Principles and Practices of Process Equipment and Plant Design
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Module - 04
Lecture - 58
Process Vessels

Good day to you all. Today, we are going to talk on Process Vessels under module 4. So, what we have here is any process.

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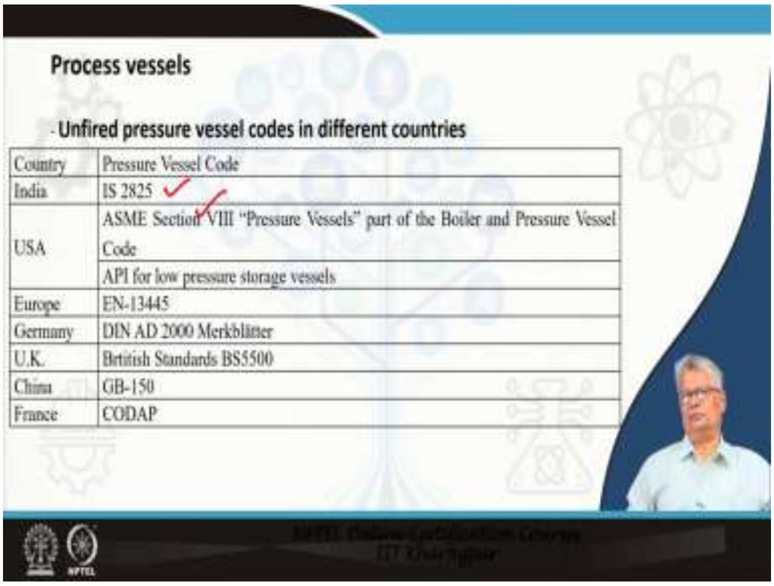

Unit will have vessels. And we write in the first few lectures, we have seen that normally in order to keep interchangeability ease of manufacture and some sort of standardization is always required. And there are quite a few standards which are maintained for these vessels. In India, the applicable standard is basically IS 2825 which is a code of practice for unfired pressured vessels; that means, if I have a furnace, it is not applicable. Or if you have any vessel inside which there is a fire or a high temperature with a flame IS 2825 and the others are not applicable for that.

We have in USA which is also quite popular in India, ASME section VIII which is the pressure vessel section or the boiler and pressure vessel code. For the petroleum industry or rather the hydrocarbon industry in general, you have the American Petroleum Institute for low pressure storage vessels. There are codes from API there are various codes for this as well.

In case of Europe, Germany, UK, China and France, they have their own codes. You have the DIN and these are basically the codes which you will always find. Particularly in Indian context, you will find most of these and most common will be IS 2825 as well as the ASME section VIII, because quite a few equipment which we use in India are serving the technology and the technology which is imported often they refer to the vessels to be designed as per specific codes and ASME section VIII is a very popular one in that. In hydrocarbon industry, extensively you will be finding API codes being used.

Now, I will just add one more line here. The codes specify many aspects of it not everything. And in general, the codes are not very different also these codes will tell you what should be the thickness, what could be the standard material of construction. They will also tell you what should be the inspection and what should be the constructional details and the procedure of constructing it.

They will also tell what are the ways of it reinforcing a particular vessel and they will. It will also talk about the supports to be used for different types of vessels. Indian code also states why Indian. The ASME is also states that what are the typical standard dimension of the vessels which should be used for example, it will say that the diameter of a vessel should be in multiples of maybe, 50 millimeters or something in a particular range So, these are the things which are covered by the unfair pressure vessel codes.

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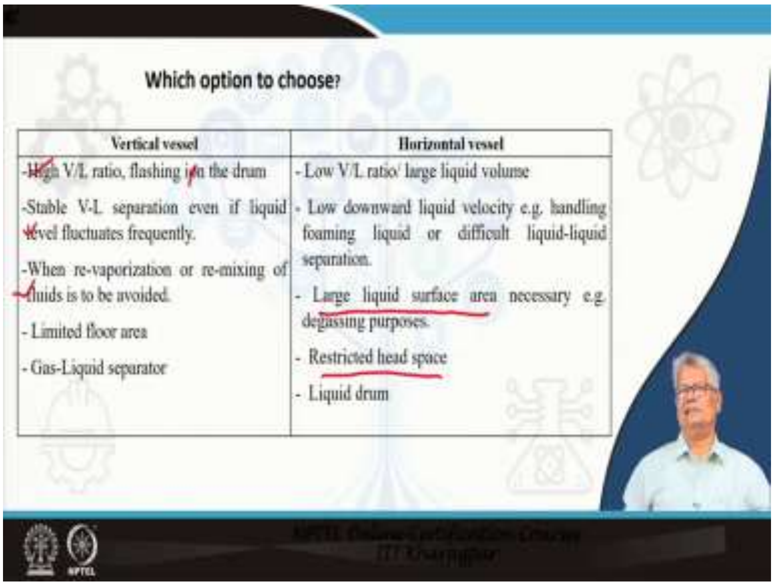

