oil. The total capacity is 2000 kilo tons per annum. The overall conversion is 40 percent.

So, all these are the general information about the plant and your hydro treated product is supposed to contain not more than 500 PPM or sulphur in the treated vacuum gasoil. The major products are naturally the hydro treated VGO and the light and the diesel and the lighter products are these three. You also have other streams which we should not call exactly by products. It depends on the vendor how they call it you have sour water; that means, water which is contaminated with H2S.

You have a small quantity of slop oil which is a waste oil which is reprocessed later on in other sections of the refinery and you have a recycle gas grid which goes through the flare. You notice one thing, this is particularly true in case of catalystic processes. The yields rather the activity of the catalyst at the start of run and the end of run the start of run and the end of run will be different.

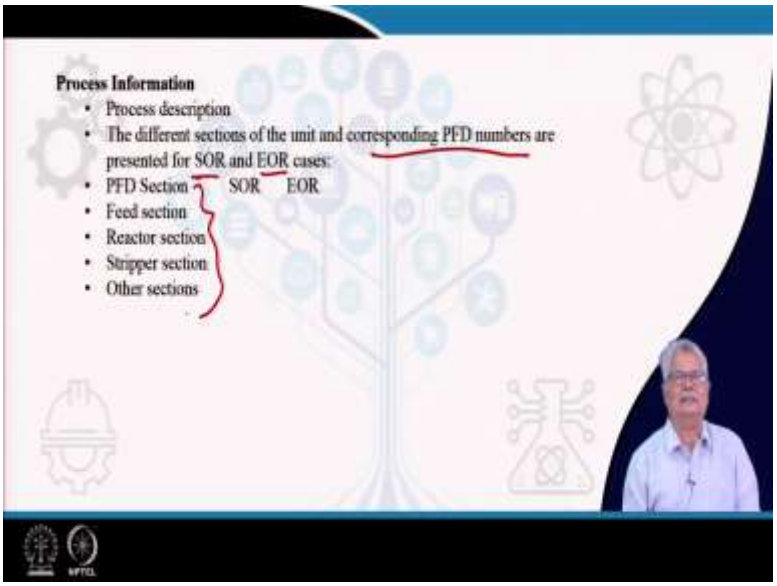
So, the product yields are always to be specified under these two conditions both at start of run and at end of run. The product properties are also to be specified, but more or less it really does not matter because you have to meet the product properties that is a requirement.

The unit material of construction has to be specified. You have seen that there are amine. You have injection water in the various equip various equipment in the PFD, which has been shown to you. In fact, it is not exactly a PFD it is basically a P and ID part of it at least and these also have to be specified.

You have definitely to be satisfied with the battery limit conditions. I had defined what exactly is battery limit earlier, but I just repeat it saying, it is basically the boundary within which the physical plant lies. Whatever crosses the boundary has to be specified quite naturally. And infact, it is this battery limit boundary which defines your plot plan. In plot plane when you say you may have to have provide another some other additional information.

For example, about the wind direction because that is related to safety, because if this be the wind direction you will prefer to have your furnace here, downstream of the wind. You should not have the furnace upstream of the wind because in that case you are subjecting your entire space downstream within your battery limit to chance of fire. The chemical requirement naturally is another important point.

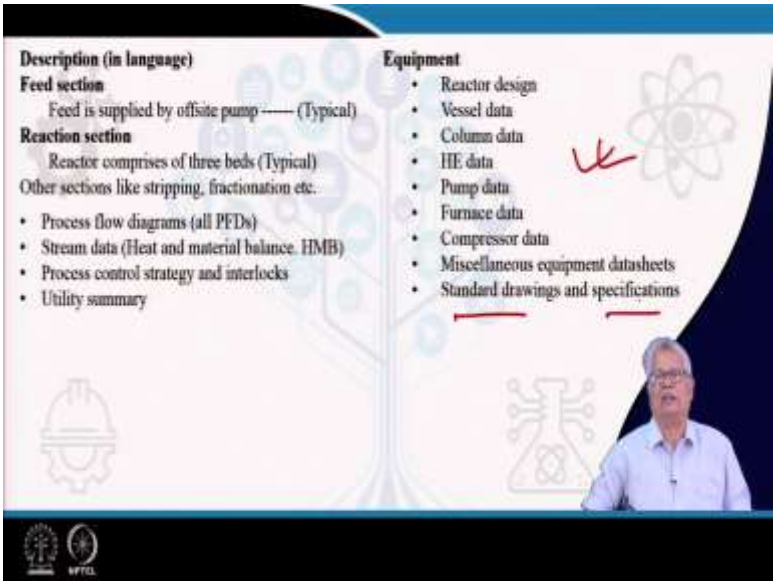
(Refer Slide Time: 27:49)




The process information normally is again I have repeated here, it will be specified in terms of different sections of the unit and quite often in case of a plant like this, you require separate process flow diagrams which are numbered and this PFDs may be different for start of run case and end of run case; why?

The reason is very simple the reason is during start of run and end of run your catalytic activities are different. So, will be your yields you may be having the same amount of product same product quality, but their yields possibly will be different. So, you have sections which will be detailed this way.

(Refer Slide Time: 28:44)




You definitely have a description of the language. For example, these normally at least in this particular process package, there was a description of the feed section. Normally the feed section will also include the offsite pumps, which is a typical system reaction. Section here all other sections like stripping fractionated will also be outlined separately including the process flow diagrams, stream data, process control strategy as P and IDs and interlocks and the utility summary.

The equipment normally will be specified in terms of or rather by using certain forms which are standardized by the vendor. The reactor, the vessel, column, heat exchanger all specified in terms of data sheet so, these are standard data sheets which are to be filled with with respect to individual equipment.

And it must be specified very very clearly along with the standard drawings and specifications. I think this gives you an idea that what you can expect in a complete process package which comes from a vendor and what to look for if you get one in your hand. With this I stop here today.

Thank you.