RAC Product Design
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Lecture – 14
New Product Launch Process

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So, welcome everyone this is our final set of lectures. What we are going to look at today is the New Product Launch Process. So, we have looked at different components, we have looked at a case study last time, and we discovered how there were certain things that were not factored in the design in the initial stage and there was a very costly way of learning. So, when, we look at companies that manufacture a huge number of products say window air conditioners, split air conditioners, then the stakes are very high. We cannot afford a scenario where we discover field issues and then have tremendous costs of product recall and replacement.

So, what is it that companies do to prevent any product risk, how do we ensure that the product meets its intended, functional and reliability parameters. So, most companies have a process. And I look at I will share with you one of the ways of looking at it in four steps. So, this is common across companies and they will refer to it as by different names. But remember when we look at a lead time of 3 years for a product launch, it means a lot of painstaking effort goes into collecting customer requirements, validating

them, structurally documenting them, and then creating evidence that the product meets those requirements. So, the quality of inputs at every stage of the process is very important and there has to be ownership.

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So, we can look at four major reviews in a new product launch. So, the first one is a technology review. Let us say we want a new product and in marketing could have a wish they wanted a product that can provide 4 hours of backup say for example, whether or not it is feasible at what cost will it be feasible? So, the first stage of any product introduction is a technology review that looks at what are the alternatives and what is the level of complexity what kind of prototyping effort has to be done.

And then we generate a test plan. So, in the test plan there is a development of technical plans, then there are parts and sub assembly level analysis and reliability tests. And, then we define what would be a test and qualification plan. So, a product in the US may have a different set of qualification, product in Saudi will have a different set of tests and qualification plan and, so will have product in India. So, it is important to map those requirements into a document. And then have approval processes by which those tests are agreed between different stakeholders.

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Then the next stage is the third stage is the design freeze. At this stage, we have evaluated design capability and readiness. So, which means all the work that was done in the first two phases leads to clear evidence that the product, will meet the intended objective. Then we do some FMEA and technical risks. So, what can happen to the product? In a new product launch, what are the risks we need to be aware of let us say in a country like India.

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Sorry.

Student: (Refer Time: 03:49).

Regulation ok, but that normally will be documented and you know it will be one of the first things to be addressed. Something like in our case study we looked at vibration induced failure. So, what is it that is not so clearly visible evident; it requires an engineer to think through and validate that risk.

Student: May be that conditions in which the (Refer Time: 04:12) from the conditions may be (Refer Time: 04:14).

So, give an example, they can lab to test the air conditioner at certain indoor conditions, we will use a standard. So, the standard will say 2719 indoor for performance. And, then it will raise it to 3524 as per the Indian standard for adverse operating condition test.

Student: (Refer Time: 04:35).

Yes. So, dusty environment means the condenser coil may be choked. It may perform, below it is functional perform right

Student: (Refer Time: 04:50) normally the air conditioners will be kept in a open area.

Yeah.

Student: And this is a how you might equate in a area which not so.

Correct very good perfect

Student: Not in a (Refer Time: 05:03).

Right, very right, I will elaborate. Many times, we see an air conditioner where the inlet area to the condenser is almost choked like there is hardly any gap or we find a condition, where the condenser outlet is blocked. So, at a short distance, there is a wall. And, the hot air please keeps its re-circulating. So, while the ambient may be just 45, but what the air conditioner sees is something in the region of 50, 55 when it begins to trip.

So, good, now I see that some of you started thinking, think more voltage variations. So, together with a high ambient when more air conditioners are running the grid begins to get stressed. So, we will have a condition of a low voltage. So, when we look at these scenarios, then we began to consider a test plan that will give us evidence that the product is sufficiently robust, some of it will come from products that have already been launched and have been successful.

So, we will say find this product is running fine. Let us do a stress test and see whether it can withstand just plus minus 10 percent or do we need to go below. So, for example, in residential air conditioners, the norm was to meet the IS standard. So, we look at the IS standard it has a condition for adverse operating test condition that is plus or minus 10 percent of rated voltage. So, the standard you can comply to the standard by doing a test at minus 10 percent of rated voltage 230 which will be 207 and then you can do a test at

253, 230 plus 10 percent at the adverse operating condition. And you can assume that this product will work fine right, because you met the standard. An engineer can say that I took here is the standard have done it, but in India the conditions are different.

So, most companies will create an envelope which is representative of the condition in which the real conditions in which the product will work and then have a margin around it. So, what do we do for residential products in India single phase products, we see the voltage is going down to 195. So, we devised a test where we will test the product at a 195 at the worst condition. And, then we stress it by switching it off giving a reasonable time period of 3 minutes and then switching it on, and being sure that it will work that is one component of the reliability test that will ensure this product will work as intended in the real environment. What it means from a business perspective is the number of service calls that you want to get, the cost you will have in people going to customers finding out what happened and then just educating them all that is covered. So, you have a smooth product introduction.

Then other things are noise. Now, when we look at noise we look at it from a standard perspective. So, we can test a product and a noise test room and we will define a number. Now, what happens in real life when the compressor starts and stops? There is a noise and that noise is dependent on how robust is the installation, again with residential products and particularly window type. So, what do you do? Again the mountings of the compressor and the chassis has to be tested and there has to be or the right level of isolation to prevent those shocks from creating nuisance for the user. So, scenarios like these are mapped into tests at the design freeze level.

So, when we create a document which is mapping the market requirements, customer requirements, we would have done some competitive benchmarking to establish what the product will have unique versus others. So, all that is put into a document and then the design team is taking ownership from that point onwards of meeting that spec in a defined time and cost.

So, then what do we do next we look at production release. So, when we go to a production release it is a very formal process where a combination of people from manufacturing, marketing, design and supply chain are together reviewing into what the design team has done. And, then there is an assessment of the level of risk that is there.

In some parameters being either partially met or requiring more time and cost. So, I will share with you an example from a product that we introduced in carrier.

It was a window air conditioner we were and taking a compressor change and the compressor change would pass through, if we just looked at conventional standard tests, but we when we benchmarked with the reciprocating compressors beyond the test framework. So, if you if you are looking at going to 185 or 190, we found that there was a challenge with the compressor. And, then there is a big question of cost. So, here there was a cost of 5 dollars which would have to be included in the product, if we had to make it as robust as the current solution.

So, in those scenarios, where there is not good common basis for agreement field trial is undertaken. So, what we did was he put some units in the field and we very quickly discovered that the standard compressor would not perform in the Indian voltage and installation kind of conditions. And we discovered that we would not be as good as competition. So, what competition was facing as a problem would be there with the new product. So, it was a quick learning with just 100 units and feedback collected from the field and that was integrated and we did take that cost increase to make the product more robust.

Then when we go for production release the manufacturing guys need to be happy to produce the product, which means their tooling their ability to give the right output in terms of number of units per day integration with assembly jigs and fixtures they needed all that is an essential part of manufacturing accepting from design that they are ready to produce that product. Then a production release also services essential requirement.

So, the service guys will need to at some point in time either attend to a leap or attend to electrical problems or do compressor replacement. So, they get an opportunity at the production release q r b to be able to give their opinion and these stakeholders in a process that leads to product release. Now, this even notice is very different from what we discussed in the case study on railways, which was a more be to be environment the customer requirement is pretty much there, there is more involvement. And then the risk is jointly taken, because it was being done the first time and here there is a formal process maybe a few 100, 1000 units will be in market in a few months. And the level of resource that is dedicated for test and qualification is very, very different.

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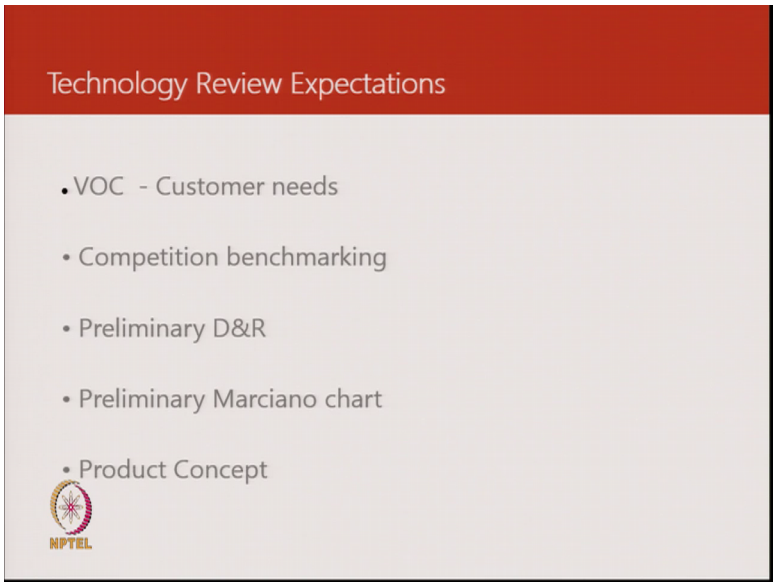

Now, during a technology review I have put in some bullet points. So, customer needs are mapped and addressed. So, what would be a good example of a mapping voice of customer into a technology review? So, here again I will give you an example. Residential product and there is a need from the market that we need to integrate fan operation with the electronic controls.

