Enclosure Design of Electronics Equipment
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Lecture - 37
Sealed Enclosures 2

Hello this is a continuation of the earlier lecture where I have brought you all the way up to saying where do you use a sealed enclosure.

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So, if you look at my sample which is there on the screen. I have given an example of how it is used on very routine common place applications or locations. So, you see here that we have a street light. I am sorry I think I should point this side. Yeah you have the street light controller, more than a street light controller. This one is for keeping cameras on.

So, obviously as per the negotiations, they have mounted and then, allow me to say I am not being intentionally circus sticker anything just that I am trying to appeal to you that you need to take interest in these things only, then things will take place.

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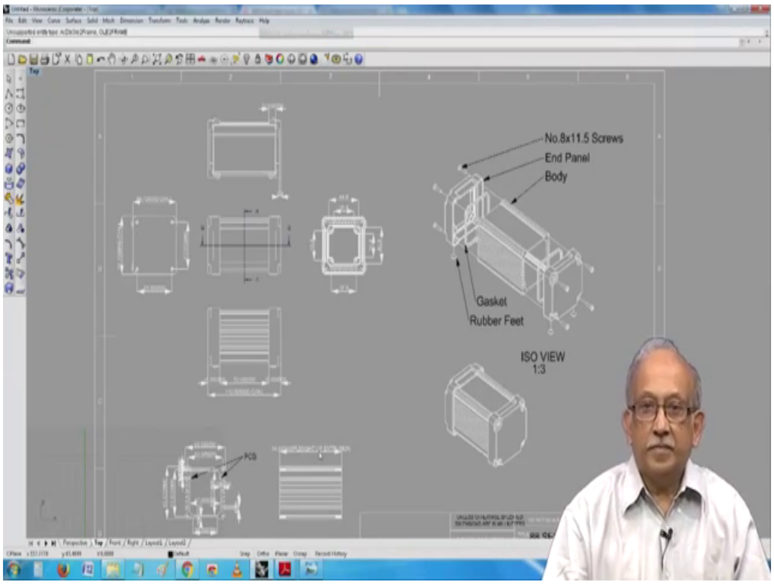

Now, I will take you to various types of data and documentation that is available for standard enclosures. Again talking about two things, that is not just a question of and this corner here. No, you will just see usual parts. One of them I am saying you know that yellow line saying gasket and then, it looks obvious. Is not it that you have got a beautiful stacked what you call parts and then, you fit everything together and magically things fit. Sadly that part which comes from the company has been tried and it fits without anything. There is no sadness in that, but if you just blindly go about copying these dimensions, chances are you will end up with, it really will not take us anywhere. Nothing is gasketing and related to gasketing while at the design stage, you can copy the geometry a little. The manufacture and after the manufacture, compliance and documentation is very critical. It is not easy. Nobody will risk putting any of this into the field directly believing as I will say unauthorized or you know non-compliant non-verified source like a lot of us. This has been actually taken from this catalogue.

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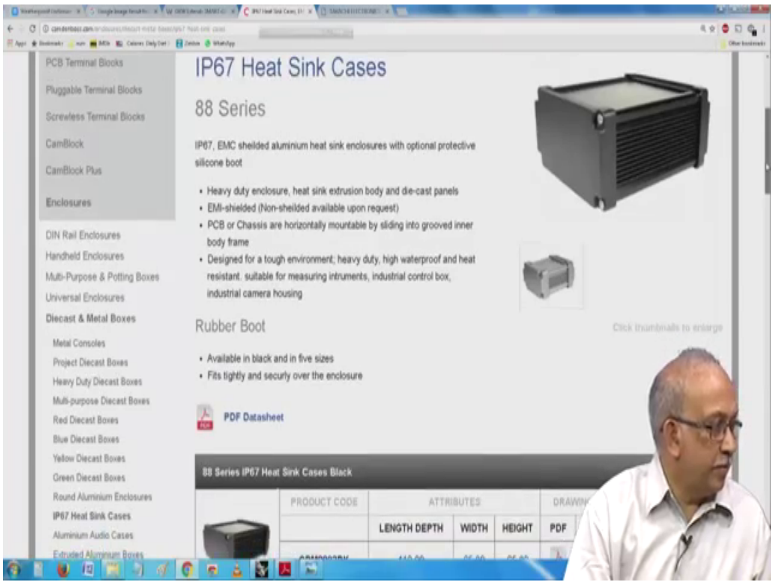