The moment we talk about a vessel, the vessel could be a vertical vessel and a horizontal vessel. You will also note that intuitively, I am talking about a cylindrical vessel. The vertical vessel and the horizontal vessel their features they are listed side by side. Wherever you have a high vapour to liquid ratio to be handled; for example, flashing its in the drum; that means, there is generation of vapour in the drum.

Normally, we will be going for a vertical vessel and wherever you have a large amount of vapour being generated, a vertical vessel with a tall vapour space is normally warranted and normally provided.

If you have a stable vapour liquid separation; that means, the proportion of vapour and the liquid which is there is not much different; that means, you may have the liquid fluctuations and it could be frequent, but the separation of between the vapour and the liquid is fairly stable. When we do not want re-vaporization or remixing of the fluids, we do not want that.

We often use a vertical vessel, because the moment they get separated, the liquid moves starts moving downwards and the vapour starts moving up. And usually, the vertical vessel will have a lesser diameter. So, their velocities would be more and the chance of re-vaporization or remixing is much less.

Its obvious that a vertical vessel will have limited floor space floor area. Gas liquid separators in fact, gas liquid separators are mostly vertical. They are mostly vertical, because they require this feature, this feature and this feature. Now, let us look at a horizontal vessel. Normally, horizontal vessels will be provided with a smaller vapour space. So, a low V by L ratio or a large liquid volume is normally favoured for horizontal vessels.

When you want to reduce your low liquid downward velocity; for example, handling of foaming liquid. If you have a very quick velocity a very high velocity of a foaming liquid which is going down, it will be entrapping some amount of vapour or gas from which it is or some amount of foam and the part of the foam will also go along with the liquid.

So, in some such cases you prefer horizontal vessels; that means, when you have the requirement of separating foam from a liquid or you have a foaming liquid there. A large liquid surface area is provided by horizontal vessels; for example, when some sort of separation of a dissolved gas is taking place. The surface area is more so, it will be more efficiently separating the gas which is dissolved there; obviously, in case of vertical vessel, the footprint was smaller.

In this case, you have a bigger footprint, but it can still be placed in a location where you have restriction on the head space. A liquid drum is a typical application for a horizontal vessel.

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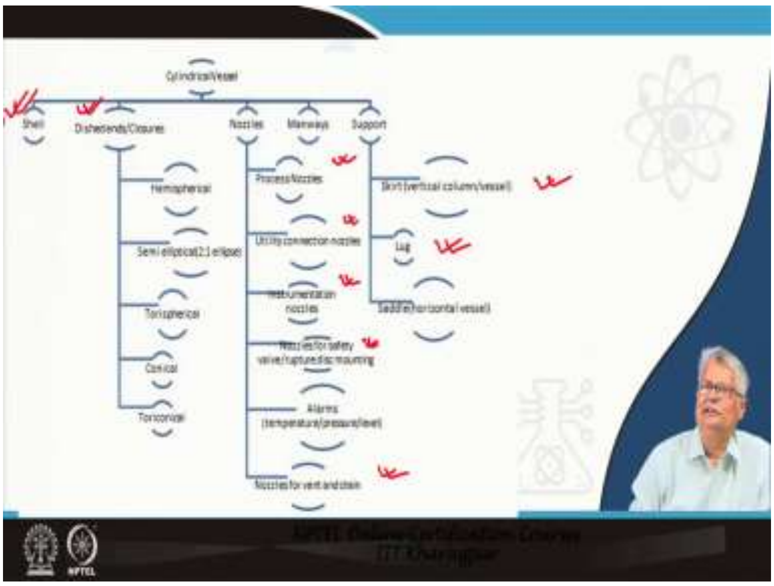

Now, what we do is we. Let us have a look at the different components of a cylindrical vessel; obviously, there has to be a shell. The shell thickness is determined as per the code and the material which is chosen. You will require dished ends or closures you required that dished ends or the closures which could be hemispherical. It could be semi-elliptical. It could be torispherical, which is a very common shape of the head. It could be conical for example, cone roof tanks. It could be toriconical as well. So, all these shapes are defined in the codes; whether it is IS 2825 or ASME.

