Electronics Enclosures Thermal Issues
Prof. N. V. Chalapathi Rao
Department of Electronic Systems Engineering
Indian Institute of Science, Bangalore

Lecture – 18

Round up of full model

[noise] Let me continue by recapitulating ah, where I stopped yesterday.

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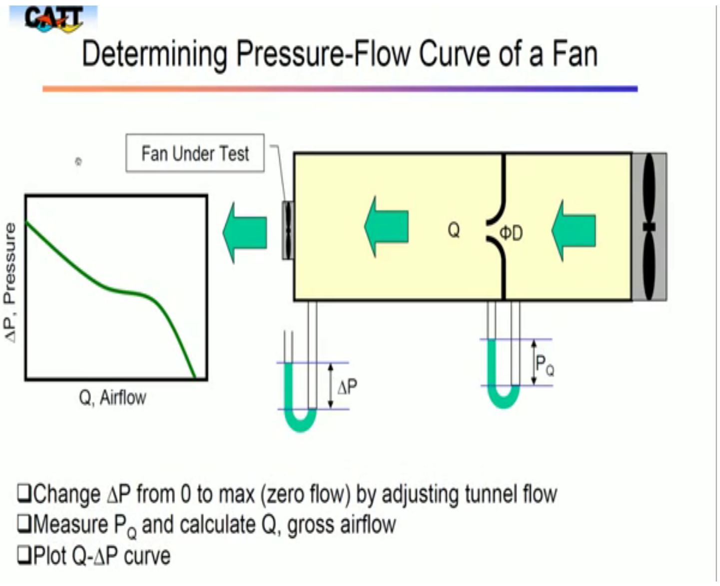

Again, [noise] as it is the norm ah this is taken from a what do you call engineered air flow intelligent cooling by ah [vocalized-noise] what do you call [noise] degree centigrade controls from 2004 and it has been presented wherever very extremely well [noise] and in general it covers [noise] what I feel is important for a designer to [noise] try and understand. Again one more time you must remember that these people have had probably 30 to 40 years experience [noise] and if you remember the earlier I mean the same slide shown earlier [noise] experience is seems to be at a premium [noise] that is the reason while everything is available out there for you you still have to depend on a professional to do plumbing from you, maybe electricians yes, plumbing call him you have no choice. Same thing with any any other thing including tailoring [noise], so, obviously, every person has a beautiful brand new machine not many people [noise] make their own clothes because the designers and merchants around there to change the designs.

So, coming back to my slide again these people have suggested know when you are very very simple way is [vocalized-noise] you must have an authentic [noise] pressure [noise] versus flow characteristic curve [noise] a fan you [vocalized-noise] it it is not what do you call, it is not that is it to determine that one particular piece which you have been using. The simplest way of doing it is make your own set up. It is not an impossible thing you see here you have a small chamber like thing here, [noise] not chamber like thing, it is a chamber [noise] a depending on the thing sometimes at circular a cross section sometimes it is square because square is easier to make and then you can always open the top and then [noise] play around with it [noise].

And, then the fan under test is here [noise] ok [vocalized-noise] and then there is a small orifice [noise] and then you have [noise] some other what do you call [noise] pair of here another fan and so on. [noise] Issue here is [noise] we need to somehow [noise] plot this curve [noise] pressure and change in pressure versus [noise] air flow [noise] and [noise] this is where we end up with [noise] real life conditions. So, what is the voltage with which you are operating [noise] and related to that [noise] is the frequency also [noise].

Imagine most of the small motors [noise] are very much dependent on [noise] both the voltage with which you operate and also probably the frequency [noise]. Well, a larger motor it is very easy for us [noise] for a smaller motor especially if it is AC you need close control if it is DC [noise] to some extent [noise] somebody has done this [noise] experiment for you and that [noise] being a DC motor [noise] life is relatively easy [noise] because DC motor you have only one simple parameter increase the voltage it works well without any problem in the case of AC you need to characterize this and then [noise] this is where things come is [noise] the small change of it sometimes [noise] makes a curve [noise] which is significantly different and it may or may not [noise] you know follow like this.

For all we know some times it may cross and come over here [noise] small change in I mean similarly low little lower voltage may lead to other things and there is also self heating when you run a fan something happens both two things; one is [noise] happens to the motor itself and happens to the air all around like this [noise]. So, if you have an authentic curve using this plenum chamber and this [noise] it is very much possible [noise] for you to [noise] plot this things.

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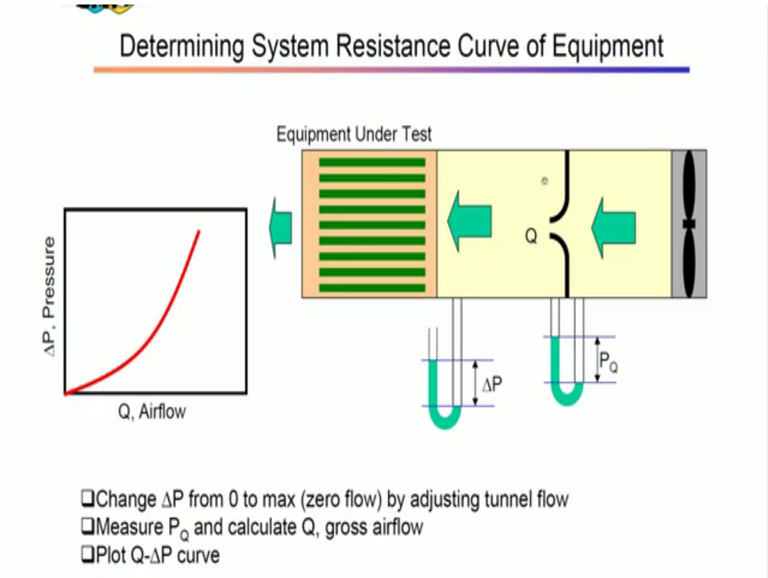

Similarly, the much more important or difficult thing to for you to [noise] probably [noise] difficult for you to plot [noise] is to have the [noise] equipment system resistance [noise] which if you ask me [noise] is [noise] even if you have measured it, it is a little dicey [noise] because very rarely [noise] in the final equipment [noise] can be directly used here [noise] you still have a scale down model and then whenever you have a scale down model is principles have dynamic similarity apply [noise]. So, only to a certain extent you can probably make a scale down [noise] version or even a full scale mockup.

So, [vocalized-noise] if you do the same if you find out the what do you call change in [noise] pressure [noise] from 0 to maximum by adjusting that turn in flow measure P Q and calculate Q [noise] and plot Q versus delta P curve [noise]. It looks easy after that you superimpose one over the other and everything, no miraculously [noise] everything works [noise] exactly [noise]. They are not many miracles [noise] that happen. you have to make your own miracles [noise].

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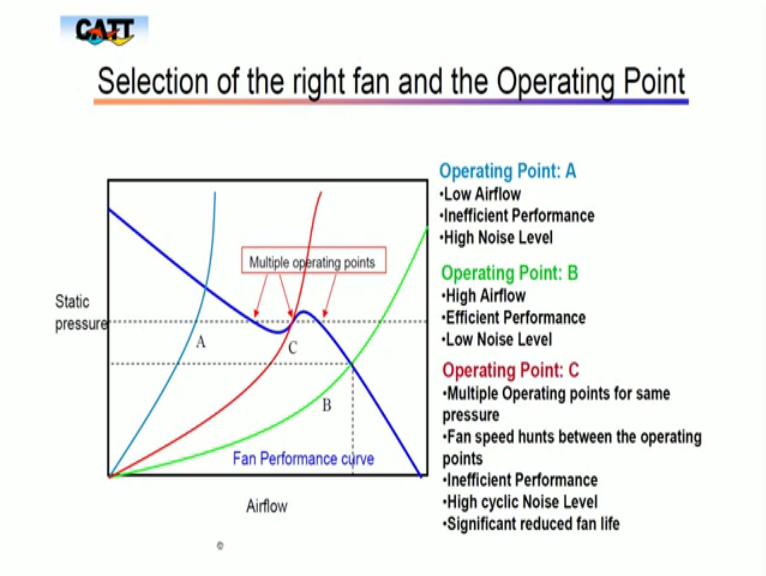

So, we see here [noise] if you have obviously, we have this B is a beautiful good what do you call [noise] ah [vocalized-noise] what do you call [vocalized-noise] a nice and you know properly laid out [noise] equipment [noise]. So, in a properly laid out equipment you have made you have ensured ah that you know the static pressure for a given air flow is very less and in properly laid out equipment and ends up with this [noise] and this may be something our bad luck because Murphy is at work Murphy is not at work only when you lose a nut or [noise] you know when you will otherwise there Murphy ensure that we end up with this funny things [noise] and [noise] anything you do to improve any other heat transfer seems to interfere with these things.

If you put more fins what was you know perfectly fine and started it has more that side [noise] and then if you tried to what do you call add baffles to ensure that you know your air is [noise] properly channeled over your hard surfaces [noise] you may even end up here by which you do not know where you work with. So, again if you recollect the very first picture I showed you a [noise] video game in which [noise] there are there are this is a big fan [noise]. Now, probably it was 80 mm fan [noise] and then we have a heat sink [noise] then they have put a beautiful manifold like that to spread such that the heat sink no there I will just show it the other way saying you have fan here [noise] then you have heat sink here then we have a manifold which is blowing everything and directly in front of it we have the main device which is also [noise] there.

And, obviously, it does not go then what did they do that they have to do mill the heat sink in particular way so that the air can go away like that. Now, all these things [noise] there is no simple way of modeling and calculating it. So, what people do is they try to make a [noise] CAD model.

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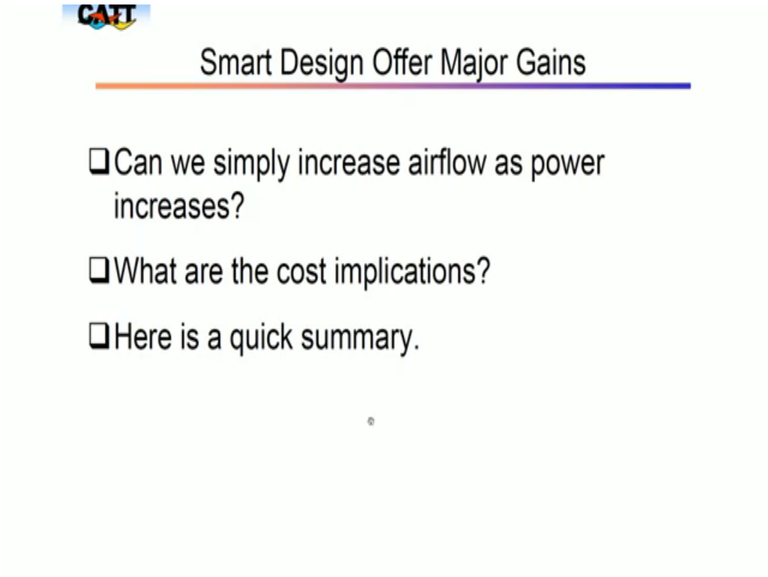

The next two picture if you remember you know [noise] shows you [noise] what to do with it. So, ah if you [vocalized-noise] I mean as you see if I can insert it after wards [noise] we have this issue of [noise] smart design. It is not about you know new type of smart design, but what we are talking about is [noise] being smart in design and eventually it trying to put proper sensors [noise] and all.

Can we simply increase the air flow as power increases [noise]? It is obvious. It is not over rhetorical question saying yes or no and cost we also know no. Sadly [noise] cost is very much around.