It looks like there is not too much of an IP issue about it, not the index and index of protection. It is about the intellectual property because if you buy it from them, you are welcome to use it and use it apply and so on. Here you have seen this EMI shielded horizontally mountable into grooved design for tough environment, heavy duty waterproof, heat resistant and everything has been tried and tested, hence also you pay for the quality.

So, even if you are to make it yourself, you should run throughout the tests and probably ask a professional to validate your design. Again this case is not a matter of filling a new number here and there. It is not a partial differential equation. Though some people have tried to modulate, I have nothing against. Differential equations are good and maybe they can even predict whether the case will file or not. Just like they can, I am sure they can accurately predict whether it is going to rain on your picnic and if you carry an umbrella, it will not rain. So, you are protected absolutely.

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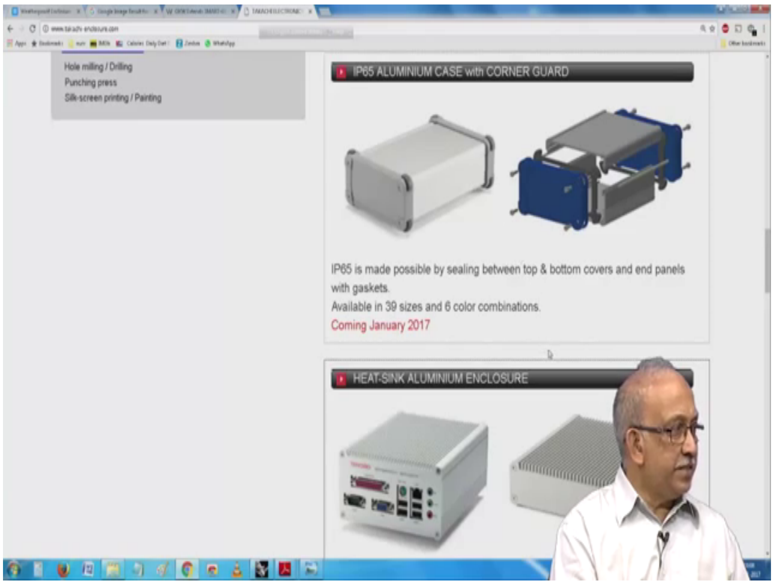

Coming back here you see here two types called 65 aluminium case and then, the aluminium case with enclosure. These things are available with a large number of suppliers and some of you may have seen waterproof mobile phones. So, what you call I wonder I held for maybe a few days, a Samsung Marine Mobile phone. The beauty of it is guaranteed. If you can somehow prove that without it opening, you throw it into the water and it still works. So, I think it is called samsung marine or samsung life style or something.

The beauty is an ordinary mobile phone has been made that it is IP56 IP65, both meaning temporarily. If you use it, however it is not the same as go pro underwater house. Gopro underwater house and all are special. You would have seen those things. Now, I will draw your attention at this point to lot of documentation that is available online to make something which is very important.

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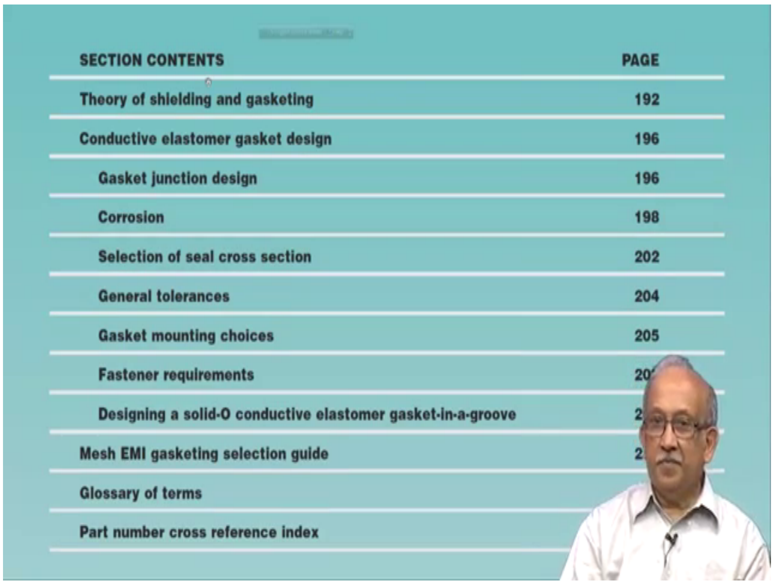