Now, if it is a vessel, the fluid must come in and it must go out also. So, you have to have nozzles there. So, what you have? You have nozzles for the process. You require nozzles for the utility connections. You require the instrumentation nozzles. You require nozzles for mounting your safety valve or rapture disc. You require alarms for temperature pressure and level; that means, these levels could be this alarms could be for high level alarm or a low level alarm both.

But you require some nozzle to sense these parameters and generate the alarms; obviously, every vessel is to be provided with vent and drain. The other component of a vessel is the support.

The support could be a skirt support, a lug support or a saddle. We will just have a look at these; skirt, is for tall vessels which provides lot of stability. Lug support; it is also known as bracket support. It depends on the code nomenclature. The saddle support is for horizontal vessels and there is another type of support which is for horizontal vessels which is called the ring support. Let us have a look at these.

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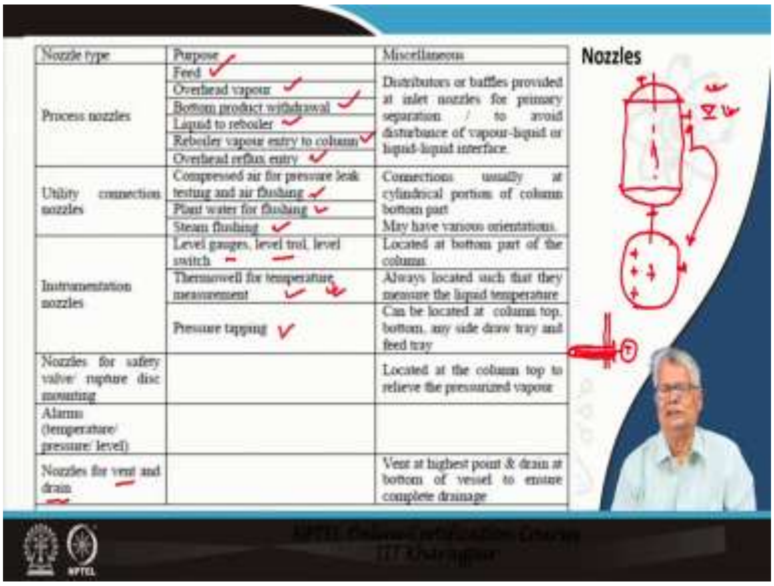

Before we look at the supports, let us look at the different nozzles, because one thing is very true that if whenever you have to design a vessel, as a process designer you are supposed to specify all the nozzle connections. So, whenever I say nozzle connection, it means the size of the nozzle and its location. Normally, in case of a vessel or a nozzle connection, the location would mean specifying its elevation with respect to a standard reference height and also you have to specify the orientation.

For example, if I have a vessel here. If I have a vessel here, which is fitted with a nozzle here, I have to mention the elevation of the nozzle here and possibly I will be mentioning it by writing it down here. I also have to mention what exactly is the location of the nozzle. So, if I look at the plane of this which is a circle which is a circle here, this is the location of the same nozzle. So, what I want to say is all nozzle level has to be mentioned and its orientation also has to be mentioned.

Quite naturally, I will have a nozzle here, possibly I will also have a nozzle here. So, this nozzle will appear it could appear here, it could appear here or it could appear here as well. Wherever it is and whatever it is, the location of the nozzle has to be cleared we mentioned by the process decided by the process designer and communicated for drawing it finally, before it is sent to the fabricator.

Here, we have a list of typical process nozzles. For feed to a column, overhead vapour from a column, bottom product withdrawal nozzle. You have a liquid which goes through reboiler in case of columns; columns are also vessels naturally, reboil vapour entry to the column at the bottom, the overhead reflux entry to the column. So, all these are process nozzles, but this is just a set of nozzles regarding the process there could be even more. And you may have multiple number of such nozzles in a single vessel as well.