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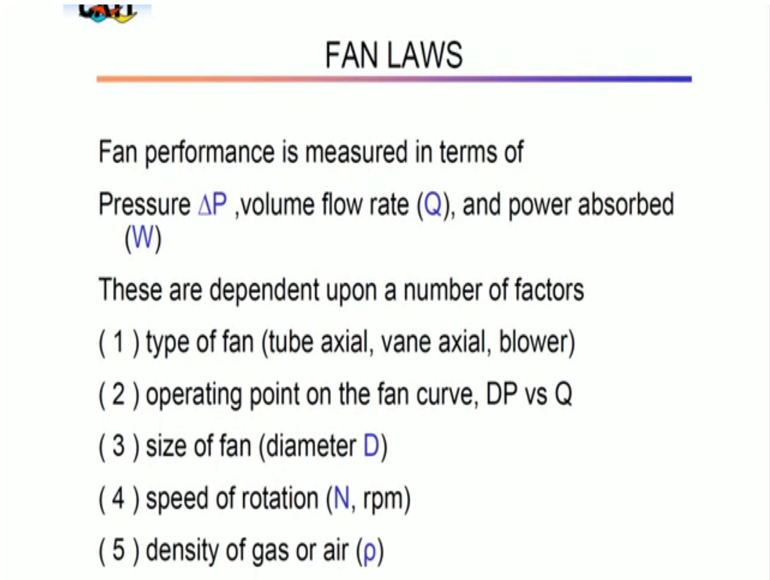

And, next pick things [noise] through it says a quick summary it is not a as quick as summary as it is. [noise] You have seen here [noise] type of fan tube axial, vane axial, blower operating point on the fan curve, [noise] size of fan diameter, speed of rotation, [noise] density of the gas or [noise] air. So, most of the time luckily you know we use a normal what do you call whatever ambient air is there, but once in a while you may be forced to dry ah dry the air or you may be [noise] using a chiller in front of it by which no marginally it changes things [noise].

So, we have this speed of rotation faster obviously, you get better what do you call flow rate [noise] and then right now, we have the issue of efficiency of the whole system as you are working for more and more [noise] what do you call the change in I mean being going green ah we need to consider about efficiency. It is not just about peak power or peak torque or peak blower or anything like this.

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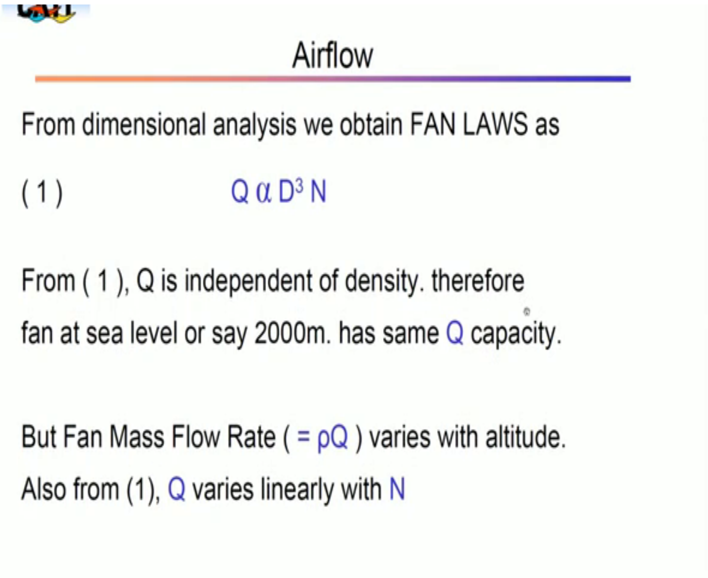

So, [noise] they have given so many things here, ok ah I think those things are all considering a point of operation on fan curve it is possible to derive some simple scaling laws [noise] between change in pressure what do you call the total wattage, then the speed and the diameter of the fan and so on. So and rho for a fan you can read them here is a function of this and this saying diameter is large and the speed is more delta P is again a function of these things [noise].

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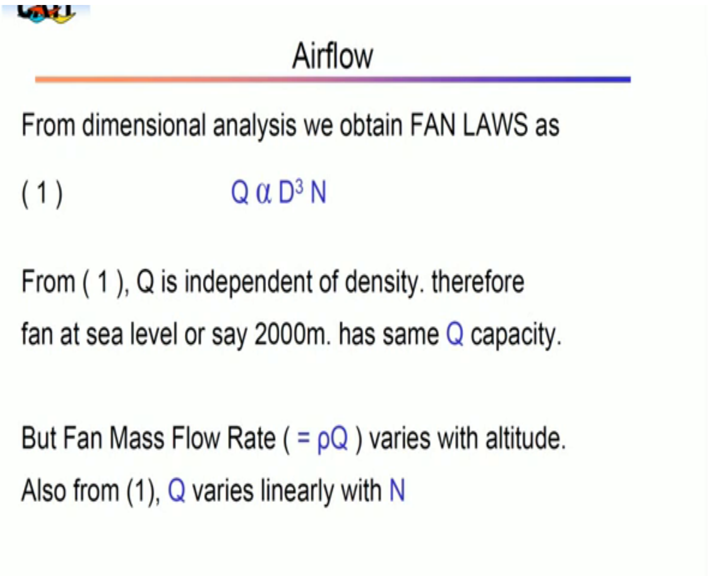

And, [noise] he has shown [noise] that [noise] Q is independent of density [vocalized-noise]. Therefore, fan at sea level or say 2000 meters has the same Q capacity fan mass flow rate varies with altitude. Q varies linearly with altitude [noise].

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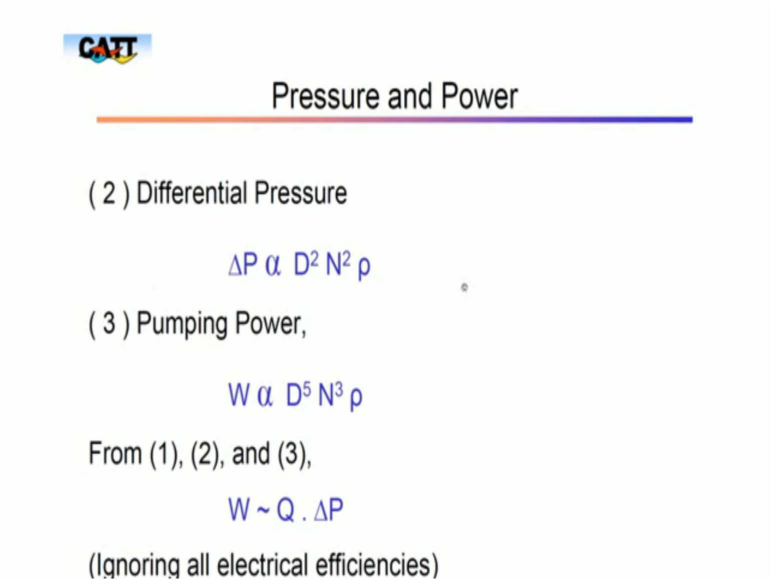

So, there is something about the differential pressure then there is a pumping power required and then I you know the total if you ignore electrical efficiencies suddenly something else has come into picture [noise] you have seen this [noise] fan motor itself has a resistance and which slightly depends once again on the speed of operation back a back pressure and so on [noise].

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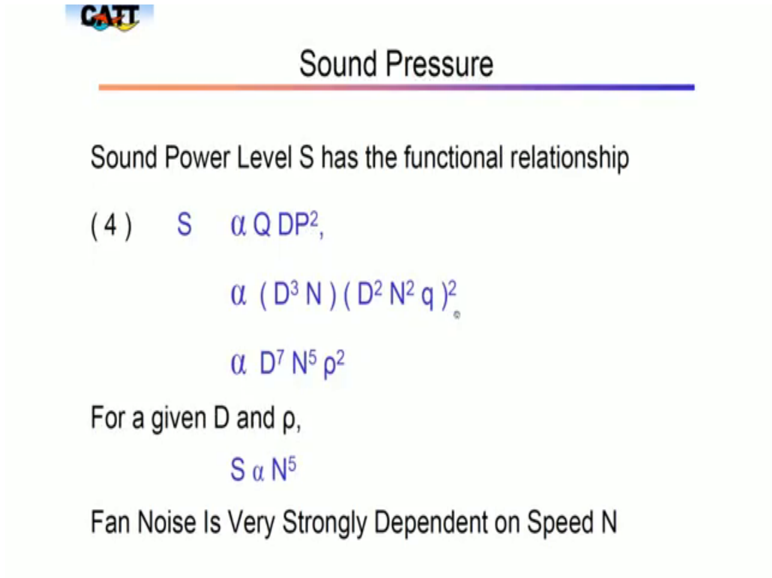

So, we have this pressure and power characteristics and [noise] some nuisance which is getting real actually if you are stuck in a [noise] room where lot of these equipment operate we end up with [noise] sound, too much of too much of sound [noise]. So, it is real [noise] [vocalized-noise]. You have no way of getting over just taking a fan in the air flow panel and compared to what I have told you make it face a lot if there is a hot component you make it face that does not seem to cure all problems. One problem, it solves one problem is it makes the peak temperature less actually it has not that that much of direct control on peak [noise] junction temperature as much as [noise] cooling the fins of the heat sink [noise]. Once a fins of the heat sinks are cooled a lot depends on [noise] fin efficiency [noise].

So, at very high velocities if you take a standard normal what do you call extrusion [noise] fin effectiveness comes down. So, with that beyond a certain point that is where (Refer Slide Time: 12:37) mentioned do not exceed 6 meters per second beyond that you know it does not seem to make any difference [noise]. Except it is already you know neatly packaged and so on. So, they have [noise] given things like noise is dependent on speed, [noise] ok.

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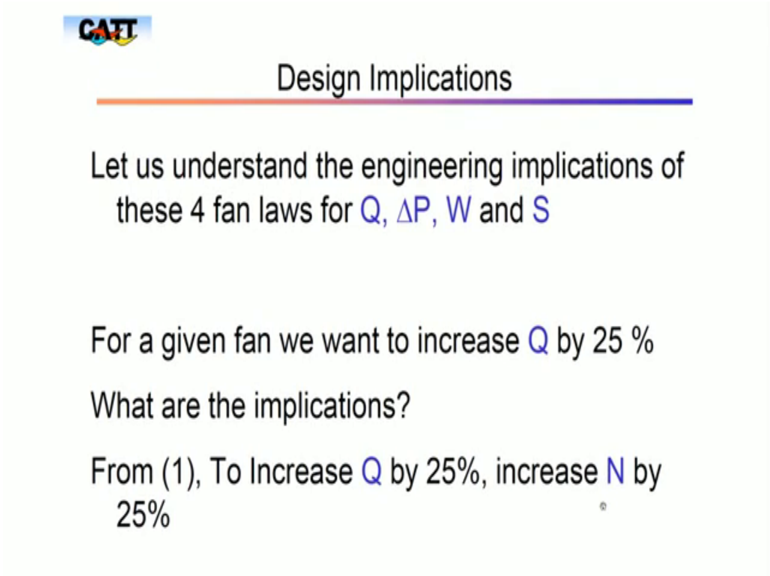

Next is [noise] engineering implication or the 4 fan laws for [noise] sound then the total amount of a discharge, total amount power dissipation and then total amount of a what do you call static pressure. We want to increase the discharge by 25 percent to increase we increase n by 25 percent [laughter].

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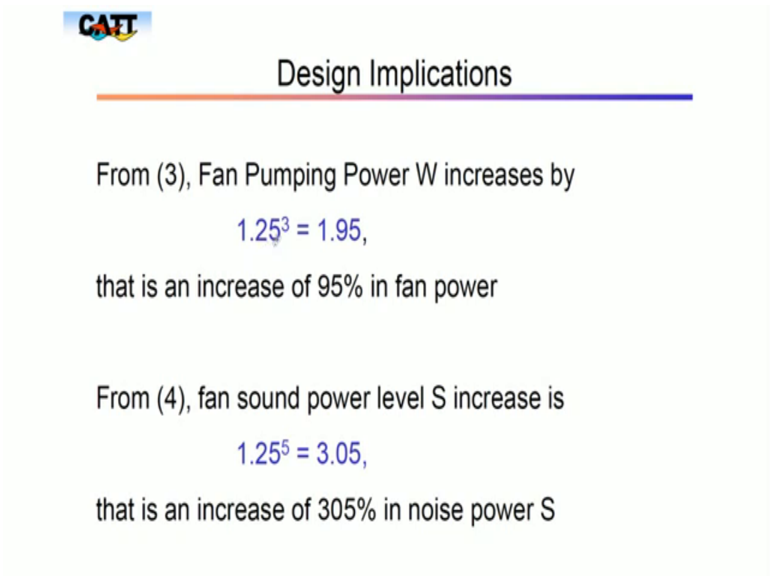

We you see here pumping power seems to go up by three times. It it fan pumping power you know certainly has become doubled. What was 1.25 [noise] has become such ah you know horrible [vocalized-noise] this thing [noise] 95 percent. Sound power level increases [noise] three times [laughter]. So, now, it comes the trade off saying what do you do [noise].