In the case of our electronics because most electronics they are indoors, there is no issue if you have a mobile like this. In fact, our recording person has told me kindly switch it off. Now, I remember it I am switching it off. If you have to take a mobile like this and keep it near a microphone, due to some very peculiar radiation issues, some noise from here is picked up from the microphone.

Next time if you see any of this, the TV shows and all that you can see one peculiar, it is not a ringtone, it is nothing which you can hear from the outside, but from by some EMI what you call interference which is one peculiar signal which your mobile sends to the nearest tower to show that I am here. That GPRS locating signal keeps getting picked up with these things, but it is not a big issue. You can always find out whichever whoever is carrying it.

Tell them can you please switch it off. It is not about muting it. If you mute it or if you put in silent mode or vibrate mode, still this EMI to MIC affects the performance of this recording. In normal courses, it may be just irritating sound, but imagine on the other hand you have some type of automatic something, something control I loosely use the word gain. I will only use the word volume, I will use the more technical word VU. So, you have VU meter and this sort of things you know over is look VU meter and then, trying to keep it at the optimum recording potion chances will lead to an error.

So, in the case of such equipment which are used close to each other and so on, this shielding and gasketing has become almost you know synomous. Synonymous saying in the case of oil and mechanical and fabrication and chemical industries while gasketing is used to prevent leakage as in the case I have given you an example of your automobile, are given an example of your bikes, a little bit of oil here and there does not matter. In the case of an automobile, occasionally the gaskets given inside and then, there are cases are the old systems.

Now, if you do not do scheduled maintenance, cooling water leaks everywhere including into the crankcase. Sometimes occasionally few drops into the actual combustion chamber which is rare, but then still water gets inside, but in the case of electronics that is not the only issue. The issue is interference related to electromagnetic as well as conducted is very critical. So, here if you see there is a beautiful what you call paper. I will call it a white paper because anybody can read through it.

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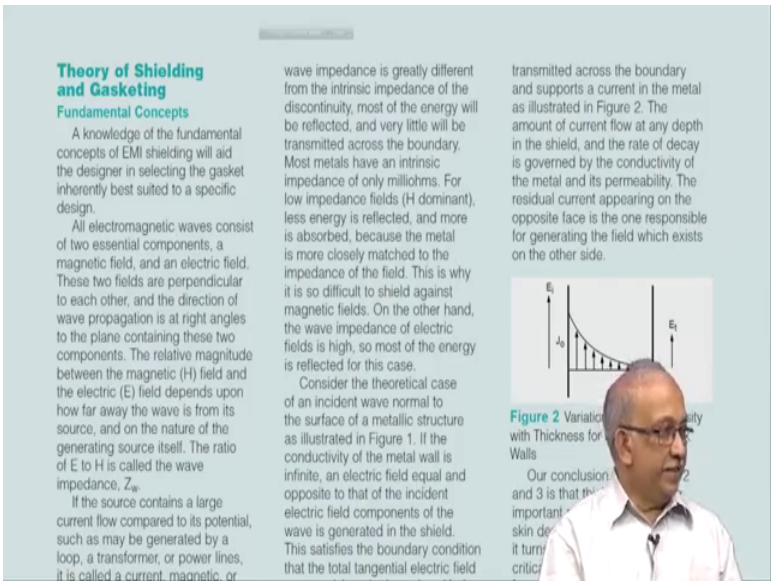
Theory of Shielding and Gasketing

Fundamental Concepts

A knowledge of the fundamental concepts of EMI shielding will aid the designer in selecting the gasket inherently best suited to a specific design.