Normally, every vessel will have some utility connection; compressed air for pressure leakage checking and air flushing of the vessel. You often have a plant water connection which is primarily used for flushing. You have a steam connection for flushing the unit with steam. You have lot of instrumentation and processes. You require the level gauge, the level troll, the level switch. So, they will also require nozzles. Now, what is a thermowell for the temperature measurement?

Normally, if you look at the vessel if you look at the vessel wall; what you will find that there will be here a nozzle which goes like this and there is a tube which ends here. And through this, you will be inserting your temperature gauge. This particular tube is called thermowell and the thermowell protrudes outside through a nozzle.

So, what you have here is basically a thermowell for temperature measurement. In order to measure the pressure, you have to have pressure tappings. There could be one more at different locations as suggested by the designer. The vessel has to be protected against overpressure which is which could be done either by a safety valve or a rapture disc. So, naturally for mounting these, you will have a safety valve or a rupture disc mounting normally on the top head.

You definitely will be having alarms. The alarms will be for temperature pressure or level and at in adequate at I mean in appropriate positions these are to be provided. The probes for these will be inserted through these nozzles. All vessel must have vent and they must have drain also. Very often you will be listening to this term when you are in industry; high point vent and low point drain.

It simply refers to the fact the vent is provided normally at the most feasibly location feasible location at the highest point in your vessel so that; everything gets vented out from there and the drain is at the lowest point in your vessel.

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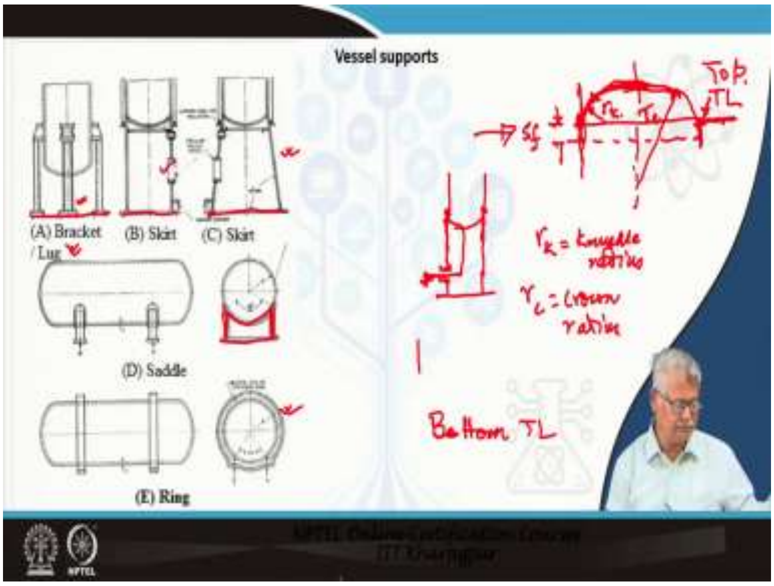

So, for about the nozzles. I was talking about the vessel supports. The first thing the first one is a bracket support or a lug support. The skirt support is basically something like this. If I have a vessel here if I have a vessel here, I will have a continuation of this. In fact, its not exactly a continuation, but its an arrangement which goes like this. Again, a cylindrical support which is a solid cylindrical support which is attached here and possibly what you have here is an access. It is an access through which you can have; you can have your bottom piping coming out.

So, this you can see here. This is the opening through which your bottom piping may come out or if you require anything else to be put in here, that can also be connected here. The same thing you find here as well. The skirt in this particular case you are trying to guard against its tilting over of the vessel. So, you have a larger diameter at the bottom and a smaller diameter at the top.

You have a saddle support. These this is basically the saddle and actual support is through these members and there is a base plate and the base plate is there in each case in each case. And you have anchoring bolts here. You can see the anchoring bolts being marked to fix this particular base plate to your foundation. In case of a ring support, the support is all through the support is all through that is why its called a ring.

I would just like to add one more thing here. It is also a definition. In case of heads, what I have if you look at a head. I will put it like this. You normally will have an arrangement which will look like this. You will have. This is the centre line of the head. A portion which is cylindrical. It is called the length of the straight flange; that means, the head though curved as it appears will normally have a straight flange length and this part of it is cylindrical.