So, we all used to using an air conditioner and then you know having a sleep mode, in the sleep mode takes care of the temperature increased in steps of 1 degree over 2 hours automatically. But what would it be like if we cut down the power consumption by switching of the compressor, let us say at 3 or 4 o clock based on user preference and we switch on the fan. So, it is a new feature, it can differentiate a product and what would it take in terms of integrating it into the control logic.

So, it requires the marketing and sales team to interact with a few customers using focus group studies including that agreeing to it, and then there is a cost assessment. And when we are doing a new design the relative cost adder is small, because making a change in the program putting an algorithm putting a relay is almost insignificant cost, when we are having the resource. So, the controller can be programmed you can put in options and all that was quickly integrated. And this became a part of a global design although the feature is not available it is an optional feature.

So, the time the product was launched it was not included, but, but this is an example on how voice of customer can be integrated in the stage of technology review. And then of course, it includes competition benchmarking. Then there is a basic. So, when I say D and R it is design and reliability spec, which maps what we talked about in a Marciano chart and then a product concept. So, some, some assessment on how the product will look like. If you are going to at a high energy efficiency ratio what are the means to getting, there is it a higher efficiency compressor, is it a larger condenser coil, are we using some other new technology means all that comes in.

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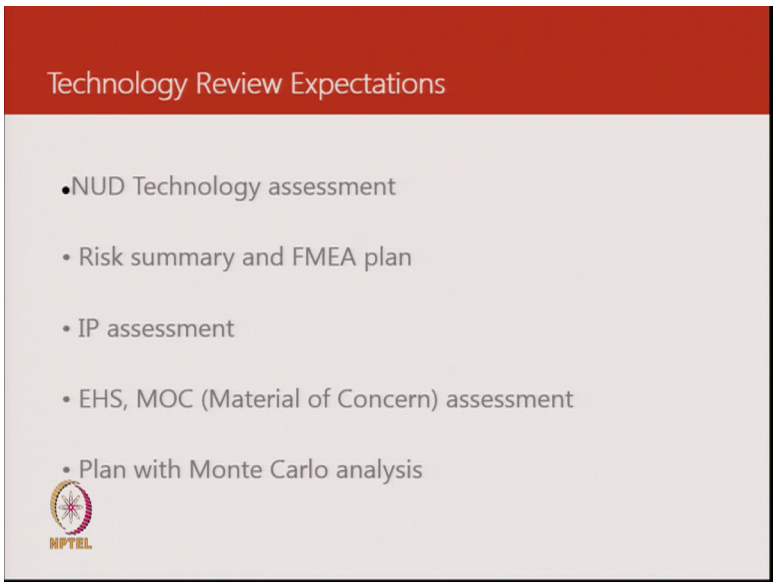

Then there is an expectation of what is new unique and different. So, we want to look at a case study in which I will share with you a particular feature, which was new unique and different. Then summary of the risks, if there are any patent issues need to be looked at and then there is a employee health, and safety. So, what are the materials that different operators would get exposed to during the manufacturing this product doing manufacturing and again during service or the end user. So, this again gets into very formal process.

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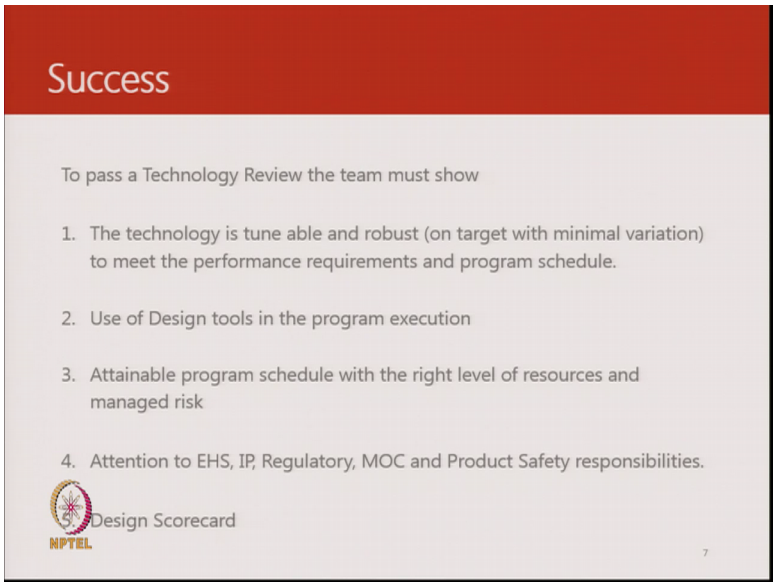

Now, for a technology review to be successful, the technology has to be tune able and robust on target with minimal variation to meet the performance requirements and program schedule. So, here it is a group of management people who have experienced, but are not directly involved in executing the project. So, there is a project team and then there is a group of people who are going to be saying yes or no. So, success means they get approval from those people.

So, when we have a senior group with experience, but having no direct stake. And they are the people, who are approving and going to the next level and the approval is significant, because it means spending resources, money and prioritizing that project over several other things that the company could be doing. And then there is a process of using a design score card which determines what level we are achieving the intended parameters.

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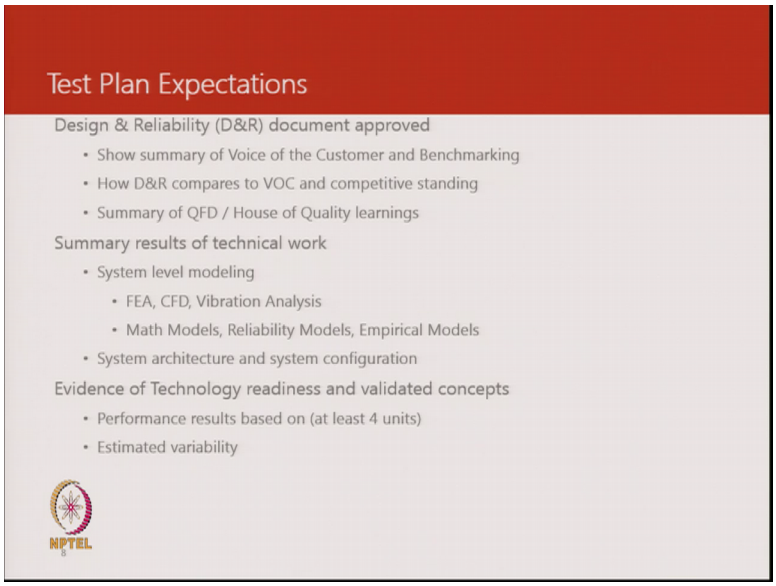

Then in the next stage test plan expectation, we have from a draft design and reliability document we go to a firm and final reliability document. Summary of voice of customer benchmarking; so, all that we said, we will do, we have done in this stage and then management is happy to accept those results for going forward ok. Then we would have some system level modeling to predict what all variants can come out of a product. And then when we say system architecture and configuration, so many a times you will see and this is very similar to what happens in automobiles happens in air conditioners also. You have a platform, which is known to address three different markets.

So, the window air conditioner product I am talking to you about was addressing the market in Saudi Arabia, India and Brazil. So, now, these three countries have their own set of a unique standards which are local. Then the voltage is different in Saudi and in India, and for that we will need to have some modularity. So, we could have the same heat exchangers, but we would have different compressors.

And then if we were to have variants of high energy efficiency product, then we would have a high efficiency variant for each market, so that is what I mean by a system architecture and system configuration. And then validation of concepts performance results based on at least four units. So, to avoid any kind of experimental error or something happening because of very, very unique components, variation is addressed.

So, we talking about achieving a particular energy efficiency ratio or cooling capacity, it is not enough to just have one prototype. You need to see what is going to happen with 3 or 4 units what is the level of variation that will have going to happen. Can we guarantee that the product which is coming out of production lines will be within reasonable tolerance levels, so that is why we look at more than a 3 units.