All electromagnetic waves consist of two essential components, a magnetic field, and an electric field. These two fields are perpendicular to each other, and the direction of wave propagation is at right angles to the plane containing these two components. The relative magnitude between the magnetic (H) field and the electric (E) field depends upon how far away the wave is from its source, and on the nature of the generating source itself. The ratio of E to H is called the wave impedance, Z_W.

If the source contains a large current flow compared to its potential, such as may be generated by a loop, a transformer, or power lines, it is called a current, magnetic, or

wave impedance is greatly different from the intrinsic impedance of the discontinuity, most of the energy will be reflected, and very little will be transmitted across the boundary. Most metals have an intrinsic impedance of only milliohms. For low impedance fields (H dominant), less energy is reflected, and more is absorbed, because the metal is more closely matched to the impedance of the field. This is why it is so difficult to shield against magnetic fields. On the other hand, the wave impedance of electric fields is high, so most of the energy is reflected for this case.

Consider the theoretical case of an incident wave normal to the surface of a metallic structure as illustrated in Figure 1. If the conductivity of the metal wall is infinite, an electric field equal and opposite to that of the incident electric field components of the wave is generated in the shield. This satisfies the boundary condition that the total tangential electric field

transmitted across the boundary and supports a current in the metal as illustrated in Figure 2. The amount of current flow at any depth in the shield, and the rate of decay is governed by the conductivity of the metal and its permeability. The residual current appearing on the opposite face is the one responsible for generating the field which exists on the other side.

Figure 2 Variatio... with Thickness for ... Walls

Our conclusion ... and 3 is that th... important ... skin de... it turn... critic...

So, there is a lot of thing about relative magnitude between the magnetic field h and the electric depends upon how far away the wave is from its on ratio of e to h is called the wave impedance and then, this is all a little bit of little theory.

So, you have here two planes and I suggest you read it. I am no good at it. There is very reason I am trying to show you these things. So, we have here a lot of issue about what exactly is current density, skin depth and thickness, critical at low frequencies, thickness of the metal or whatever you are trying to do these things.

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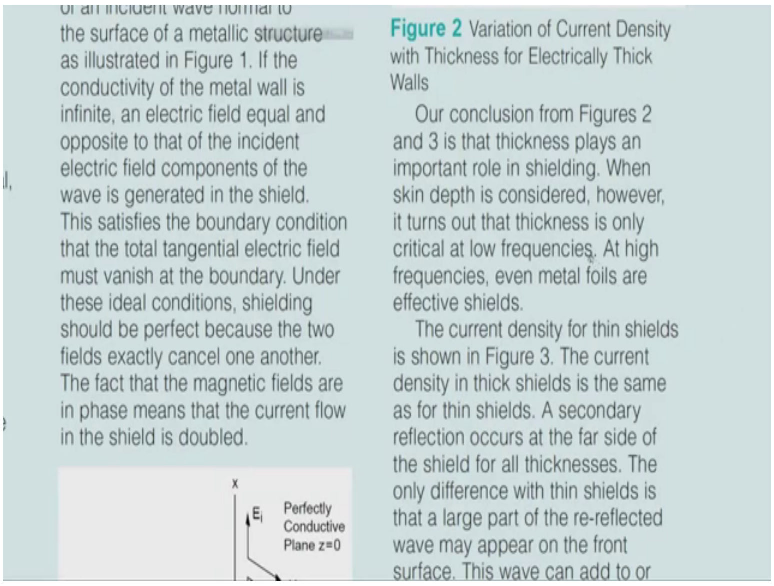

of an incident wave normal to the surface of a metallic structure as illustrated in Figure 1. If the conductivity of the metal wall is infinite, an electric field equal and opposite to that of the incident electric field components of the wave is generated in the shield. This satisfies the boundary condition that the total tangential electric field must vanish at the boundary. Under these ideal conditions, shielding should be perfect because the two fields exactly cancel one another. The fact that the magnetic fields are in phase means that the current flow in the shield is doubled.