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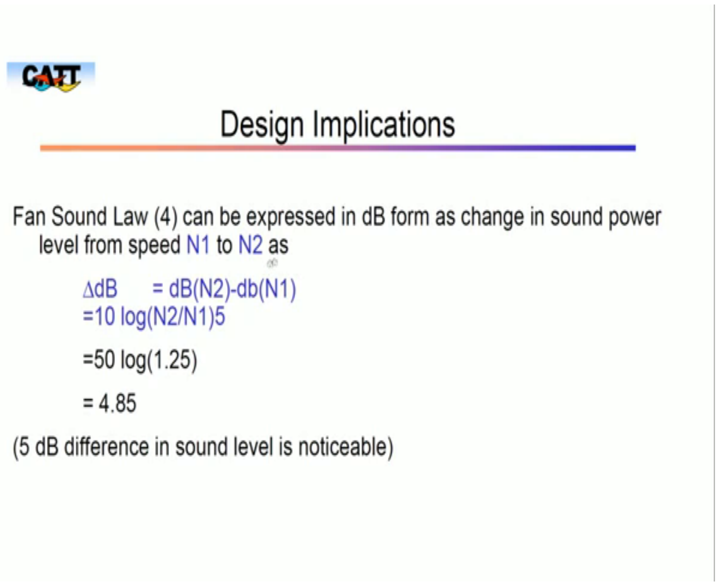

So, from sound law can be expressed in decibel form as change in sound power from a level. So, a huge [vocalized-noise] this thing is there though he says though he says 5 dB difference in sound level is noticeable [noise] ah upshot talk about the 3 dB thing ah 3 dB is sufficient for most people [noise] to feel uncomfortable from existing thing a perceptible difference is 3 dB especially in the silent this thing.

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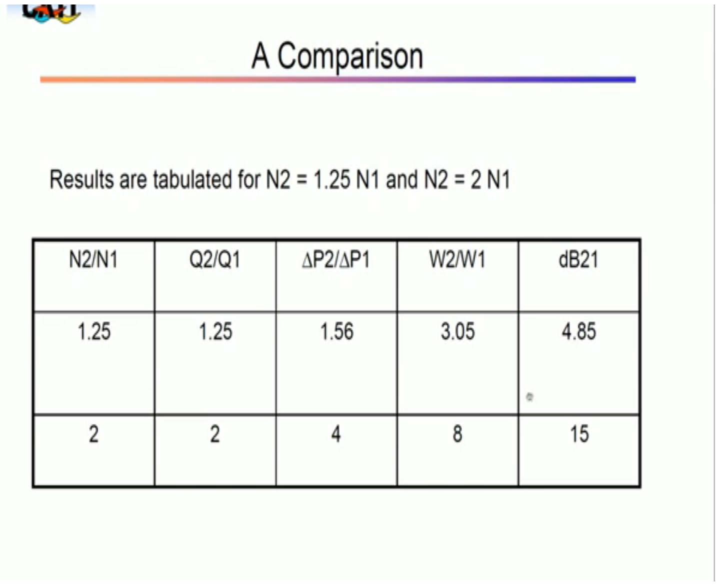

N2/N1	Q2/Q1	ΔP2/ΔP1	W2/W1	dB21
1.25	1.25	1.56	3.05	4.85
2	2	4	8	15

So, as we keep going on we end up with all this is funnier and funnier ah [vocalized-noise] relative you know nuisances. So, big this thing is given here saying what happens to you know if you increase in speed if you increase in this if you increase in [laughter] what do you call [noise] how much of power increases I mean the power demand increases and then the noise level increases while the pressure level you know. Pressure level you just going up about ah double while the you know the total discharge is you can know you just increased by 75 percent we end up with [noise] all these undesirable things [noise] follow tremendously undesirable factors [noise].

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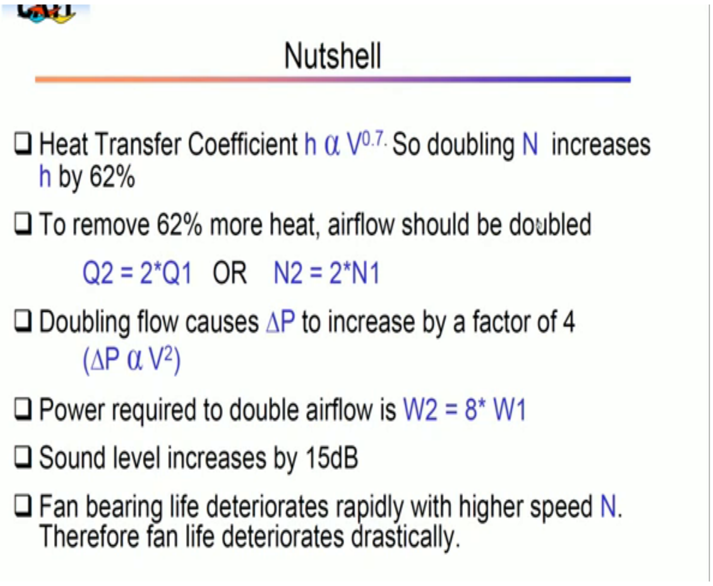

So, this is probably [noise] the sum up of all that things relating to fans [noise]. Doubling the speed increase heat transfer coefficient [noise] by 62 percent only [noise] to remove more heat air flow should be doubled [noise] doubling air flow causes delta P increases by a factor of 4 power required to double the air flow is. So, much 8 times [noise] sound level increases by 15 dB hm [laughter]. It is a lot of thing and then something which [noise] we forget a fan itself [noise] deteriorates drastically [noise]. So, it is not just enough no to add a fan we have a problem, you can just you know marginally increase this speed also it is not constant this is where they the what do you call people who have that experience they have said [noise] this is what, ok.

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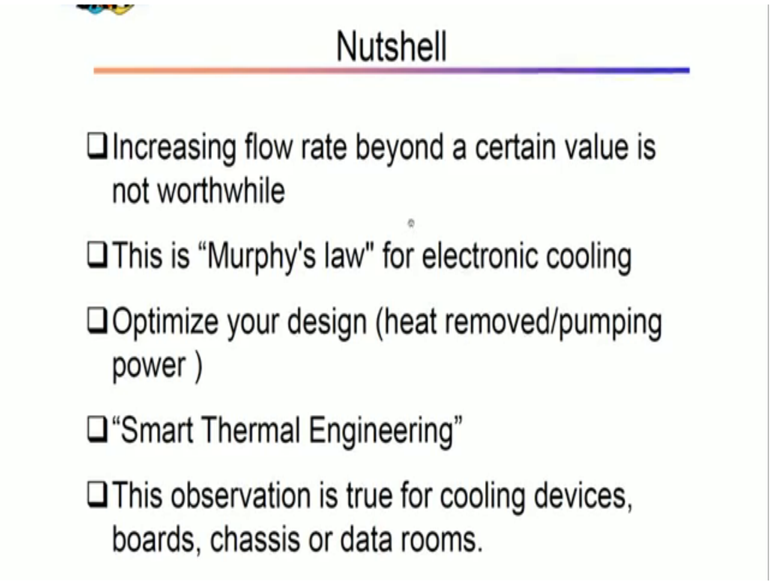

Increasing flow rate beyond a certain value is not worth while Murphy's law for a electronic cooling optimize your design heat removed pumping power smart thermal engineering is true for devices boards chassis or data rooms [noise]. Cooling devices you would have notice know long long ago [noise] the [noise] what do you call chips them self we have a little problem with the chip next come [noise]. How do you cool things is it just about ah you know simply [noise] increase conduction or increase thing or do we now talk about fan face change or do you talk about paltrier mechanisms things like hit bytes ah same to go in and out of fashion they come to fashion they go out of fashion they come to in [noise].

As of now you cannot beat simple conductive heat transfer from the chip and a little bit of better geometry on the chip including mounting it upside down and some of your audio antaes may remember the old [noise] audio chip this a 8 pin duel in line chip [noise] I am sorry 16 pin duel in line chip [noise] and the center 2 pins had a tab. So, you have a dip package with 2 small tabs which are thick copper plates thick means hm maybe 1 mm or 1.2 mm. So, I will just see if I can make it to a little bit of circus you have this package [noise] and 2 of this things no [noise] are spread out then there are holes and you can mount the whole thing on to a heat sink; one of the earliest thing this typically was called this CA810.

CA810 audio chip [noise] probably was designed sometime in the late seventies and the package itself become a very popular duel inline package then later on single inline packages came about. So, some of the new audio amplifiers and all everything is single inline and you have nice beautiful heat sink like thing on one side they come with multiple pins the smallest multiple pin is probably the [noise] TO2 20. Earliest on in one of the slides I shown you there are things which have you know even 12 pins and all in one line. So, there is special packages [noise] all of them have a beautiful mounting thing and if there again know we end up with a very peculiar thing if you give a mounting hole you will spoil the contact area. If you do not give a mounting hole how do you mount it then [noise].

So, all the variations I can think of out there next to comes to boards [noise] board itself [noise] is there a way you can do you can you know increase the [noise] heat conductivity of the board and as I told you at one extreme you know we have metal boards [noise] and then we have the chassis [noise] ok. Chassis means usually that what do you call the unit in which you mount, then the whole room [noise]. We are very strong in the devices where may be a little ok issue with board and heat sinks now we come to the important thing when you have the large room here [noise] you understand we have huge room and when we have rows of racks [noise] any of your small thing will help only. So, much [noise] and then even may be a rack now how do you cool the rack [noise] without freezing the poor operator [noise].

Now, we are in the modern world. So, it is not know it is ok saying they are dispensable they are indentured labors. So, that they are not dispensable you cannot train one and you cannot get it. So, now the cooling of the the racks itself you know it is done very well [noise]. I have a picture of a solar installation outdoors [noise] when I retrieve it I will show it to you. It is done [noise] extremely well and room cooling is isolated from the [noise] that what do you call installation [noise]. At this point may be it is appropriate for me to mention that if you go around and see [noise] these [noise] cell tower installations.

Sometimes you see there is a small enclosure [noise] and you have a panel mounted air conditioner [noise]. We have two air conditioners we all know one of them is the window air conditioner window air conditioner there is the rectangular box like thing part of it which is not visible to you has the condenser [noise] and the part which is you know visible inside the room has the evaporator and all that this is the window air conditioner then we are all familiar with split air conditioners. We have an external unit and indoor unit.

Now, this panel mounted air conditioners are very similar to this thing except that [noise] you have a flat panel which is fixed on either the side or the back of one of these racks [noise] and the whole rack is [noise] sealed [noise]. So, air is taken from inside [noise] the evaporator is you know fitted as a part of the panel. Depending on the design the evaporator is sometimes in the outside itself or it may be a long box. So, the air is pass through that and then continually air you know it gives cooling the air and then at the little you know towards the top more portion of it [noise] you have the condenser with the fan outside [noise].

So, internal working fluid like dry air is isolated from the external air. You can see this occasionally on [noise] installations [noise] outside. Now, anywhere when next time when I self as cell tower is being opened in check I suggest you to have a look. If possible I will try to [noise] have a look at it, ok.