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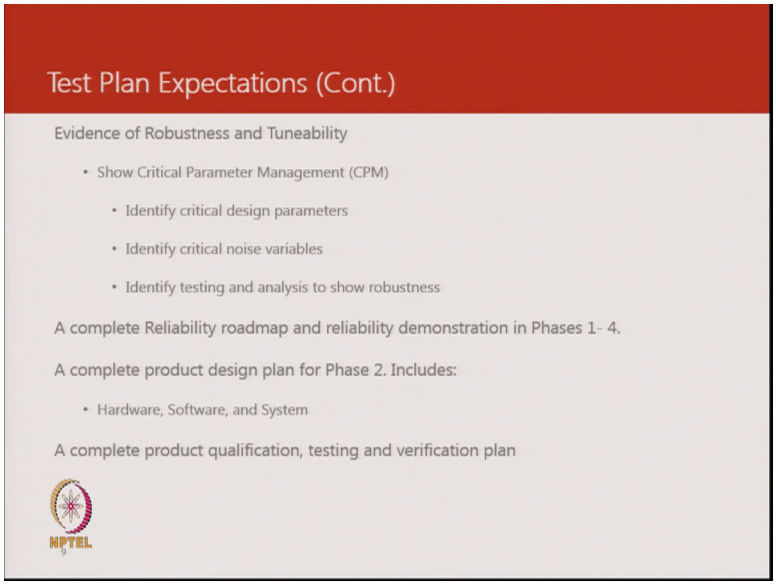

Then we touched upon robustness and clean ability a little while back when we said we do tests at lower voltages than the standard may require we try and map what happens in the environment. And then we also need to demonstrate reliability roadmap, so that could include doing stress tests on individual components as well as the whole product. And I will touch upon some of those desirable tests in the next slides. And then, if there are new software's to be developed, so while air conditioners look like a mechanical product, but the control algorithms that are there involve electronics and then there is a lot of feature integration that happens based on those algorithms.

So, to give you a glimpse and you may have an algorithm which ensures that the compressor runs for a minimum of 3 minutes after it starts or a minimum of 1 minute after it starts, so that oil returns back. And when it is switched off, it is off for a period of 3 minutes, so that there is no stress, because of pressure difference across the compressor. So, these are two examples and the sleek mode which is a function again requires electronic integration.

So, an algorithm with and what period of time the temperature will rise. Will it rise with reference to the set point, will it reset to the set point after the cycle is over? So, the moment we start getting down into details of product design and executing it, there is a lot of formal agreement that needs to be reached for individual teams to work in parallel.

Now, finally, we have a complete product qualification testing and verification plan. So, this product qualification testing and verification plan will not only address external standards that must be complied with from a regulatory perspective, but also the reliability tests that have been assessed internally and any unique feature integration that has been a at the design stage.

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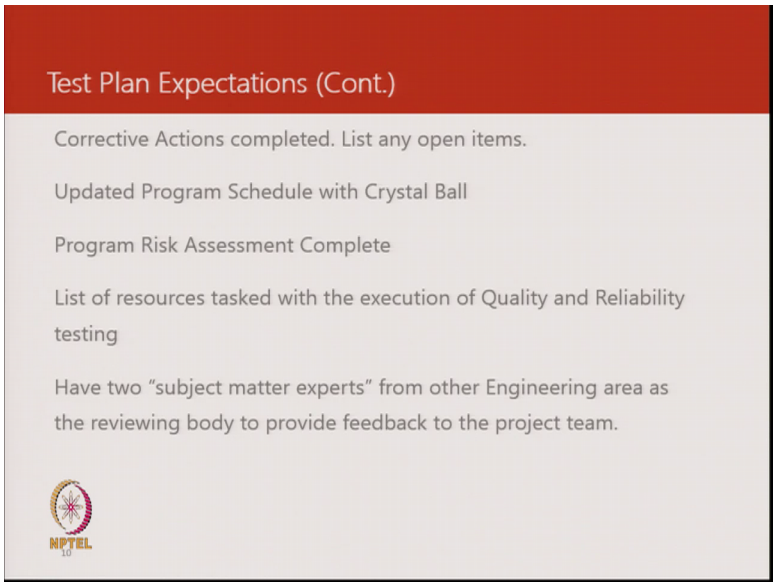

Very often things do not go as expected. So, when things do not go as expected, there is a corrective action; and normally there could be time and cost implications for that. So, there would be that will be listed and agreed to in terms of approach. Any risks to program should do. So, very often we see that and there is a motor, which is having a risk of failure because of rain, you certainly discover it has some holes and you need to change it. So, there is an implication on the supplier availability of that particular part, what will take for him to modify and get back it has an impact on when the product is available; again things that come up in a formal review and are openly documented and agreed. And then one of the ways of keeping this whole thing very objective is to have to

subject matter experts who are not connected with the project evaluate and give their assessment.

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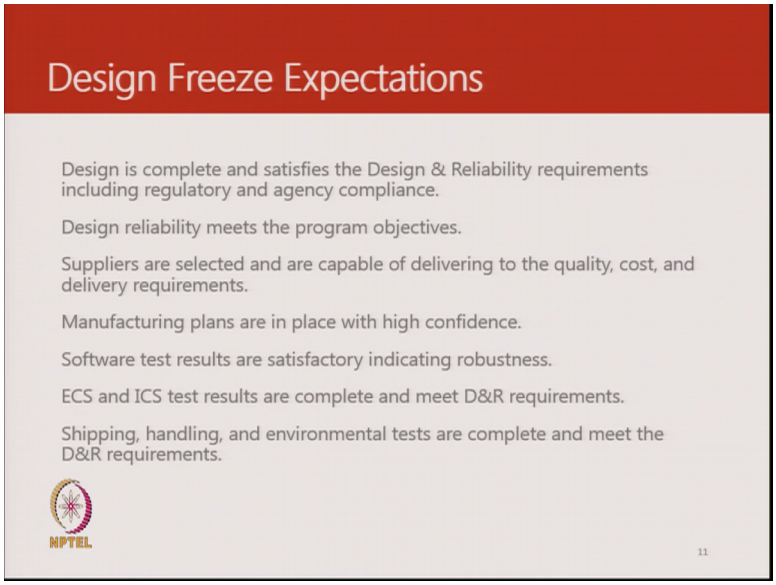

In some of the terminology here when you are looking at freezing a design is that all the reliabilities (Refer Time: 21:02) discussed suppliers. So, supplier selection and capability is another important part. Before we can get down to any realistic estimates of a volumes that can go to market when we say ECS as it is an engineering check sample and test results are complete. So, engineering a check sample is different from the initial check sample which is more closer to a prototype and unit sample means they can be reproduced you have more than three or four units.

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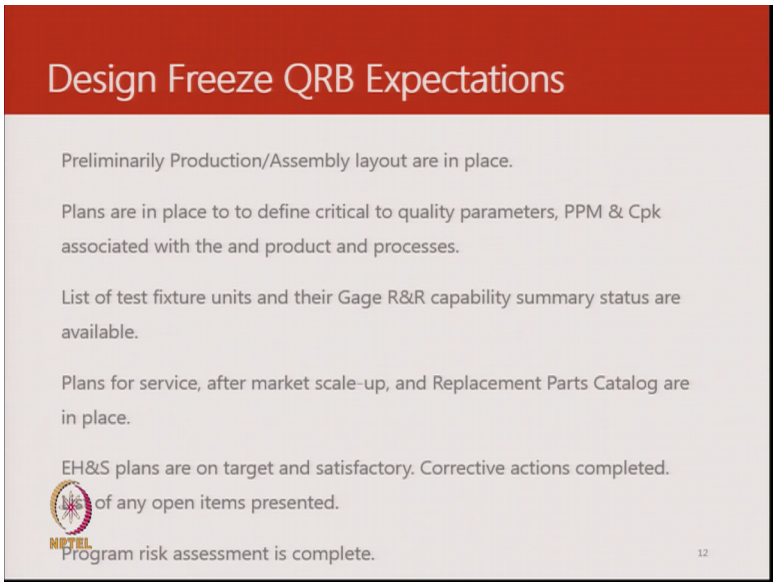

Then we talked about production assembly layout. So, if there are changes, so very often we introducing a new product of the refrigerant change, it would require a new charging station, it may require a new approach to handling how the unit is going to be charged. It might mean shorter exposure of the product to air. So, when we move from a mineral oil based refrigerant like R 22, short exposures to ambient air are not very critical, but the moment we go to refrigerants like 410A the oil that is used for lubrication is very hygroscopic. So, operators were used to handling it the old way end up spoiling the compressor, because the short duration of exposure moisture gets and it binds with the polyester kind of oil. And then we see performance impact.