Figure 2 Variation of Current Density with Thickness for Electrically Thick Walls

Our conclusion from Figures 2 and 3 is that thickness plays an important role in shielding. When skin depth is considered, however, it turns out that thickness is only critical at low frequencies. At high frequencies, even metal foils are effective shields.

The current density for thin shields is shown in Figure 3. The current density in thick shields is the same as for thin shields. A secondary reflection occurs at the far side of the shield for all thicknesses. The only difference with thin shields is that a large part of the re-reflected wave may appear on the front surface. This wave can add to or

So, what are low frequencies? Typically it is 50 hertz and 100 hertz or in the case of some places where you have 60 and then, the 120.

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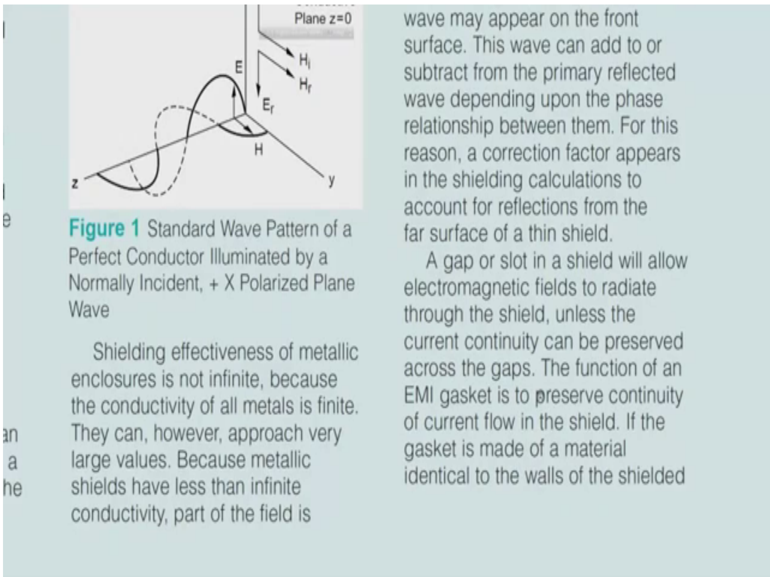

Figure 1 Standard Wave Pattern of a Perfect Conductor Illuminated by a Normally Incident, + X Polarized Plane Wave

Shielding effectiveness of metallic enclosures is not infinite, because the conductivity of all metals is finite. They can, however, approach very large values. Because metallic shields have less than infinite conductivity, part of the field is

wave may appear on the front surface. This wave can add to or subtract from the primary reflected wave depending upon the phase relationship between them. For this reason, a correction factor appears in the shielding calculations to account for reflections from the far surface of a thin shield.

A gap or slot in a shield will allow electromagnetic fields to radiate through the shield, unless the current continuity can be preserved across the gaps. The function of an EMI gasket is to preserve continuity of current flow in the shield. If the gasket is made of a material identical to the walls of the shielded

The harmonic of it is still considered low enough and there is no simple way of getting rid of it. So, if you are a serious audio filler enthusiast, you will notice that whether you like it or not, hum is real and not the type of you know humming you enjoy your noises in my head, the one that whenever you take cables and try to connect them together, for some reason hum gets picked up early. Professional electronics guarantee if you use their own in proper connectors and then, their own equipment because the issue is not about just thickness, it is about something called impedance matching, something about the source impedance, something about the target impedance and so on.

So, a gap or slot in a shield will allow electromagnetic fields to radiate through the shield, unless the continuity can be preserved across the gaps. The function of any EMI gasket is to preserve continuity of current flow in the shield easier said than done. If you remember the 2nd or 3rd lecture, I talked to you about typical what you call enclosures used in normal day to day things. What you have see one of them was a game and that the game is built on what you call CD drive. So, if you open it, you will be surprised that there tremendous amount of care has been taken to have a proper shield. It is not a simple gasket. It is a shield made of a material called the new metal.