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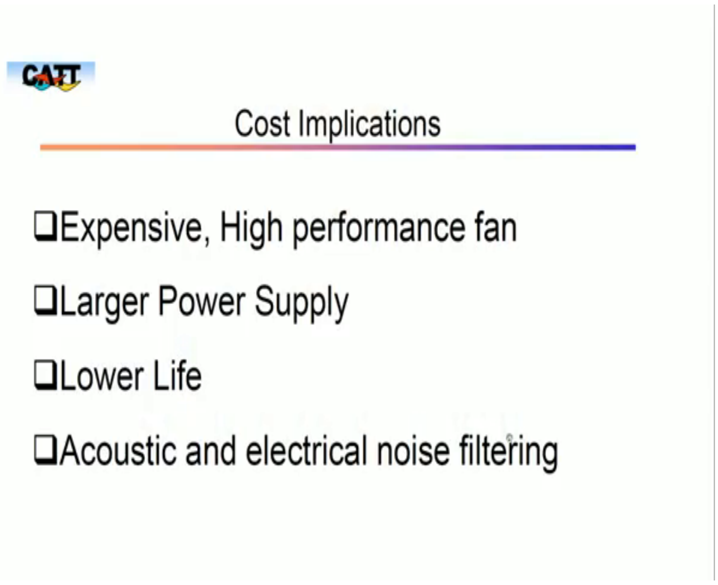

The earlier thing is [noise] just make a better fan [noise], but are we ready for a better fan? [noise] The military if we can afford it and others can afford it [noise] and then the movement [noise] you have we end up with [noise] ending over larger power supplies [noise] and then overall you know [noise] are put up with lower life and we have this big nuisance of electrical and acoustic and electrical noise filtering [noise]. It is real [noise] ah [noise] it is just real beyond that you know at this point I cannot comment on that [noise].

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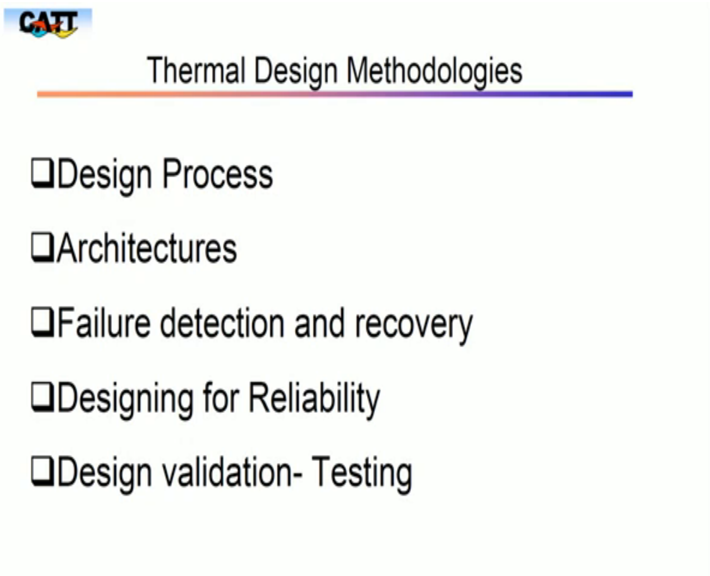

So, we have here saying you know this we have the design process, architectures, failure, designing for reliability, design validation and testing [vocalized-noise]. This is where no it looks like [noise] only [noise] space does this thoroughly and [noise] aerospace aero people are able to do a certain extent, but right now even when you talk about a small thing like a mobile phone you probably have to go I have to I will just show you [noise] this to me is a wonder [noise] understand you know.

I have a this small beautiful [noise] hearing aid, it cause a lot of money, ok. It is really really lot of money. Sir, can you focus it on this, if it is possible to zoom? You have seen this this small device has everything I can talk about, ok got it [noise] and you see this I am sure all of you have this you know carry this nice fashionable watch [noise]. This is the tracker [noise] it tracks my health and my whereabouts to other what do you call [noise] ah [noise] people have a staken me other stakeholders in my good health other than the insurance company obviously, lot of people [vocalized-noise] need to know about it.

So, if you see all these small things [noise] lot of this designing process, architecture, [noise] failure, designing for reliability, design validation and testing have all I have gone in to it [noise] because it is not just about if you fail like and repair it [noise] it is about increasing [noise]. The reliability over the end the time to [noise] what do you call quickly [noise] try to [noise] recover from a thing.

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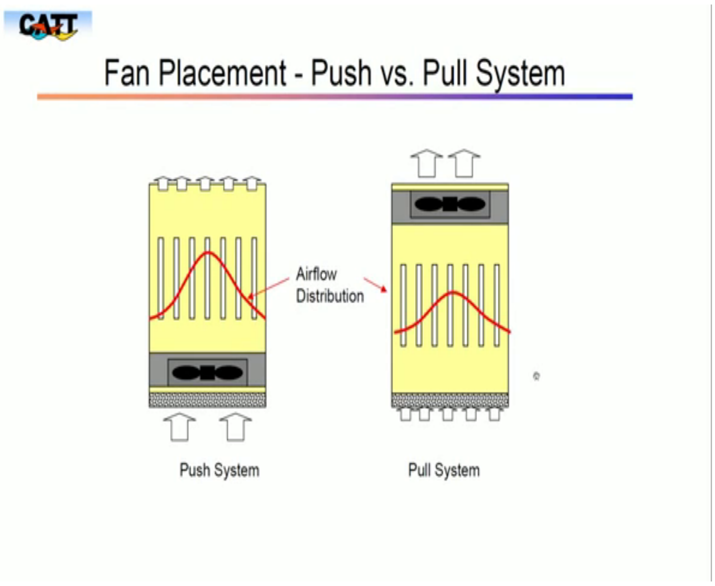

So, this is what I try to tell you about it earlier in a push system [noise] you see the air flow distribution directly you know air flow much more air is here and in the other thing it is a little lower air flow distribution. There is only a [noise] illustrative [noise] example like what you are likely to see on your shampoo ads saying creative visualization [noise]. Ah the model the girl or boy [noise] may or may not have it everything could be shopped be shop. So, this is also one of the creative visualization, but it is as good as a this thing here just to illustrated [vocalized-noise] lot of air flows in the direction we wanted. So, it is possible for us to decide you know [noise] which way to mount these things [noise] and in this case luckily you know this is [noise] the I mean it looks like almost a [noise] laminar flow [noise] thing for a pipe which is not true [noise] just there showing in.

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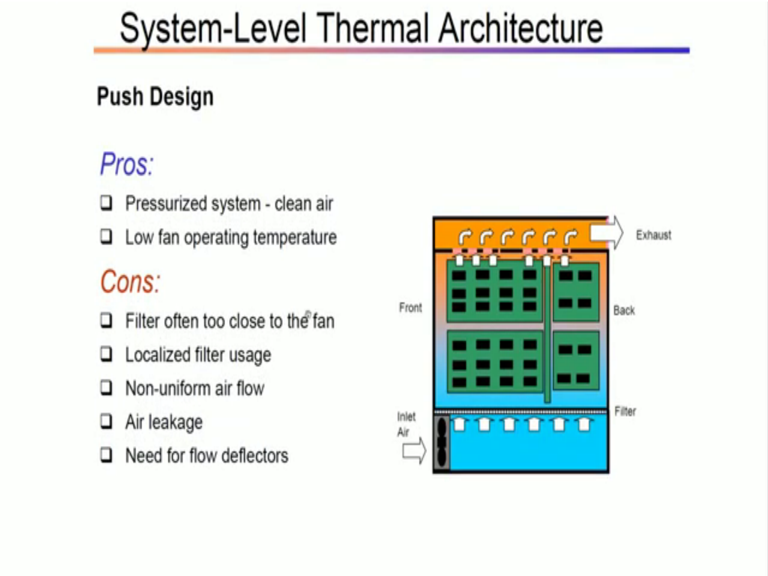

So, it you can decide where to put what in these things [noise] you have seen this here very very important. I had mentioned to you [noise] in passing, pressurized system, clean air, low fan operating temperatures [noise]. You understand in the case of the push design main thing is directly [noise] you direct air and fan itself is seeing ambient air which have been cooler than the exhaust air [noise] and this whole system very very important thing in the system is the whole system is under positive pressure [noise]. You have seen that thing which happens if you go to most clean room all that they adopt that system [noise] this whole chamber is positive. So, to the extent when you open the door or ever there small gaps everywhere [noise] air blows out of the gaps [noise] and any air pressurizing inside is filtered neatly and it is kept pressurized [noise]. So, unwanted dust and outside thing does not get tracked into the space [noise].

I hope you appreciate the point whenever you push this then when you have the inlet air pressure which is coming here [noise] this whole thing is under positive pressure [noise] and the color depends again you know visualization about cold versus hot and you see here everything is cool and [noise] you have a filter in which know you have slightly different better control over it. But, the con is [noise] air flow is not uniform. If you have so many of these racks and then thing you have a fan here and a fan here [noise] I am sorry. So, many of the PCBs you have a fan here and fan here we do not know [noise] where the air is flowing [noise] you have really [noise] you know strict to control on it [noise] localized filter.

So, if you have a square filter [laughter] and if you put a small [noise] you have a square filter and you put a small fan in it you will see that the air no does not get you know [noise] gap for development of the flow. So, you will have a nice patch and remaining you know it is still be not useful then you have a air leakage issue here [noise]. Well it looks nice the smallest gap or in our case you know let us I have a connector or let us say you have a switch or you have access you know some where one thing this things any small leakage will [noise] allow the air to escape. So, we have a problem there and he calls it flow reflector you know [vocalized-noise] you you you end up with [noise] almost trying to use aeronautics and [noise] I am sorry QFT and those things you know [noise] to push air. If you do not use that analytics you will end up with [noise] trial end error fit end you know see blow end you know see [noise] what it is [noise]. So, while it is complicated the professionals are there who do it all the time, ok.

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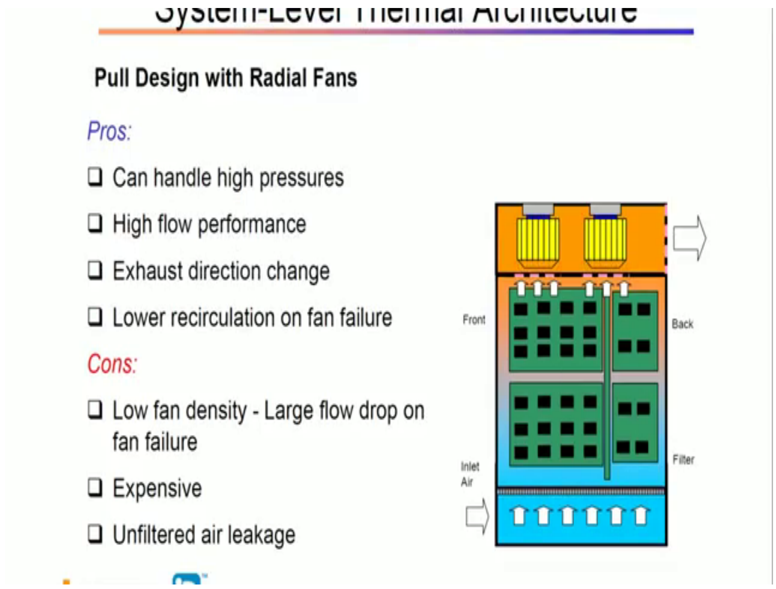

So, now [noise] we come with [noise] equally interesting thing saying can we have radial fans with a pull configuration [noise]. If you remember I have shown you that two circular fans in the center there is an inlet and exhaust is there all around just simple radial fan which goes in all the directions [noise] sucking in. So, and then it throws it in all directions. Now, we have here [noise] if those fans have an involute housing [noise] if you make an involute housing it will become like a regular blower. A little like the blowers you may see at home in your kitchen [noise] ah that what do you call hood [noise]. So, if you have a hob and you have a hood about it know there are very simple once which have only a small one are fan stuck they are very complicated once which have these abstractors which have these [noise] what do you call special involute casing blowers which are attached to it.

So, [noise] we have here [noise] the advantage inherently about this things is [noise] it can handle a higher pressure for the given other parameters. Again know they also take a little more lot more power, [noise] high flow, exhaust direction change. So, it is possible for us [noise] that you know we can [noise] play around with which way it is which is what I telling you about lower is circulation on fan failure [noise]. In the unlike the case if the fan failure means not that fan it will start running slow inside you know the chances of you know [noise] things getting circulated are poor [noise]. Low fan density large flow drop on fan failure expensive unfiltered air leakage you see.