And the same thing applies for service wherever there is a change, a new feature leading to a different way of servicing the unit we would need and then, proper documentation in the parts catalog ways of removing and replacing components. So, as you can see the whole thing is very formal structured when we look at high volumes and high risks.

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Now, earlier we were looking at mapping the operating environment. So, I put down a few other things in addition to temperature and loads as a refrigerant migration, and start stop situations. So, we typically would not use the air conditioner in the month of November to say February. And in that period, if the outdoor unit in a split system is in a cold environment, the refrigerant tends to collect inside the compressor. And then the first time we started, the oil together with the refrigerant goes out of the compressor leaving the compressor without any oil and that can lead to quick seizure and failure.

So, those kinds of tests can be envisaged. So, what is normally done to replicate that scenario as we create a condition where we put ice around a condensing unit And we let it rest for a period of 24 hours. So, the compressor in the condensing unit exposed to something like 0 degrees centigrade for 24 hours. And then we run the compressor, and we get special compressors where we can monitor the level of oil. So, to be able to verify that this product will not have a risk, because of refrigerant migration, we need to guarantee that there will be a certain minimum even in this worst scenario. Once that happens then the product is allowed to go forward; otherwise, it is reset do what it takes to get the compressor robust enough to handle liquid migration.

Then some of the start stop scenarios can be again unique. So, when we normally consider a product, it is expected to be a one or two unit installation, but many times the same product is installed in hotels or restaurants, where there are 10, 12 units. All of

them coming on at the same time put a heavy inrush load on the grid or on the transformer or whatever is the connection. So, this again can be looked at and what can be a feature which can stagger their starting.

So, you have a power failure and then all 15 units 100 units want to come on at the same time what can be done are they are staggered. Again there are features which can be integrated into the electronics algorithm. So, you have a random number. So, one of the units will start within a second, another unit may take up to 10 or 15 seconds this will be depending on how you program it. You can make it smarter and, and then prevent adverse situations coming up.

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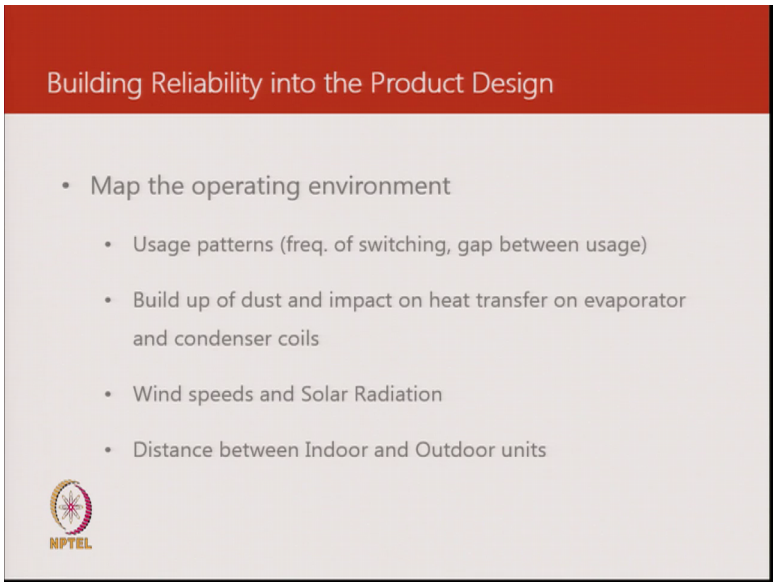

Then one of you already identified this risk buildup of dust, and how it can impact so probably we are talking about condenser, if the same thing happens in the evaporator. It happen in the evaporator more, because the evaporator is wet. So, first the filters catch the dust. And then, if we continue to delay cleaning the filter some of the dust goes onto the coil and begins to create a thick crust. And then the heat transfer gets impacted. So, we came to see the unit operating at lower pressures cooling is impacted you might even have freeze up or frost conditions on the unit.

And then when we install a unit outdoors what all can happen; it was very windy in a coastal area. And you, if you have the fan opposing the wind; obviously, something we will not encounter in a test room condition. So, what are the things we can do there?

Right now, I am not aware of manufacturers addressing this by a design very few environmental chambers that can create artificial wind scenarios probably a few in the US otherwise, it is not something, it is addressed more by recommendations and the time of installation or for large units we make the condenser air discharge vertically. So, no matter what the wind direction it is only going to help the air get into the condenser and discharge.

But something to keep in mind that not every site is conducive to a vertical air discharge. If it is in a shed the height available above the fan could be. So, there are for example, designs where you can create a horizontal discharge condenser and at site you can just modify it. So, you can relocate the fans. So, so you have a box and the air is taken from one side being thrown to another, and then it is not conducive to site. So, you can remove the panel and put it on top; not all units have this feature functionality built in, but it is there are some units which are keeping this in mind. So, you can do it at site either vertical or horizontal. And that is how you address some of these limitations by design. Even after installation you discover this to be a problem in a unit which has that modularity and you know the convertibility built into it, you can just remove one panel swap, it with another. And you overcome a constraint and you have a reliable product operation.

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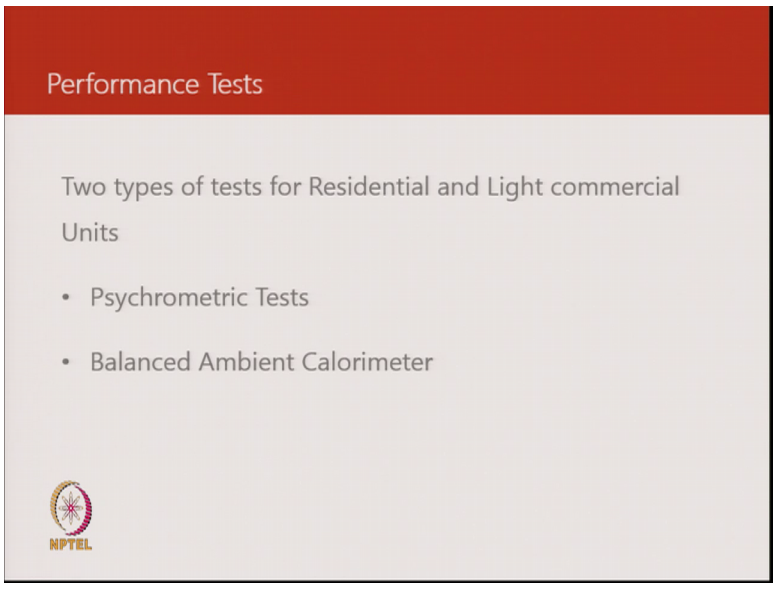

Then I think we have not discussed any time the type of tests we can do for checking performance. So, there are two types of tests for residential and light commercial units one is a psychometric test not the psychology one, but the psychometric. And the second one is the balanced ambient calorimeter. So, psychometric, if you have done anything in thermal, you might have seen some, you have had exposure.

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Right

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Psychometric chart you have exposure, but test. So, is the type of test where you use the principles of psychometry.

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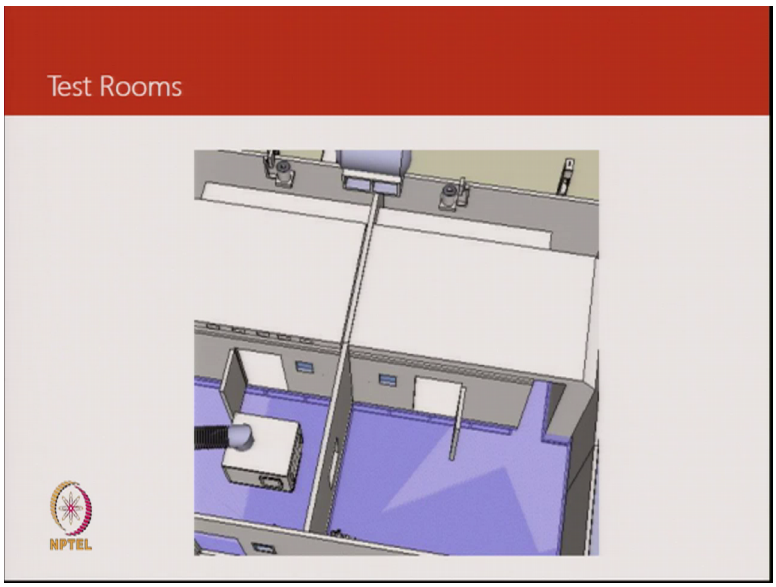

So, what we do is so let us say we have a chamber like this. So, one of the chambers is the hot side, another chamber is a cold side. And we measure the flow of air by using a duct. So, there is a standard which specifies the diameter of the duct. And then through the duct we have the entire airflow of the unit go through the duct. We neutralize the pressure drop in the duct by putting in a booster fan. And this requires a certain technical capability to measure the static right at the outlet of the unit, so that when we are testing, we are not disturbing as the unit would operate if there was no duct. So, to the unit here

is going to come into an opening which is in the wall. So, this separating wall and let us say this is a window unit, it gets connected to this wall.