Then what you have is another zone where its rather highly curved and naturally, this is the radius which is called what is it called? It is called a knuckle radius oh sorry. This is called the knuckle radius. What you have here. You have after the knuckle radius zone finishes, you have a less curved zone where the radius is the crown radius. It is obvious, because it is a radius of curvature for the crown section.

So, what I would like to say here is though it appears, but still, you should not miss the straight flange length. You will also note one more thing that is if I extend this; if I extend this, actually this it is a tangent to this particular curved section the knuckle at this particular point.

So, I would like to say here this is a point which is where this straight flange is a tangent and this is a tangent line. When I am talking of the top head, it is the top tangent line and it there will be a similar thing for the bottom head and that I am going to call as bottom tangent line.

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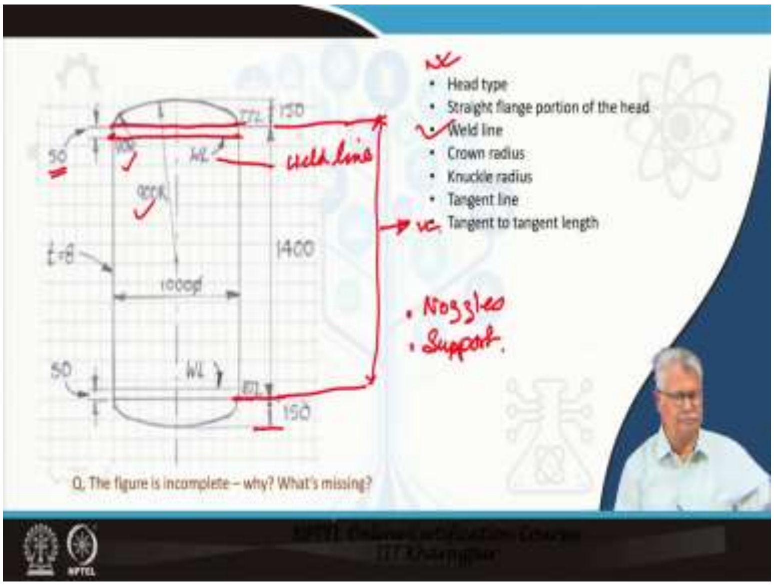

Here, we have a sketch. The head starts here the head ends here. It is welded to the shell along this line. So, this is the weld line. What else we have? This 50 millimeters is a length of the straight flange for my head; here, as well as in the bottom closure. The nominal diameter; the nominal diameter is 1000 millimeters here. I have shown you the bottom tangent line and the bottom tangent line is ending here. The crown depth is 150 in this case. In this case also it is 150 in the upper one. And similarly, the top tangent line is this.

So, we have another new term here which we are going to call as the tangent-to-tangent line which is this distance between the top tangent line and the bottom tangent line. I believe this will give you an idea of the nomenclature. The crown radius in this case is 900 and your knuckle radius is 90.

Now, I just have a question the figure is incomplete why what is missing. Let us list it out. Nozzles, support anything else head type you have not mentioned. So, these have to be included and in order to describe for fabrication, you are supposed to make a hand sketch of this along with the required number of views. In most of the case, a plan and elevation suffices and you may have a general arrangement requirement, if it is slightly more complicated.

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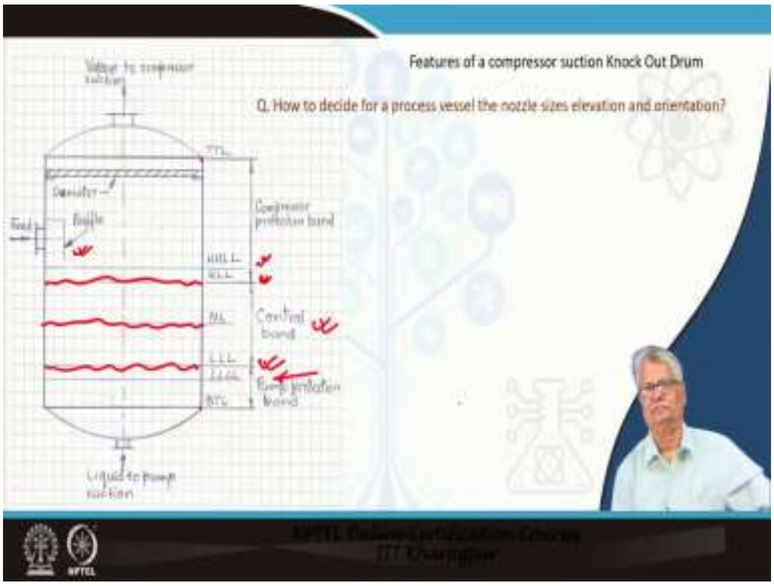