If you see the whole plenum is [noise] under [noise] that whole cabinet is like a plenum chamber it deserve the lower [vocalized-noise] what do you call air pressure than outside. So, first thing that happens is [noise] it acts like a vacuum [laughter] anywhere there is a small gap or anything or you have forgotten [vocalized-noise] that is a you have a potentiometer for adjusting something which invariably comes with [noise] ah cap which has to be [noise] closed or you have a connector which already has a cap [noise]. Not all connectors [noise] are fully IP 67 sealed and all that.

So, anywhere these gas come [noise] air keeps going of inside and power is reality [noise]. You have power cables and then usually you have various types of what do you say [noise] I want to call it a full-fledged ah [vocalized-noise] what do you call, bus bar [noise], but you have places where the cables have to inserted all this places are [noise] they will suck here [noise]. So, we have this problem was it is not just about here leakage it is about unfiltered air getting inside [noise].

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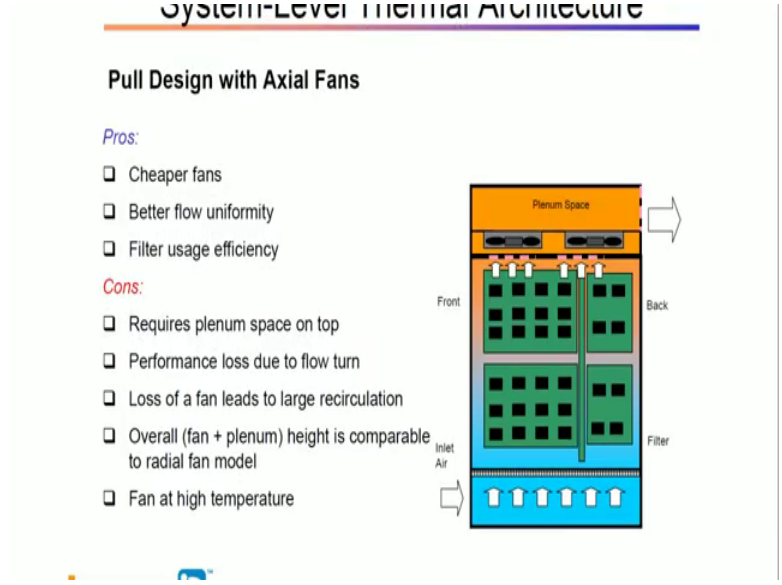

So, we have [noise] while that was shown with [noise] you see the previous thing is about radial fans. Now, with the axial fans [noise] it seems very easy to manage all you have to do is take the fan which was originally at the bottom here and then remove it and then I am sorry [noise] ah [noise] yeah what was originally at the bottom take these whatever fans here [noise] and just you know put them on top, put a space here and [noise] you can buy these fans off the shelf and [noise] I expect that they once what we get now are the 100 ah, 120 and 110 fans they are little about the size of a CD. So, they do not cost too much in our Indian rupees a good metal frame fan probably costs about 500 to 600 rupees and which torts works directly on the AC. So, you can you know maybe 10 [noise] US dollars [noise].

So, you can stick as many as you like all around [noise] better flow uniformity the flow can be controlled and most important is filter usage efficiency, because while here the pressure drop can be like this as it comes down all the part of the filter can be directly used [noise] which is good, is it not? [noise] So, now, if you see here in the [noise] problem here is, there is a space that is required on top of the previous picture not much of a space was required as such [noise] if you remember [noise] yeah, you see here the it is only limited by the total gap of the fan that is available only for convenience.

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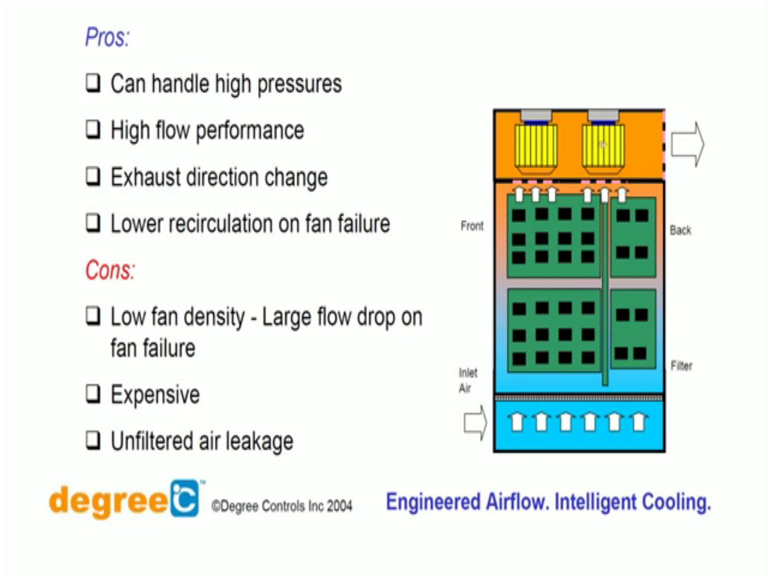

And, it is not a scale he has shown all of them you know about the same size [vocalized-noise]. Other than the fan proper itself you know this much extra place is required for us and whenever there is an attempt for the flow to turn you have a small problem here. One of them is [noise] this is already it is slightly positive pressure compared to this area [noise]. So, this fan know the way we arrange them whichever way you try to arrange this space there is always a compromise [noise] while last (Refer Time: 34:57) loss of a fan leads to larger recirculation. So, I am not very clear at this point why what I expect is in the case one of these fans fails [noise] so, the air no ah [vocalized-noise] does not behave the way we wanted to behave. Fan plus plenum height is comparable to radial fan model which is what he has shown fan at fan sees the high temperatures you see here this red you know already the hot temperatures are all seen by the fan [noise].

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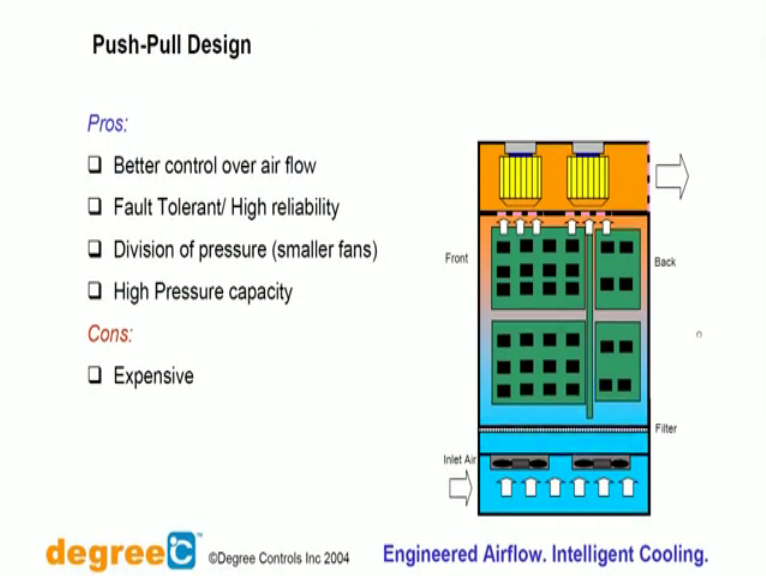

So, the next slide talks about can we have a compromise? Can we have a push pull design? Saying you are something pushing here and then you know something there and like all other what do you call design considerations it still a hotchpotch and a what do you call compromise [noise] [vocalized-noise]. So, air flow you have some control ah slightly higher reliability [noise] though I would like to what do you call contest that because the more devices you have chance of its failure are little higher, but in the case of [noise] a fault in the case of a fault [noise] they are still you know parallel things operating which happens with nature.

So, you must have heard of something called sympathetic circulation which happens to when people have a heart problems. Suddenly they discover that they have been leaving with it for [noise] let us say since 50 years then they will say no, no you had this as a [noise] as a in a very young time and then [noise] nature has compensated in it has given you alternate circulation hence you know you never noticed it. Now, when you come you have this. So, coming back here [vocalized-noise] the [noise] pressures between this and this no can be improved fault tolerance is about the then high pressure capacity [noise] because we have full control on it no one side you are blowing and one side you are what do you call exhausting it is there, but the main thing is extremely expensive [noise].

And, contrary to what we think it is not as easy to control as we think [noise]. Where do you put the sensors, where do you put the what do you wend switches [noise] and how do you take care of temperatures and which one do you switch on and which one do you switch off it is not known that well [noise].

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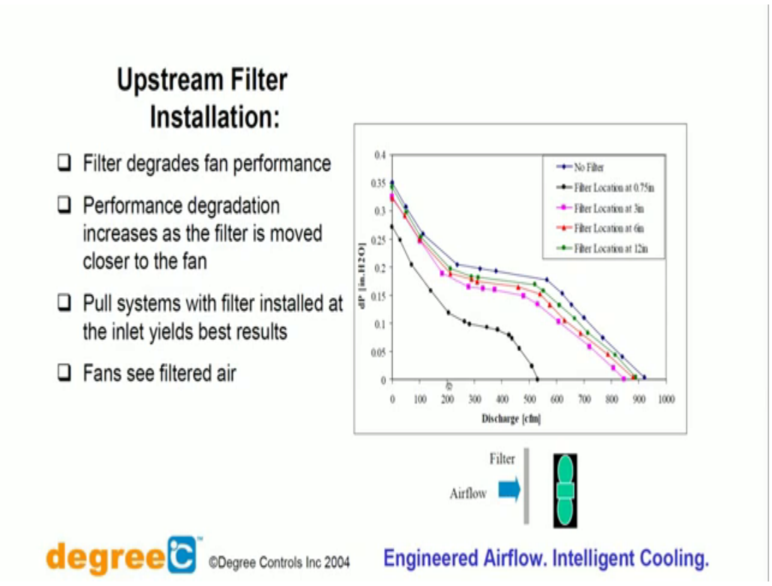

And, here ah [noise] this is more for what do you call I would not call it a filler, it is nice for you to know. So, I will glass over it all it means is [noise] you have an air flow [noise] there is a filter and if you leave a gap there is a place for it for the flow to develop [noise] ok.

So, ah lots of you know things are there you know about the a thing about a drop in pressure versus what do you call the discharge and so on know, in case you have no filter [noise] and filter location is far away how these things behave ah lot of these things [noise]. So, any filter degrades fan performance which I mentioned in passing earlier [noise] performance degradation increases as the filter is moved closer to the fan because smaller and smaller area only [noise] is available for you [noise]. If you were to shift this thing here it gets worse if you put a little more gap and make it back here. It is better pull systems with filters installed at the inlet yields best results fans see filtered air [noise] which is a beauty compared to other one. Just like you have this thermal heat issue you know if you want to keep the what do you call filter here fan has relatively [noise] cooler this thing. So, when the fan is rotating all the dust get settled here. So, maintenance is a little less.

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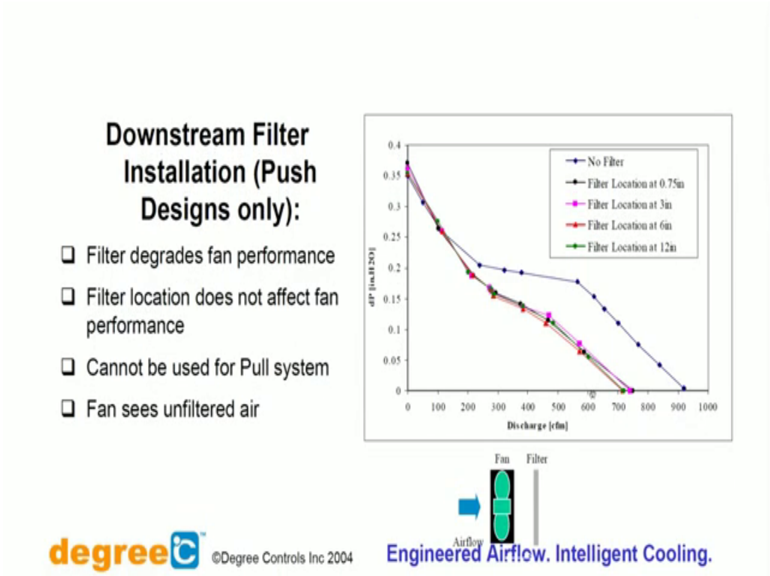

So, we have that the same thing is maintained here filter degrades [noise] fan performance location does not affect fan performance cannot be used for power system fan sees unfiltered air. So, you have the advantage and disadvantage this you probably would have noticed in case you have a exhaust fan in the kitchen it always gets coated with grease. I think you are taken all possible precautions, but then you know the reality grease here the same fan when it is used in your [noise] rest rooms, toilets and all that you do not have the grease problem as much as you have other problems. So, the I mean specifications and all are significantly different [noise].