And then there is another side way we have a duct. So, the duct connects to the supplier portion of the unit. And then inside that duct, there are there is a chamber which has nozzles in it. So, the pressure drop across the nozzles gives us a very accurate indication of the total air flow. However, if we just put the duct, we would have changed the unit from its normal operating condition, because it is going to overcome the resistance in the ducts.

So, therefore, we put a booster fan and the booster fan flow rate and or rather the static pressure of the unit is adjusted to 0 at the outlet, so that we replicate the condition as the unit would operate if there was no duct. So, that gives us a measure of the flow of air. And then from the psychometric chart, we can get to know the enthalpy of air at supply condition and at return condition, there is a condition in which we maintaining the room.

So, this difference the density of air and the two conditions would give us the rate of cooling. So, this is one method. This is the method which is used in development of units. So, in all air conditional manufacturers first when they are doing prototype tests which is initial check sample or engineering check samples would use this method. When it comes to compliance to standards, then the method used is a balanced ambient calorimeter.

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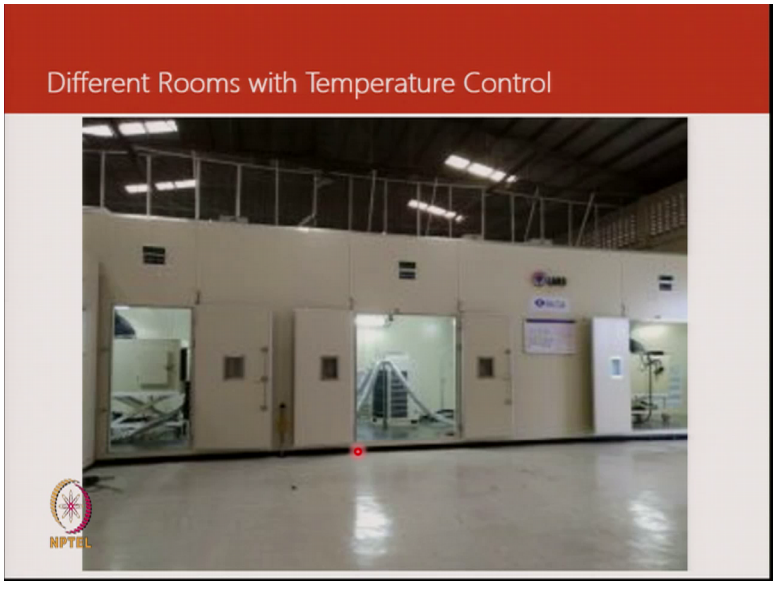

So, what is in the next picture? I can show you some examples of typical test rooms and so here this is a unit where there are different rooms with, different temperatures and you can see three rooms here. So, if you were to even test a unit which had to indoors and one outdoor in a test room some of this type it could do that. So, you could have in regional capacities of the two units and then when we use the psychometric method we can also make use of the condenser side capacity.

So, the compressor together with whatever heat it has taken from the cooling side it is going to reject it in the outdoor side. So, we can measure the airflow in the outdoor side the temperature difference across, the condenser in the outdoor side and come to an assessment of what is the heat rejected. So, the heat rejected has to be a sum of the compressor power and the heat removed from the cold side. So, this becomes a way of checking out, if there is anything missing in the test, if there is some probe that needs to be recalibrated or it is like a like a verification. So, you check capacity from the indoor side and on the outdoor side and be sure that it is consistent.

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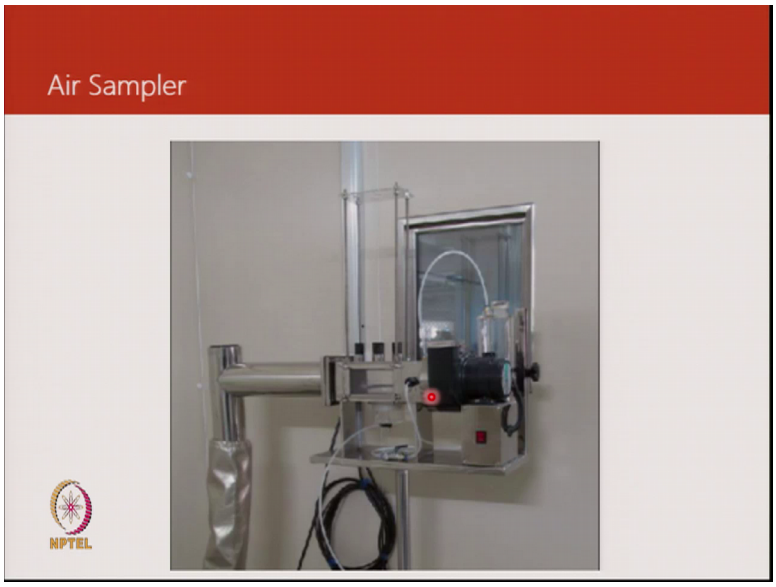

Then when you are doing all this and we need to be taking an average value of the temperature and humidity to get to the enthalpy. So, a unit of this nature would be connected to a set of pickup points. So, tubes with multiple holes and the small blower here is essentially taking air from multiple points and passing it over to the sensors to give us an average value of the air condition.

So, the supply air condition or the return air condition whatever you are measuring a sampler air sampler like this would be used. So, this gives us a certain reliable reading of the enthalpy from it will be derived from the wet bulb and the dry bulb conditions. So, finally, when we have these then what you said about the psychometric chart is correct you know. So, you put on the psychometric chart take the parameters and calculate the capacity.

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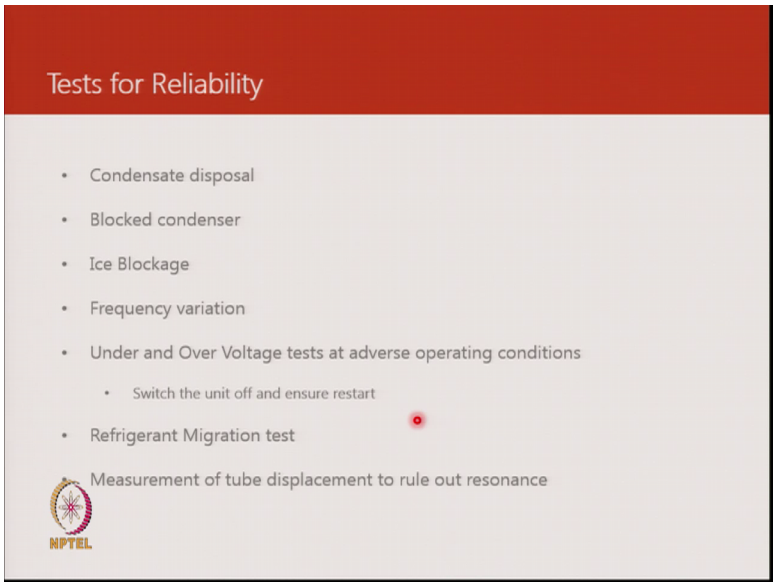

Then we look at tests for reliability. So, while we did not discuss something called condensate disposal test ok. So, in window air conditioners, you will normally see, some amount of water which has been removed from the occupied occupant side or from the conditioned side. Now, that is used to cool the condenser coil. So, there is a slinger ring on the condenser. So, while all that is there, it needs to be validated that it is. So, a condensate disposal test is carried out to ensure that this water does not splash into the inside or over the unit. So, a test is done. So, this is one of the tests for in meeting intended requirements that were captured doing a voice of customer.

Then about dust and dirt and all that we talked about for the condenser. So, you can map all of it by doing a blocked condenser test. So, one of the tests that we found very effective in checking robustness for units designed for India was to take the outdoor air condition to 50 degrees centigrade. And then block 50 percent of the condenser coil. So, you cannot reliably create a dusty environment, but you can create a restriction flow.