Here, we have the features shown for a compressor suction knock out drum. The feed comes in. Now, there may be particles which are present. You have seen that whenever the reflux enters the column top in case of distillation column features, there is a baffle which ensures that whatever comes in does not go too far and it hits the baffle and the liquid falls down. So, you have a similar baffle here also. You will also notice a few other things in this particular case. This is supposed to have both liquid as well as gas.

So, the BTL and the top tangent line; they are all marked here. Normally, what you expect is a normal liquid level which is denoted by NL. There is a maximum limit of this particular liquid level also. So, this is the high level and there is a corresponding minimum liquid level. You normally is expected to operate within this control band.

Now, whenever your level comes to the high limit or the low limit, possibly you will have your alarms associated, but there will be requirement for a trip of the compressor. So, that if your level goes high you may have to trip your thing, because you have to protect your compressor as an equipment and no liquid carrier goes in the compressor suction pipe. Similarly, you may have a low level indicator here, which may or may be associated with a trip. It all depends on the process which is taking the service from here.

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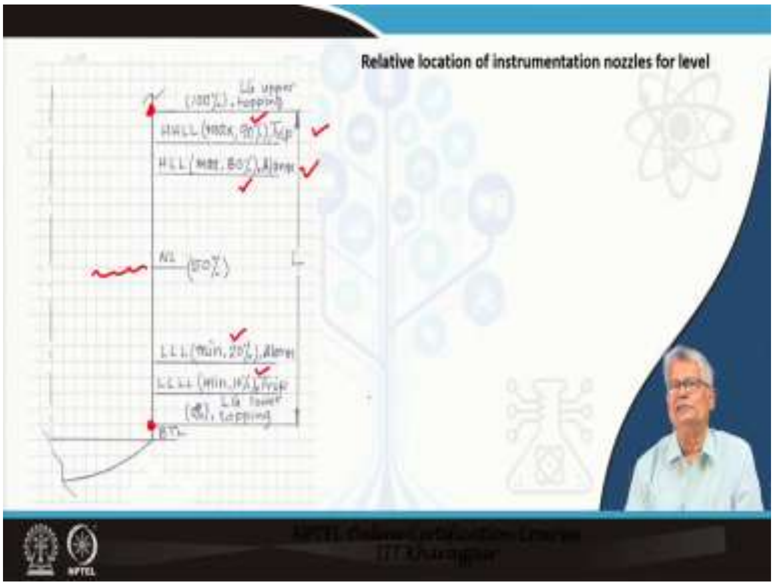

Now, what we have here is a similar thing. Here, we have a column. Normally, you will have a normal level. The level usually is measured by either a differential pressure measurement or any such thing, but normally you will be requiring two tappings; one the upper tapping at the lower tapping.

The upper tapping if it is at 100 percent elevation with respect to the lower tapping, the meet is normally the normal level. The typical alarm and the trips are at 80 percent and 90 percent level. The minimum level alarm is at 20 and the trip is at 20. So, these are the relative location of the instrument nozzles for level.

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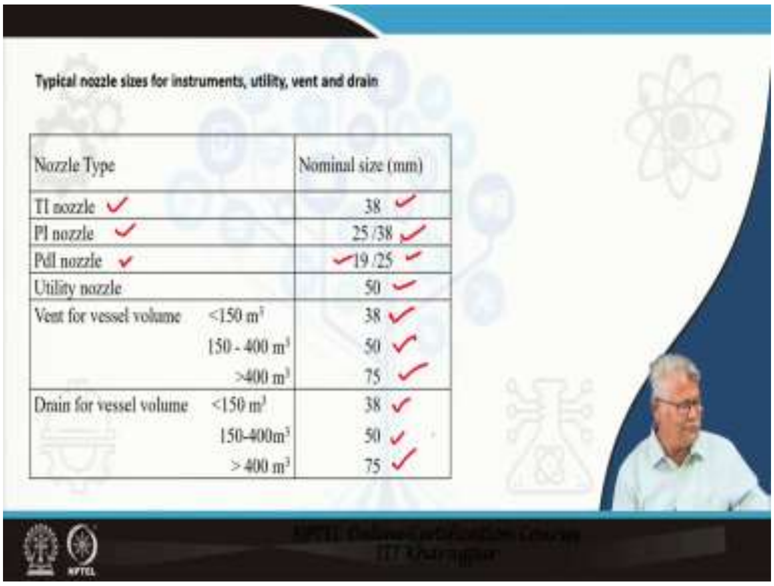