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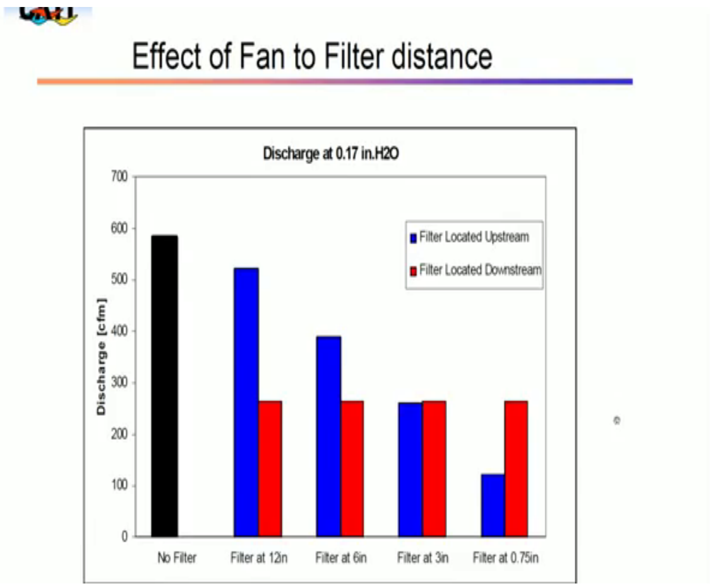

So, these are all been plotted ah saying ah filter located downstream, upstream the gap and you know no filter how [vocalized-noise] discharge changes with a [noise] so many what do you call centimeters comes sorry calls it 0.17. So, I am not familiar with it I expected it is about 5 millimeters water, [noise] ok.

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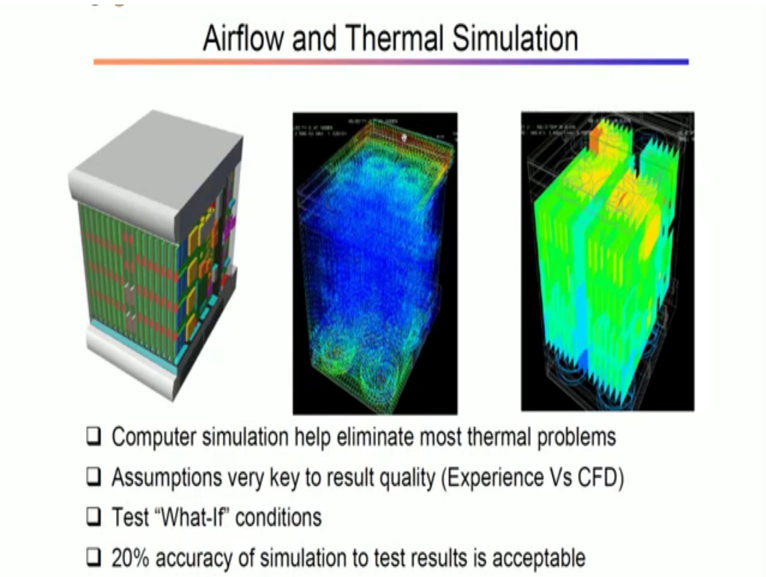

Ah now we come to very very very very very first [noise] what do you call changing first evolving what do you call things. So, we have a nice computers [noise] he has made (Refer Time: 40:24) of statement saying [noise] computer simulation hell you know helps eliminate most thermal problems, I do not agree with it at least it knows where the problem is and then next stage of optimization of [noise] positioning all this does solve the problem. So, I mean air flow and thermal assumptions very key result to quality [noise].

So, [noise] garbage in and garbage out, so, unless you know the actual heat transfer coefficients actual you know performance everything [vocalized-noise] and main thing is this what if conditions. If I put more spacing, how does it happen and what to do and all that [noise]. So, the thing like that no they have shown something which is simulated [vocalized-noise] why I I feel embolden to show this is we have done a similar thing in in the case of one of the early what do you call telephone exchange racks in [noise] India.

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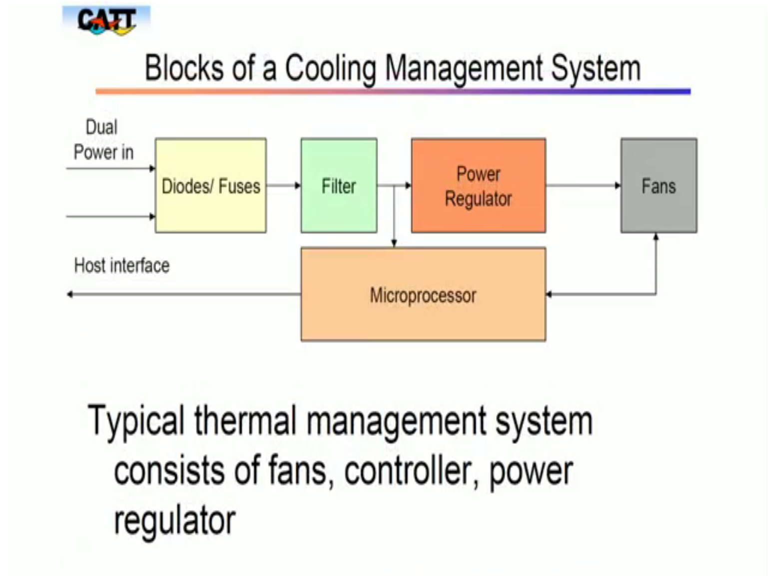

So, [noise] may be ah it is a lot of [noise] what do you call control ah of a cooling management system you have diodes and [noise] what do you call fuses [noise] and then you have filters we have regulator microprocessor [noise] coming back you see here we have a computer simulation ah which I will repeat again you know does not [noise] you know what do you call really solve problems, but it can test what if conditions saying if we do this what will happen [noise].

So, in the case you know the you see here they have put one two three some devices which will you know [noise] the configuration and we come here slowly [noise] various types of you know things [noise] saying thermal management system consisting of [noise] a power regulator [noise] and the actual fans then you have filters [noise] and these are all some backup things saying in the case of something what will happen especially [noise] to prevent they have given a diode logic here. So, you can in fact, have to dual [vocalized-noise] two supplies. So, one of them will come [noise] then this microprocessor is attached to the [noise] host [noise] interface where it will take it is input from various sensors which are mounted [noise].

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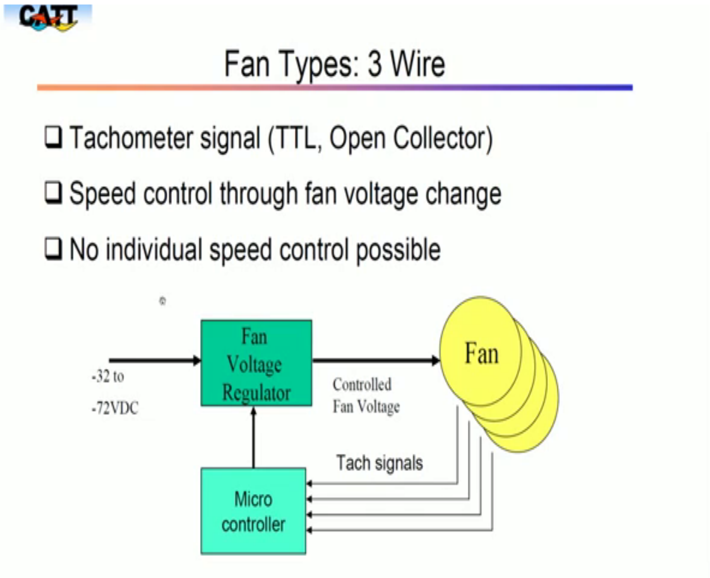

So, next picture you know [noise] talks about [noise] fan voltage regulator then tachometer signals meaning they are showing the what do you call ah [noise] what is the speed of the fan and very critical thing they are only using simple voltage control on the fan [noise]. Ah, we are coming in to some assumptions saying [noise] individually fans [noise] can or cannot controlled [noise]. So, we have only a single fan voltage and then the [noise] microcontroller ah gives you ah you know [noise] changes the voltage irrespective from something and runs the fan a little low I mean slightly lower speed or slightly higher speed [noise]. So, we have here [noise] he calls it [noise] three wire the succeeding pictures you know explain [noise] control input signal analog and pulse width tach output speed control through control signal precise individual speed control is possible.

So, what it is done here is [noise] each fan you know you have seen that control signals are there and then individual fan voltages are [noise] measured here. Instead of the fan having only two terminals each fan now execrable of having [noise] four wires. Ah it is used in normally in electronics whenever you want to take a measurement of even a resistor to prevent the [noise] leads from affecting that you have leads directly at that point say instead of taking something here you need to take for everything you end up with total eight. So, if you have a full four wire system like this you have much better control [noise].

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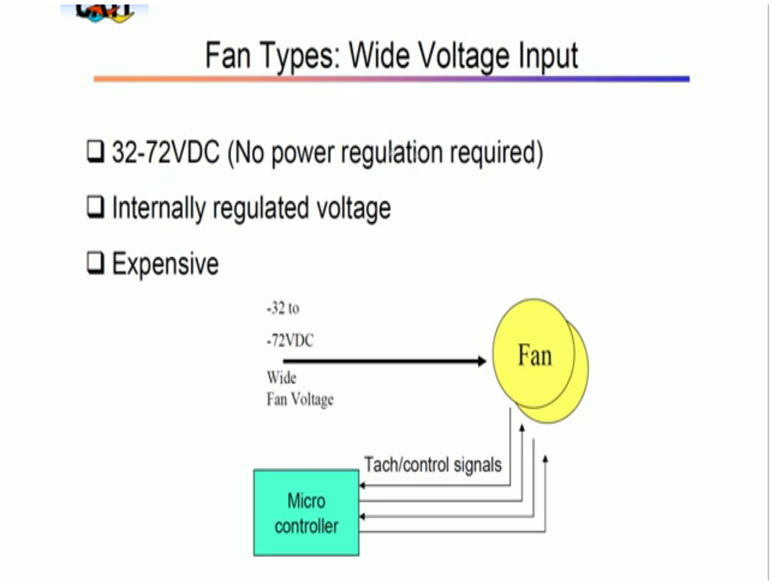

No power regulation is required if voltages are available here internally regulated only problem is [noise] expensive something somebody has to work on it. I feel [noise] it has it is more taken as a challenge by this company, but tough [noise].

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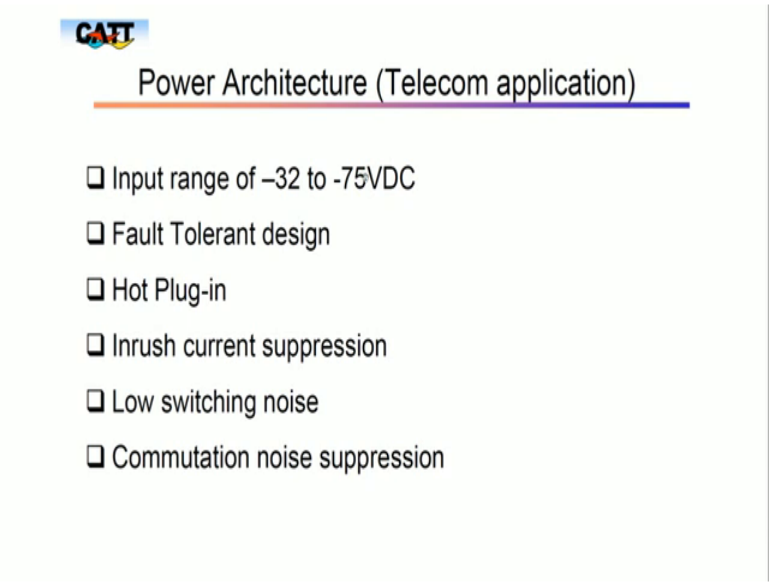

You seen this input range can vary fault tolerant [noise] and something very very important is hot plug in, meaning when the equipment is running you should be able to add or remove fans. It is a little tough, if you have some redundancy and if you can at least know things can hold on for some more time [noise] meaning as you remover a fan maybe you have access everywhere and you can divert it you should be able to quickly [noise] have another fan not running already to run remove it push it in and startup and the whole thing should be operated very quickly I expect it should not take more than around you know 5 to 10 minutes. Typically that is the time required you know for the whole system to [noise] malfunction [noise] [vocalized-noise].