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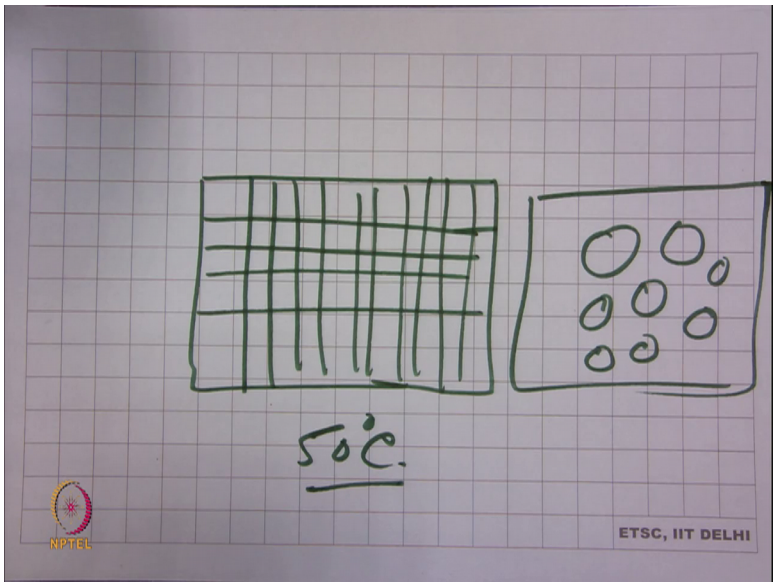

So, so you have let us say, so if you have these are the tubes and these are the different fins. So, what we find a very simple way to do is and takes a piece of cardboard. And then just make holes consistent with 50 percent blockage. This put over this and the unit is tested at 50 degrees centigrade. And if the unit is able to withstand this operation for 2 hours, then we can be sure that there will be no problem and this is not something, which is in any of the standard, because it is devised based on benchmarking and based on what possibly can be done in field.

Now, the same test can also be used to test the life of the compressor. So, instead of limiting it to just 2 hours and verifying that the unit can operate you let it run in a cycling method. So, you switch off the compressor switch it on and, and keep running it until the compressor fails. And then check what failed in the compressor. And then benchmark, and compare with another unit and that gives you a level of robustness as well as the life of the unit. So, this is another way of looking at tests. Then some of these tests are there in the Indian standard as well where we create an icing condition.

So, what we did on the condenser was created a very hot discharge gas temperature or a high condensing temperature on the evaporator side, we create ice. So, we reduce all air flow we let ice buildup. And then we allow it to melt and see that none of it falls into the occupied space, it can be pretty messy if you are having a split air conditioner on your wall and one fine day you discover it is making a floor wet or a carpet wet.

So, many of this is already envisaged and tests are done to make sure that this does not happen. Now, what are the conditions under which this can happen, if you have no refrigerant the evaporating temperature can go down and moisture can begin to condense? If the filter has been cleaned for a long period of time again, this can happen, if the coil for some reason has been blocked during service or maintenance 50 percent to the area 25 percent of the area is not available for heat transfer, again it leads to low evaporator temperature.

So, this becomes another area which needs to be addressed by doing tests then the next is frequency variation. So, during the railway case study I talked about varying it for purposes of vibration, but here again all units which use a moving component and more particularly where there is no isolation between the rotating part and the frame it becomes essential to look at a frequency sweep test. So, from 45 hertz again I talked about India.

So, from 45 hertz to 55 hertz in steps of 1 hertz incremental, we run the unit and check for any resonance occurring with any of the piping or components any abnormal noise the whole intention is to take care of units running on generators or sometimes a grid not behaving. So, typically the grid complies to within 0.3 hertz it is unusual for us to expect anything in the region of 47 or 48.

But when people operate units on dg sets as is common in many of the commercial application even residence is not this happens and then leads to failure. So, again during the planning of tests we can consider this scenario and then do tests to validate all right nothing abnormal is going to happen. Under an over voltage tested it was cooperating condition is something we discussed on already represent migration tests again discussed already and the measurement of tube displacement is connected to the frequency variation test again to rule out any resonance.

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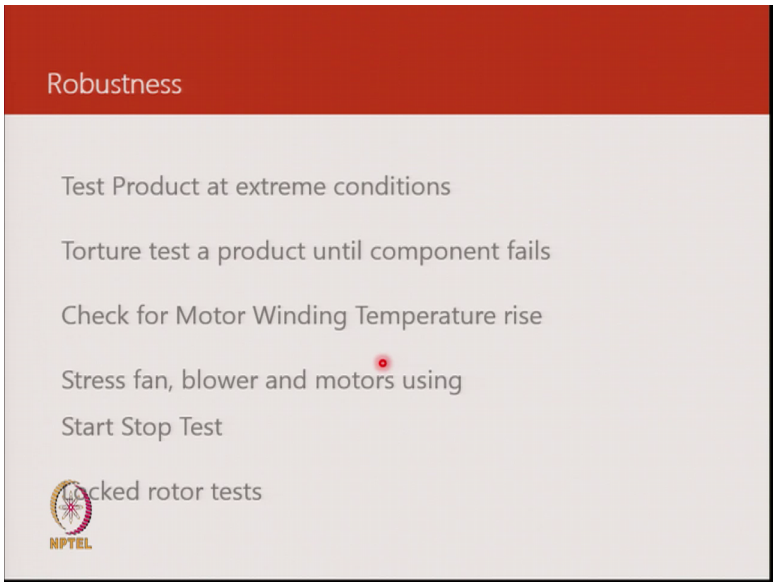

Torture testing, we discussed torture testing for the whole product cycling it at 50 degree centigrade. We also take component. So, let us say the motor what happens to the motor. So, the motor has to withstand a certain life as a part of the unit. It again goes through torture test start, stop, start, stop and the winding temperature rise is measured. In that if it is not complying, we need to redesign the motor. There are several things to do there. You can change the class of insulation of the motor, you can change the flow of the way the motor is being cooled, the windings and not all of it as a designer you need to get into, but you need to have connects to the supplier who will give you back a modified sample which will meet and comply.

Similarly, the plastic components or metal components of fan and blower can be put to stress tests or torture tests. So, you put them to very frequent start, stop, start, stop and then check for critical areas where cracks may develop. And sometimes you test them long enough that they actually fail. And then reinforce them, because the process of making tools, molds etcetera allows you certain quick corrections at the design stage

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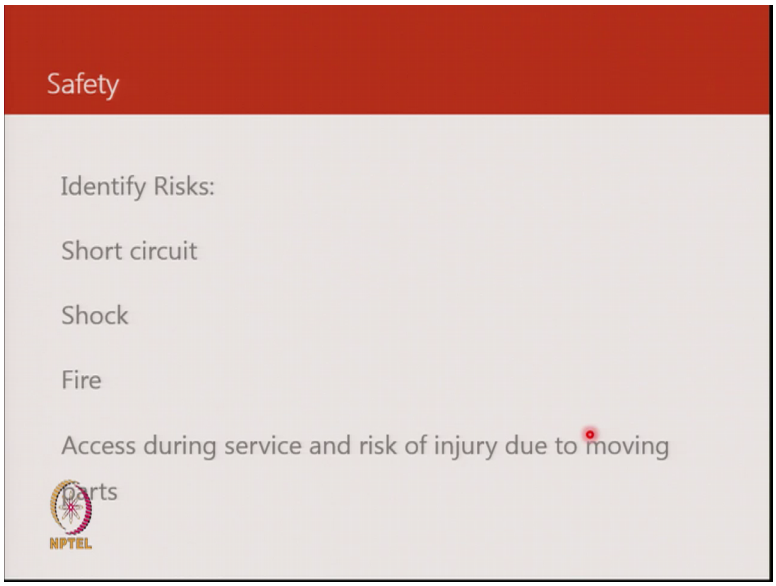

Then, we come to some test for safety. So, when you look at safety, and probably you can start getting interested here in you know speaking out from your seats what all a safety risk to you envisage. When you look at an electrical appliance, what all have you normally experienced or noticed or thing can happen? Short circuit is something very simple to understand right, wires close to each other phase neutral and loosening of the wire can lead to that.

Shock, so this is if there is no other thing or if the phase comes in contact to the metal body, these look pretty obvious and simple. But, when you want to make thousands of products, where is the termination happening, how are you using a particular type of a screw, or a particular way of termination that you are preventing this by design. The first time so for me the learning experience was when I was in Redis Lloyd, it was a not so formal design environment. When I was at carrier, it was a very formal design environment.