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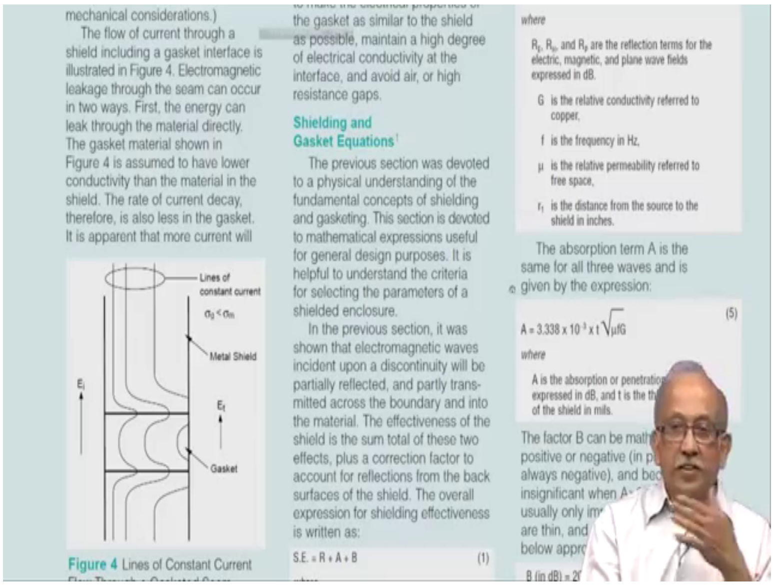

So, those of you enjoy equations, the lots of equations here, well I enjoy equation. There is no problems about it saying, but an equation will not give what you call an answer to all of your problems. One specific question; one instance. It will tell you whether this option what you are considering will lead to this or not.

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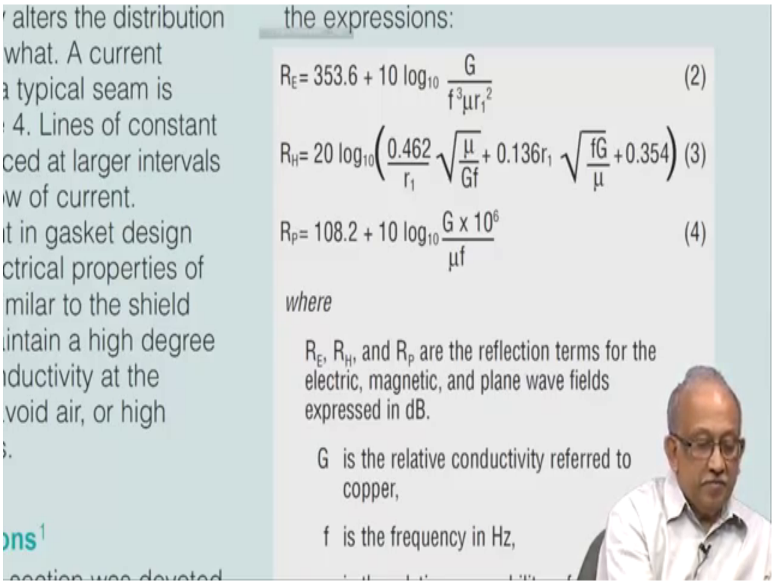

Luckily for us all this thing is available about you know something about penetration loss expressed in DBEA and then, you have nice beautiful fantastic correlations which will give you a lot of this about shielding effectiveness in DB reflection factor and then, absorption term expressed and the correction factor due to refractions from the far boundary and so on saying in likely cares that you are enclosing everything in a box. It will help, but I have non-cases. I will say serious enthusiast and they are not actually novices. I have tried to take a transformer, put it in a box, weld the box all around and put glass beads and then, still it does not escape. You see electromagnetic part you have taken care of, but the conductive part we do not know where it is coming from. Is it across the wall or is it through the beads and fit through capacitors, put it in another and still it is a trial and error hit or miss solution.