We have this a tough about you know [vocalized-noise] I am not very clear about what this switching is. It probably means cutting in and cutting off of the fans and then we also have the stuff about in rush current. So, then a commutation noise suppression. So, [noise] in case you have DC fans which are commutated through old brushes and all or even with the electronically commutated fans obviously, we have a little issue about the fan motors themselves. Now, may be ordering the various characteristics of the rack.

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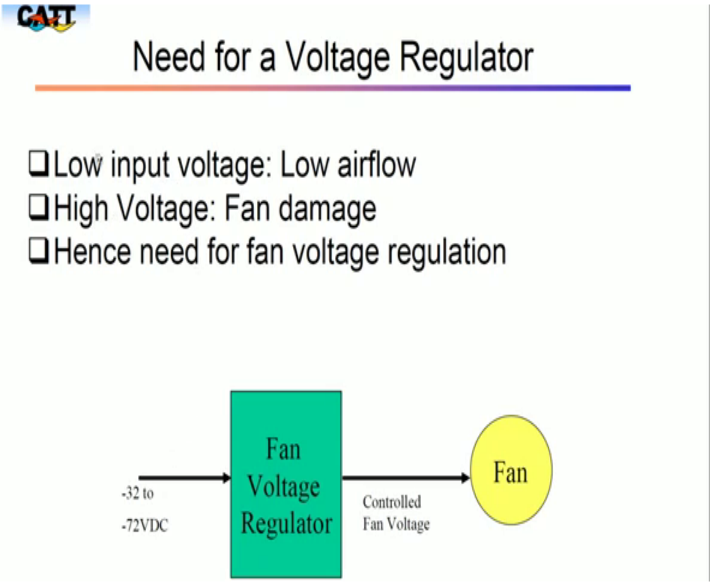

So, [noise] oh they have all this stuff about [noise] a fan voltage regulator typically for this and contrary to our popular what do you call intuitive reasoning motors never fail due to low voltage [noise] [laughter] not many people appreciated this. They say voltage you know it was there is it failed and in fact, motors are capable of operating up to a certain lower voltage below that they fail, but higher voltage is catastrophic immediately the things burn. So, we have fan voltage regulator.

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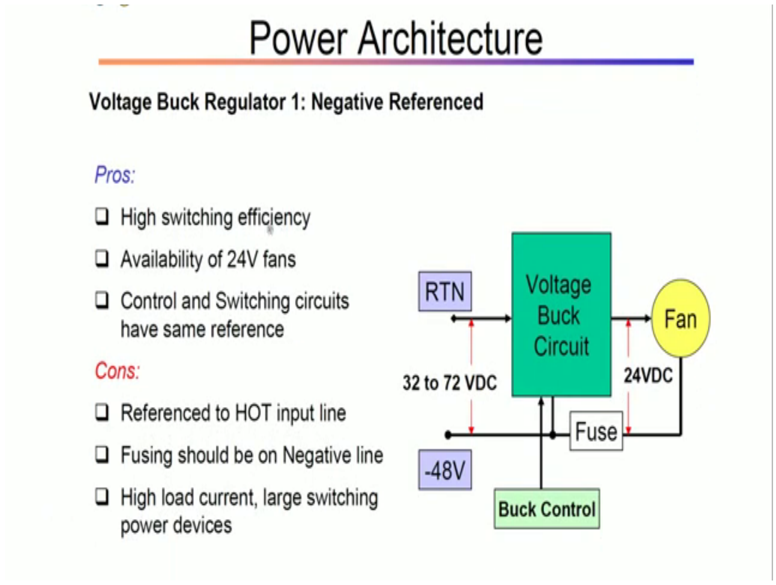

And, then oh we have so many of these you know circuit saying you know a buck circuits and so on [noise].

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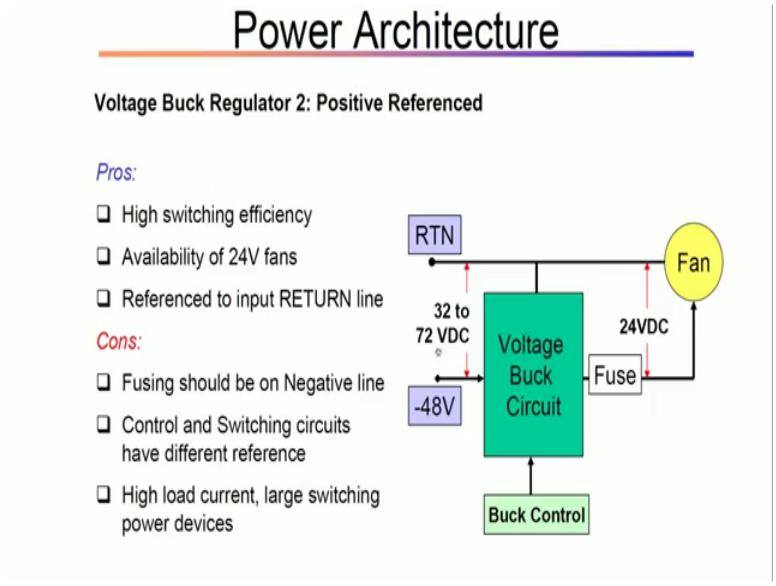

Which I feel ah is too much of [noise] thing except for actually students who [noise] work on this.

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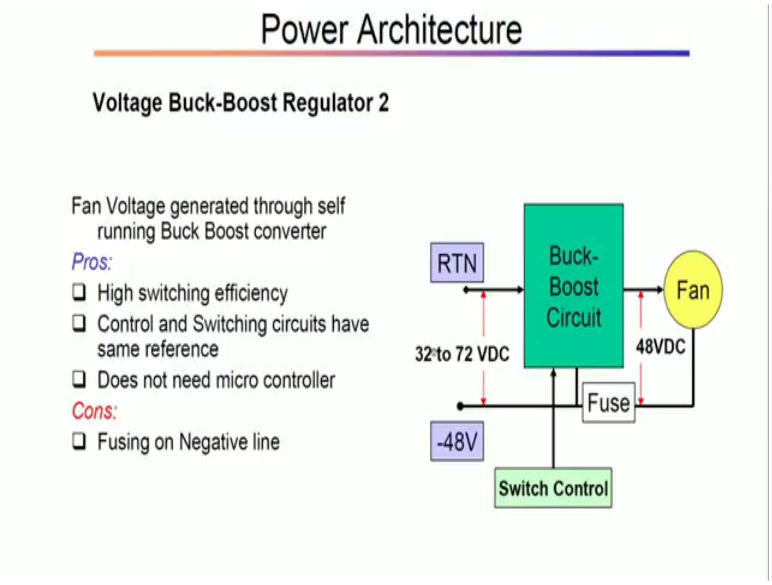

That company obviously, you know is able to have that is low voltage buck boosters and all that then voltage booster and I will just quickly just show you [noise].

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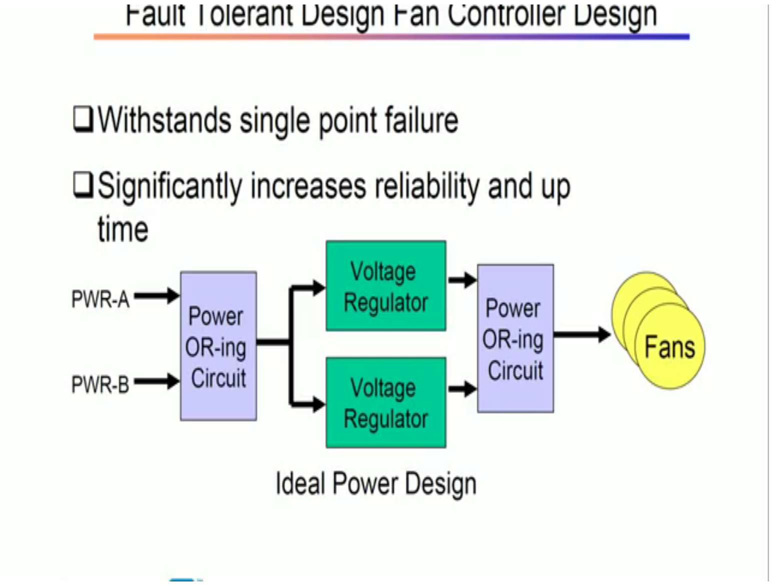

So, we have you know so much of you know or [noise] ah then even power know is giving a parallel voltage a thing [noise].

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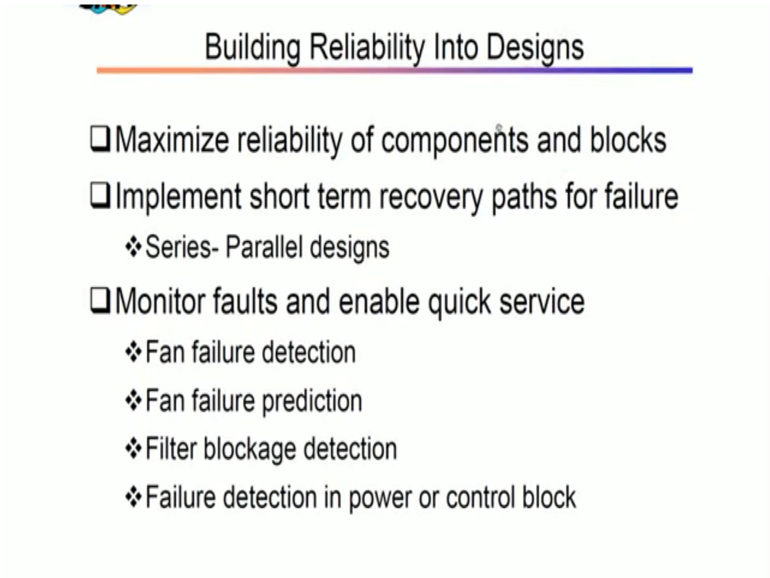

This is a general design saying you maximize reliability of components and blocks [noise] [vocalized-noise]. Short term recovery paths for failure, series-parallel design, monitor faults and enable service fan failure, prediction, filter blockage, in power control this are all this is very much you know very possible for you to do [noise], air flow rate maximize reliability [noise] [vocalized-noise] [noise].

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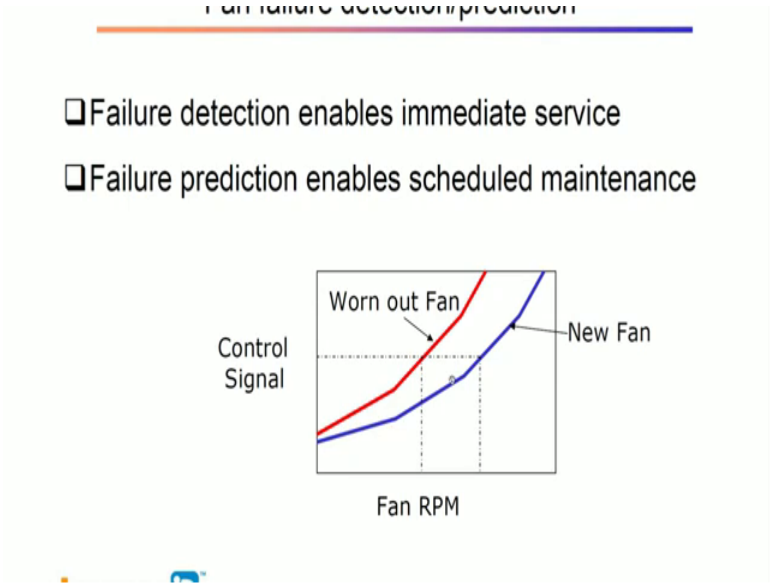

Immediate service, failure prediction enables scheduled maintenance [noise].