And many of these things used to appear very basic, what is the need to do all this. But, when we looked at field failures, and what happened with customers it became clear that this was an essential part of the design process and needed. To prevent product recalls and cost during service and some of these are also driven out of the liability. So, an item companies would be a little more concerned about what happens to them, if there is

something that happens at a customer premise, there for which they are reliable, if they are liable because of missing design compliance.

Now, when I say fire, I do not know, if you have encountered a scenario, where you noticed a refrigeration device leading to fire right in my experience. I have come across several reports from field, where air conditioners and refrigerators have led to fires and premises. Now, why those happen, and they have been always different reasons and different instances.

To prevent that from happening, we need to apply the best principles, but whatever we know in terms of guidelines. So, one of the things that can lead to a fire is if during service, a technician chooses to do a leak test with either air or oxygen, and it was one place and cp where a person had a very unfortunate accident just because of this. He was using a shortcut, he thought, he just need something at pressure check for a leak, he put oxygen not knowing the risks involved.

There is oil in the compressor; there is oil in the system. So, he did all this, and you just use the flame. The first time the flame came in contact with the leak, there was a blast, and there was loss of life. And happen nowhere, because a later stage I was called in to look at what went wrong there. So, safety is very very important. And it is that one out of a million, you have to take care of at the design stage or at now how does the design stage, how can you prevent this from happening in field.

So, one of the things is communication, what do you put in your training materials, what do you put in your service booklet, what are the precautions that you communicate to all these are there. And then, what labeling is there on the product. So, if there is a flammable refrigerant, you know an earlier lecture we discussed that the move today is from non-flammable to some degree of flammability. Now, how can we address that, it is proper labeling. So, if there is a hydrocarbon based refrigerant that is used, if it carries clear labeling and color coding, the service technician is likely to take precautions that is less likely to be a fire there, then a scenario where it is just treated like an ordinary safe refrigerant.

And then, what can happen to the occupants. So, if there is a high pressure leading to a leak, where is it, that we want to the refrigerant? So, by design we can create a weak

areas, which will fail first, which are venting to the atmosphere instead of venting to the inside. So, there is another opportunity where by design, we can make the product safe.

And what else moving parts, so can we provide mesh such that the fingers are protected, finger guarding again something to be addressed by design. So, as engineers we tend to have fun, and when we meet the target internal performance. We find all this very boring, but when it comes to delivering a product that is complying with safety standards as well as keeping people safe.

Both the user and the people, who are going to service it, including people want to manufacturing it, then this discipline and rigor is needed. So, no matter what company you choose to work for (Refer Time: 44:58) what product you design safety will be an essential part. And it is good to have a mindset, where you will embrace it, and put in the hard work and the discipline needed to address it. Then to be discovered, you know in a very very costly manner and through field.

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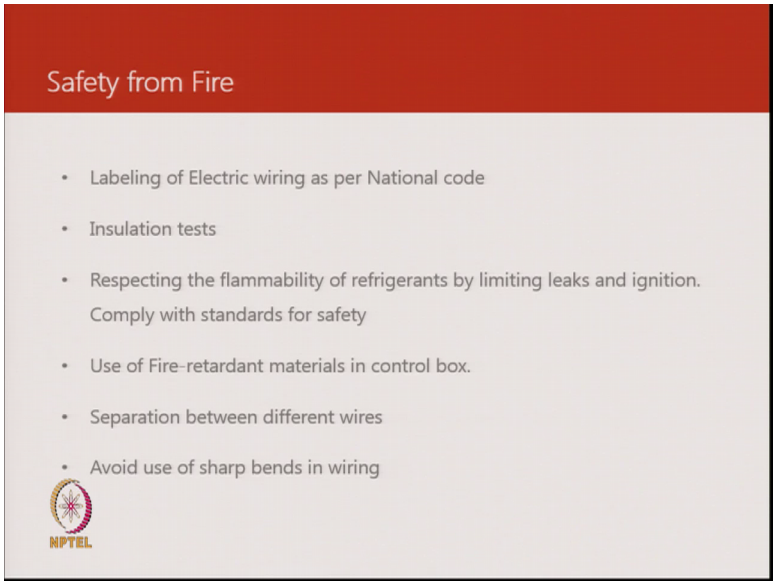

So, some of the things are to label, so there will be a national code. So, you would like to have the live wire connected to the live and neutral to the neutral, so color coding. Installation insulation tests, so making sure that the insulation grade that is used for different wires is meeting a standard. We talked about respecting flammability of refrigerants already, then using fire retardant materials in the control box. So, the control

box, there is a lot of wiring. And there could be during for different reasons there could be sparks there.

So, if you have a material, which is fire retardant. It is more likely to contain the fire than something, which is flammable itself. And then, during design there are reliability and safety tests that can be done. So, you create ignition deliberately. So, one of the things we did for residential products was to put fuel in the control box. So, you take a cotton swab say about 10 to 5 to 10 ml of petrol, you put it there. And then, you deliberately spark that and there is a flame.

And then, you can look at scenarios where the fire retardant material without a fire retardant material and the degree of spread, and that gives you some satisfaction that yeah, if you designed it well, then the fire will not spread, it will just extinguish within the box. Then the distance between different wires and of course very common sense kind of thing to avoid sharp bends in the wire.

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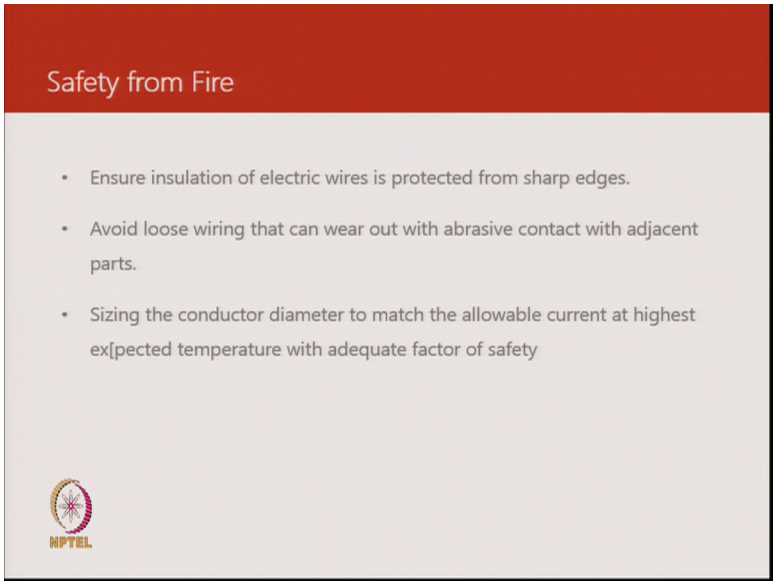

Metal normally you know sheet metal tends to have sharp edges. And in internal components you tend to ignore it, whereas externally it is always addressed for aesthetics and product handling perspective. So, to make sure that if there is metal in there is a proper rubber grommet that comes between the insulation of the wire and the metal. And then, the conductor diameter to match the maximum allowable current at the highest expected temperature with the right level of safety.

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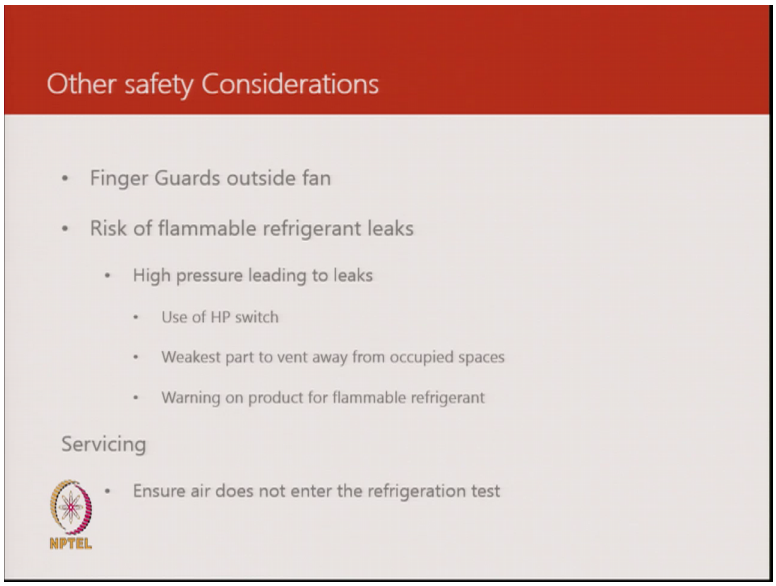

In finger guards outside moving parts like condenser fans and then, wherever there is a pressure risk, we can use an HP switch. We will also notice later that an HP switch can also be used for compressor protection, but also for preventing components like tubing from failing in high pressure refrigerants particularly C O 2. C O 2 is used as a refrigerant, then a high pressure switch. Then, I mentioned already the weakest part being vented away from occupied spaces, warnings on the product. And during servicing to make sure that air in no way finds it way into the system. And if it does, then it is to be purged using nitrogen, before any attempt to weld it or use any electrical input.