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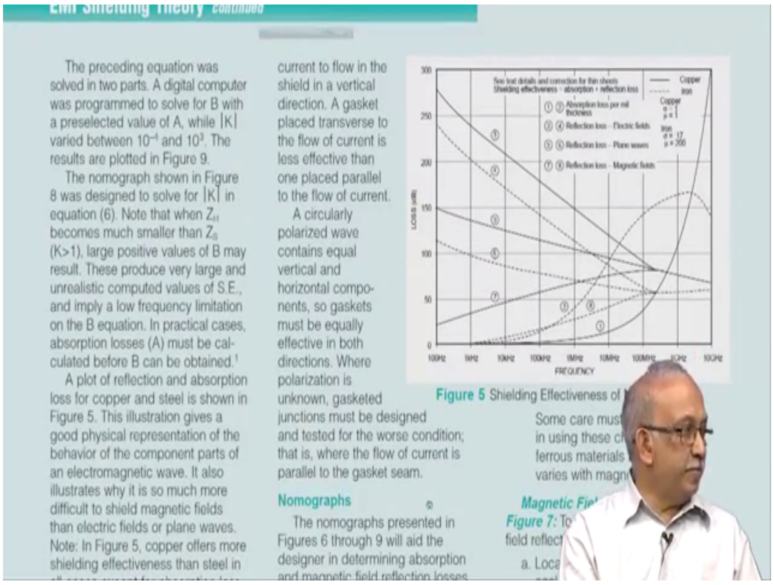

Then, if you have these equations, probably you are better off and then, you come to all the stuff shielding effectiveness of metal barriers magnetic field absorption loss.

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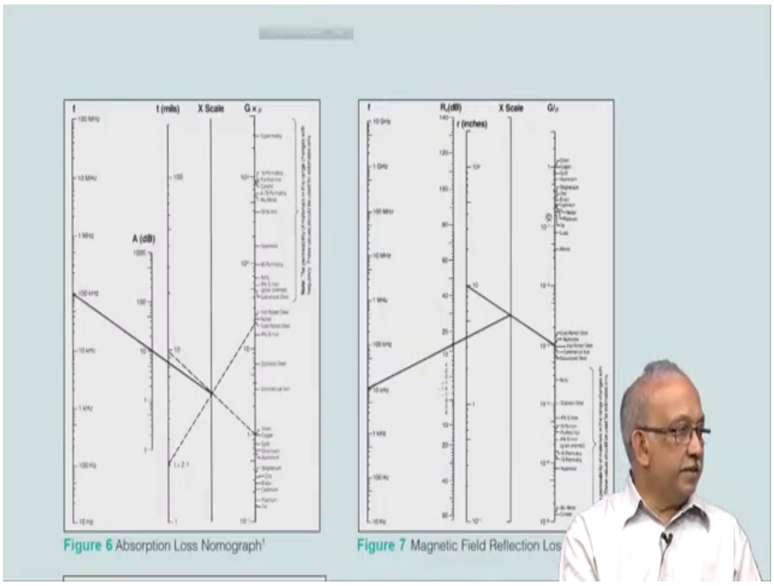

So, we have all this nice beautiful figures in which if we are attempting a first time design or already you have an enclosure which needs slight improvement somewhere.

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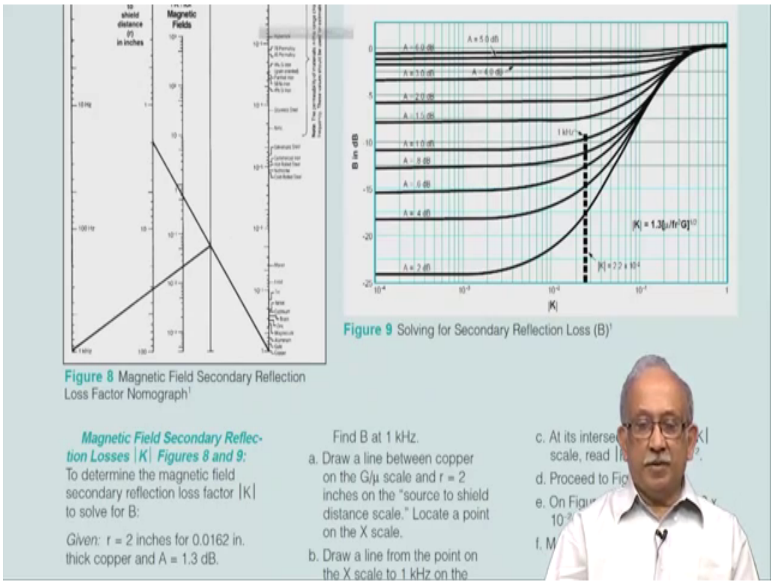