Next comes regarding the nozzles; how do you know the sizes. For temperature, measurements; you usually use one and a half inch nominal taps which is 38 millimeters. For pressure, you use either 25 or 38 millimeter taps. The differential pressures are either 19 or 25 millimeter. Utility nozzles are typically 2 inch which is 50 millimeters. The vents the size of the vent depends on the volume to be vented which is directly a function of the vessel volume.

So, you have either a one and a half inch 2 inch or even 3 inch vents. The drains similarly will be of different sizes for different different nominal size of your vessels. It could be 38, 50 or 75. I believe that with this you have an idea.

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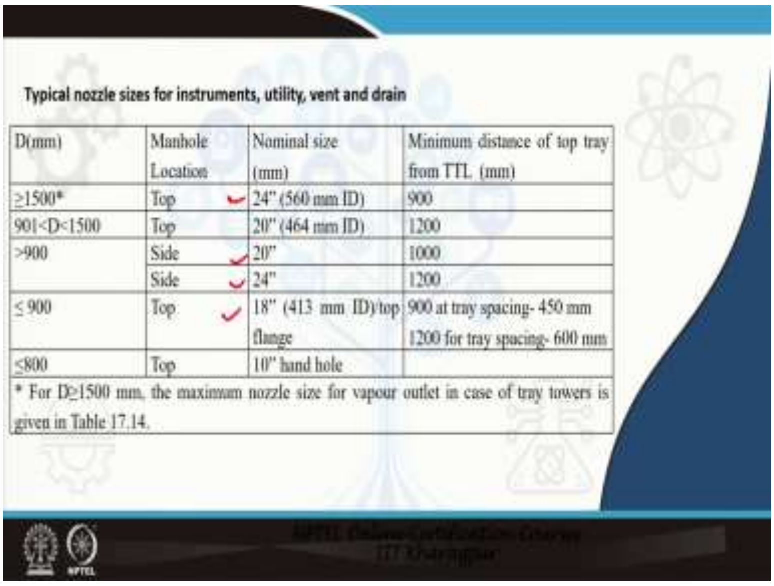

Typical nozzle sizes for instruments, utility, vent and drain

D(mm)	Manhole Location	Nominal size (mm)	Minimum distance of top tray from TTL (mm)
≥1500*	Top	24" (560 mm ID)	900
901<D<1500	Top	20" (464 mm ID)	1200
>900	Side	20"	1000
	Side	24"	1200
≤ 900	Top	18" (413 mm ID)/top flange	900 at tray spacing- 450 mm 1200 for tray spacing- 600 mm
≤800	Top	10" hand hole	

* For D≥1500 mm, the maximum nozzle size for vapour outlet in case of tray towers is given in Table 17.14.

That what to have for your instrumentation nozzles, but there is a question. Now, that there are other nozzles that will also be required; that is for your process nozzles. Normally, the process nozzle will be the batching the size of your piping and we have talked about the allowable pipe velocity which is used for draining which is used for sizing pipes and it is what you usually have and that part of it is already done and you already know it.

The manholes location and the nominal size are important. So, you have mostly the manhole locations at the top and we also have talk and this typical sizes here are 18, 20, 24. And this is a suggestion that what is the typical location from the top tray if its a tray column. I believes with this, I have been giving you an overall idea that what a process vessel is what are the features it should have and it is time that whenever you go for your design, you first look at these list out the process requirements the functional requirements.

Beyond that you start making a hand sketch locating the nozzles and all other features that is required for the functionality as well as safety of your vessel. With this, I close today's lecture.

Thank you.