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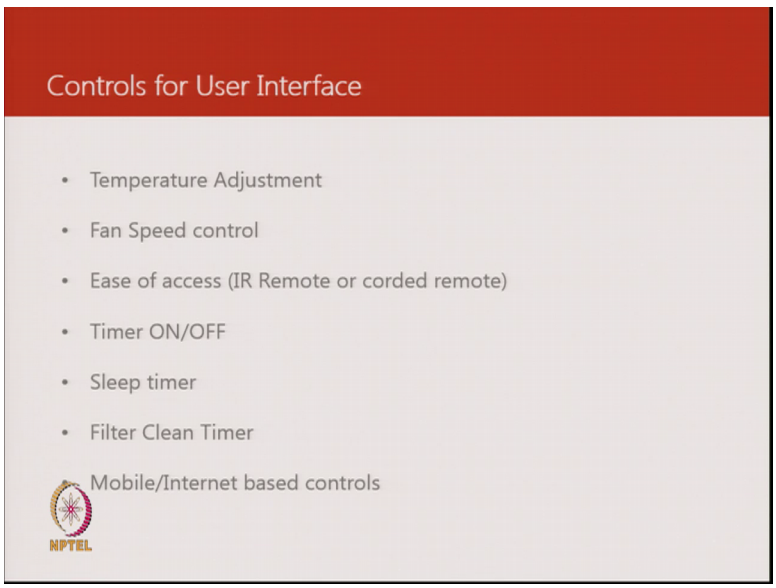

Then, we will take a quick look at some controls that we use for the user interface. So, for we looked at a different ways of addressing safety and now we looking at controls first for user interface, and then for protecting components. So, temperature adjustment is something very common simple, we need it as a very basic thing. When interacting with the air conditioners, fan speed control, and here different algorithms are incorporated into providing an auto mode.

So, what temperature difference between set point and room temperature will drive the fan at what speed, so that gets integrated. And you can use that or you could force the speed to whatever you need. Then ease of access for residential products infrared remote is very common, but then for commercial you do not want to be running around locating the remote. So, you put in wired consoles from one place, you can control multiple units, so that again something that you consider at the design stage in terms of target intended application.

And timers if needed sleep timer, we have discussed already. And it is also possible to integrate filter clean timer telling you, when it is time to clean the filter. And then, you can reset it is a very simple reminder way system. On expensive commercial systems, you can put in a pressure transducer. So, you can take the pressure drop across the filter, and that can lead to a more intelligent way of a defining when to change the filters. And then if there is a need to integrate a remote monitoring and control, then all that is possible through modern day controls think, we will not put too much time on that.

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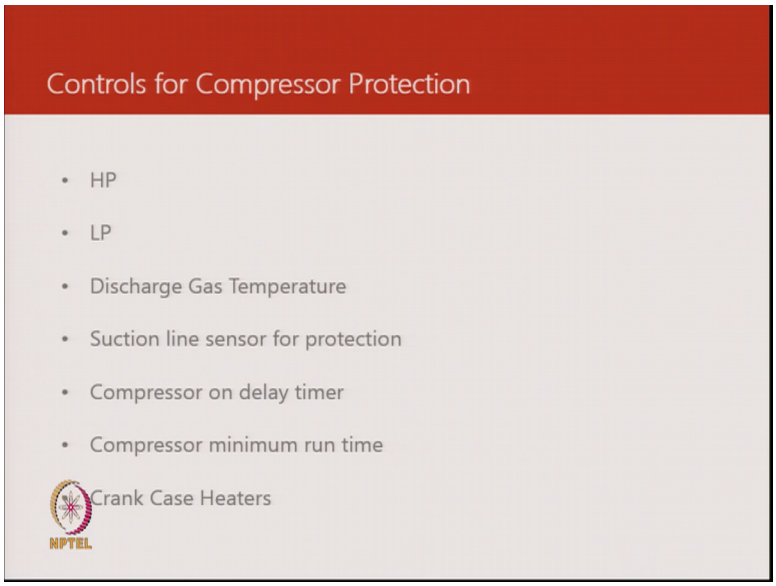

When we can look at controls for compressor protection, compressor being the most expensive part of an air conditioner; there is an opportunity, and these are all commercially available control components. So, high pressure switch, so what it does is we map the operating envelope of the compressor. And then, define an HP setting such that when the pressure goes above the limit, it will switch off.

And it is usually a manual reset type. So, once the hp has tripped several willing to come and have a look, what happened is the service guy charging it excessively that could be causing high pressure. Condenser is blocked that could lead to high pressure or there could be some other so that is a low pressure switch is typically a self-reset type. And that is because it can occasionally because of environmental conditions that can go there, but there is an opportunity here also to make it a manual reset.

Then to protect the compressor, we can also provide or discharge gas temperature thermostat. And this has become more prevalent after introduction of scroll compressors. So, scroll compressors will become popular because of efficiency cost, fewer moving parts, but they have had a risk of high discharge gas temperatures more than the reciprocating compressors because of the nature of compression that scroll undertakes.

And then, there are delay timers to make sure the compressor suction and discharge pressures are equalized before, it starts to reduce the starting current. So, this is typically three minutes, and it can be adjusted based on manufacturer recommendation, and what

time it takes in the system to equalize the two pressures. Then compressor minimum run time is to make sure the oil once it has left the compressor comes back, so that we do not stop the compressor of oil.

And crank case heaters are another way of preventing refrigerant migration. So, when the compressor is switched off for long durations, the crankcase heater is a way to heat up the compressor oil, so that that does not become the coolest part of the system. And therefore, it prevents the refrigerant from migrating there. And creating a scenario where the entire oil is out.

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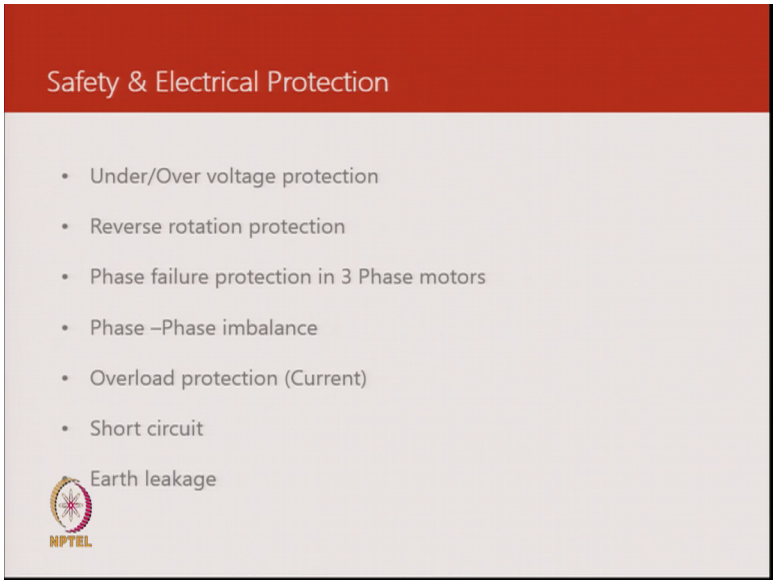

Then, when we look at designing electrical protection this is normally not used in residential products, so much as it is used in commercial products. Under over voltage protection, protection against reverse rotation, it is applicable for three phase compressors, so the scroll compressors cannot compress, then rotate it reverse. So, you need to have a way of preventing that from happening. And phase failure, the case study that we did railways had this component, so that the phase to phase imbalance is not leading to compressor failures I mean these are all costs that we are undertaking, so that we protect the most expensive part of the air conditioner. Overload protection through overload relays, and then there could be electronic relays. Short circuit is both options are used a fuse and residential products you will notice the fuse, which is only for the

control part. Then commercial, you will see mcbes and even mccbs to protect the compressor.