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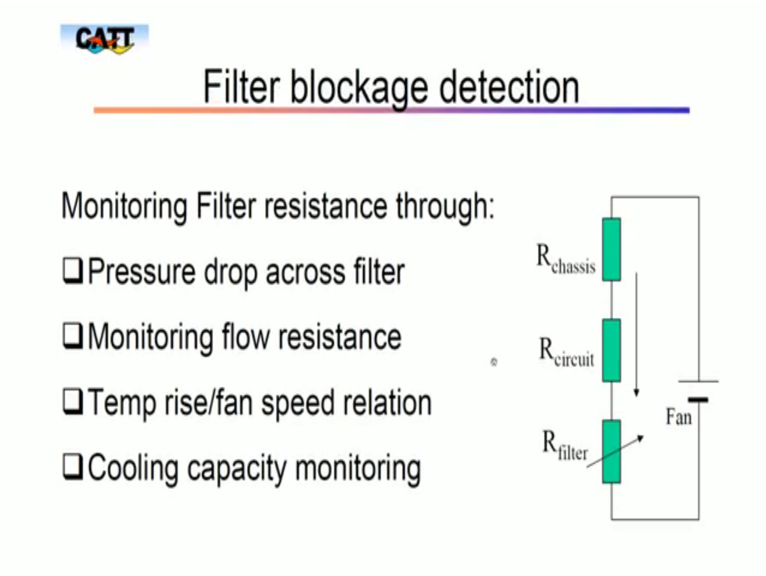

So, this looks almost intuitive and you need not worry about it saying ah we have so many [noise] you know they call a monitoring flow resistance, temperature rise, pressure drop across filter these are all very much possible cooling capacity monitoring [noise]. So, all of them it is very much possible for you to detect [noise].

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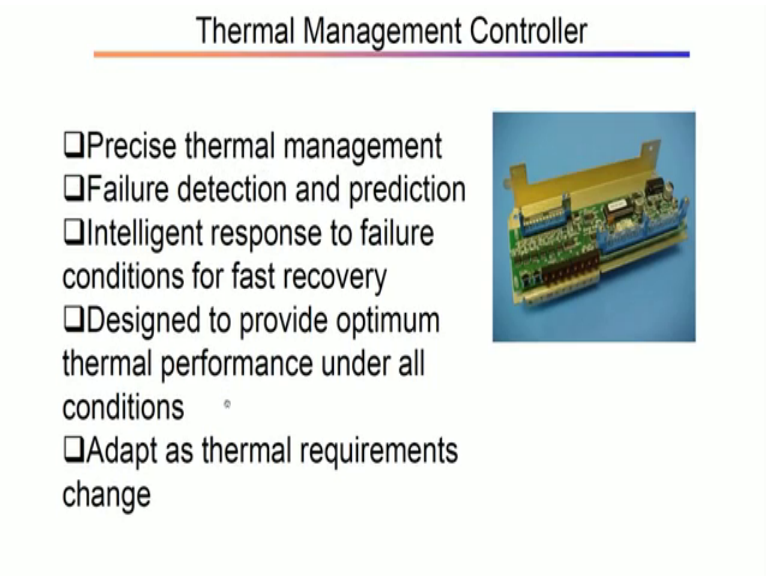

So, he has given their own obviously, you have patent [vocalized-noise] device which I have no comment on it [vocalized-noise].

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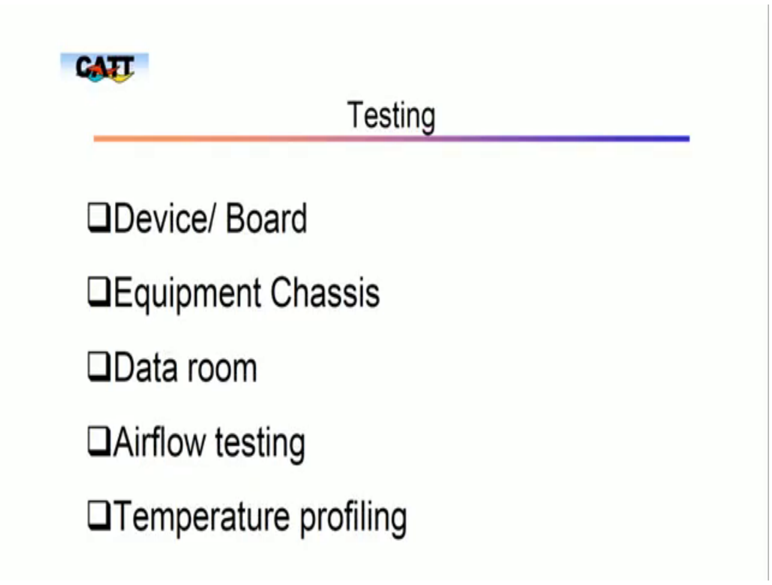

So, we try to do [noise] one somebody needs to take you know data room, device, board, equipment chassis [noise] and then work with all these things [noise].

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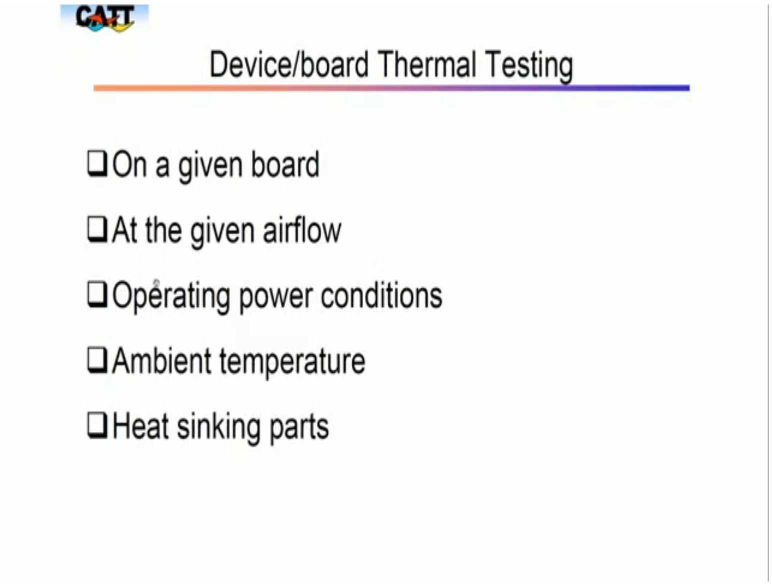

Operating flow heat, sinking parts [noise].

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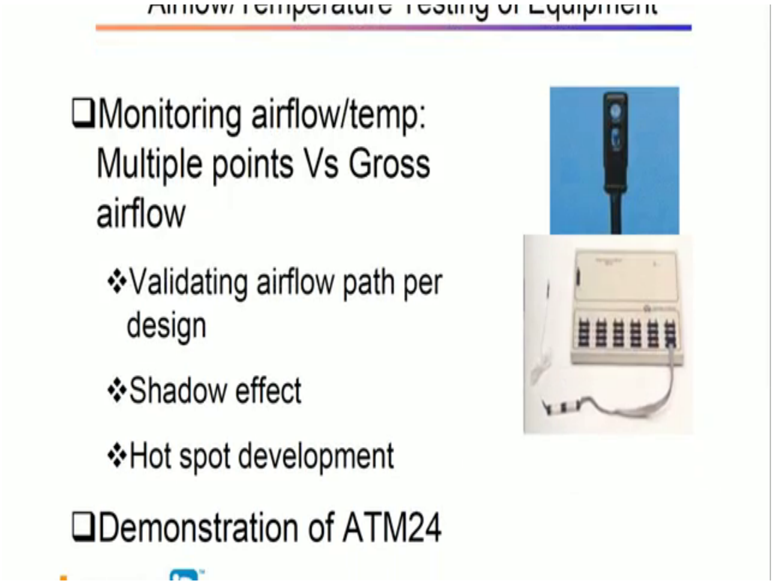

This is something I would like to [noise] show things. So, we have here you know so many what do you call data equitation systems and that small one is a [noise] it is a small turbine [noise]. So, both types are there. There is a hot wire anima meter and actual anima meter where there is a router which is turning. I cannot make out whether it is a hot wire anima meter or a normal what do you call simpler [noise] turbine anima meter. Hot wire is a little sensitive [noise] both to external factors and this, but extremely sensitive to temperature and a [noise] regular turbine type anima meter has a beautiful thing.

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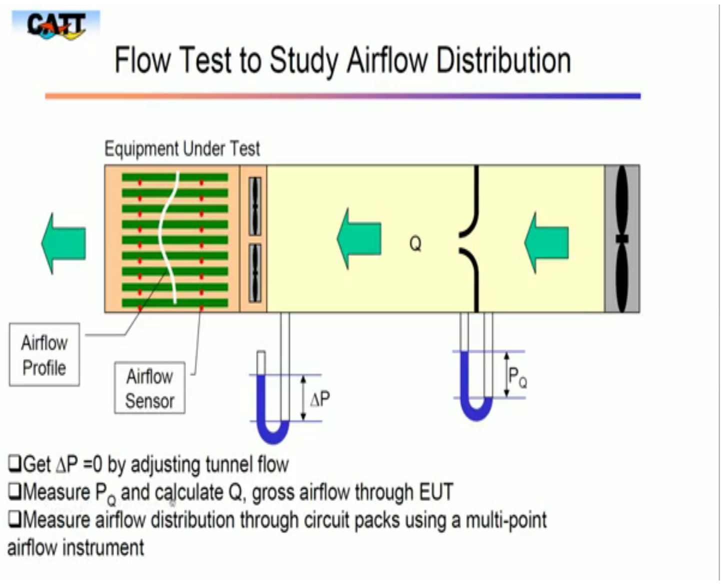

So, [noise] we have you know some way of air flow sensors mounted all over the place and then we try to make measure and calculate air flow and so on. It is nothing same sensors have been mounted, [noise] somebody has tried to plot it [noise].

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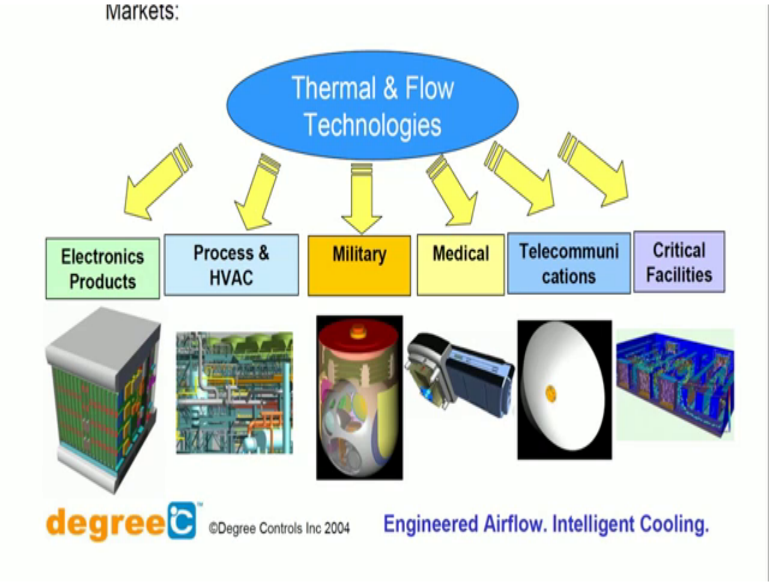

So, we have products and you know we have [vocalized-noise] heating and ventilation in the case of military I expect that this is probably [vocalized-noise] ah camera which is mounted somewhere and we have medical devices, then we have telecommunications and then I am not very clear what a critical facility is, that is a backup probably [noise]. This is again I am acknowledging directly from one of the companies which works on it. I am sure my suggestion is that you look for it on your own and then maybe contact them and you know [noise] follow them ah to the extent of this thing, because individual items they have it. Blindly coping one small part of it you know it will only solve the problem so much. So, thank you [noise] [vocalized-noise], we will meet again in the next lecture.

Thank you [noise].