Imagine whatever constraints you need to make an opening if you remember I showed you a place where there is a small filter on one side, one of those for control units and similarly, even the previous street that control with unit which is connected to that camera and talk. So, that had a small opening and one side. Now, that can lead to problems, right. Now, fortunately it is a nice selection as such there is no issue about it, however to be mounted one above the other or one nearby one very close to the other electrical things, this is real at that point. Now, you need to consider all these last factors, this nomogram and all that.

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We come to the actual gasket junction design. You understood that we have opening here, opening here, something comes in place and then, you need to put something to make sure that there is no leakage out. Now, there is no leakage in and then, that way if you look at it, if you take any of these mobile phones, it has so many antennas, I am surprised to how there is no interference. So, I asked a friend of mine and he told me he did not call me an idiot, but it was obvious that I did not know much about it saying you have a simplified view of the world. In those cases, the antennas probably work in different frequencies and then, they are mounted separately and in between there are other methods of doing. Secondly, tremendous amount of error correction and data loss of data has been compensated.

So, now you know even a very simple phone has probably have standard what you call GSM, GPRS, Antenna. Then, somebody tells me that you need different antenna for other functions. In this case, this is a Wi-Fi. So, this can be used to control my DSLR. The new ones are controlled by Wi-Fi and then, we have Bluetooth and as if this were not enough. We have NFC devices which tries to communicate when I mean the field is very nearby. I thought the last thing has been done and suddenly wireless charging has come. Wireless charging may be a simple loop or if you want to reduce the size, it is not as simple loop as may think there is something more to it than that.

So, a lot of times, a lot of interest and things are made. So, I thought we should read the first part of it. I will try it what you call enlarge. You have seen that while the correlations are the analytical things which I have shown you must be used. You also need to think about second level after you applied it in the field for some time. What is likely to happen, you seen this many gasket designs fail. It is here the designer could not or did not treat the mating surface with the same care as given to the selection of the gasketing material. By definition a gasket is necessary only when an imperfect surface meets. If the junction were perfect which includes either a solidly welded or one with the mating surfaces stiff flat and across the junction, no gasket would be necessary.

So, I will see whether I can punch up. If you see the air conditioners are at home, you have your what do you call refrigerator. If you see it at the back, one of the first thing you will notice is that main pump which pumps all the gas loosely called is fine depending on. It is in the liquid state that you pump, you call it a pump. Otherwise if it is in the vapour state, it will become a compressor. So, the compressor is typically hermetically sealed. Whole thing is welded together because we cannot allow a leakage, first problem. Secondly, the contents inside is dangerous, some of maybe toxic, some of them maybe corrosive, some of them are expensive and even a slight loss of pressure will completely damage the whole equipment because that refrigerant what they use inside once charged, it is expected to stay for a long time.

So, some of you if you remember long ago device called a frigidaire. In fact, it has become the shortened form of fridge like xerox has become generic. You put something in a fridge. So, frigidaire, some of the old frigidaires which were charged may be 50 years back, they continue to pump without any problem and the earliest compressors that is never any problem, one or two issues are there. One is it is a closed cycle. So, chances of any losses there and somebody has maintained the correct quantity. If you put too much of it, it refuses to operate. If you put too little of it, it refuses to condense. Somewhere there is a latitude of operation between evaporation and condensation and based on that they have charged it and weld it. The whole thing except that you have a small nipple on one corner which is used in the case of emergencies. So, it is connected to a charging cylinder and once it is fully charged, it is crimped and after crimping sometimes that it is breast also technology has changed a little now.

So, in the case of your split AC, they come separately and nobody charges. If you have noticed, it comes in fact in two boxes with the words made in PRC all over the world and then, I want to call him what you call a lowly technician. I will say highly trained technician. He comes and only effort required is probably to make an opening in the wall. Some of the new constructions already have small plug built into wall. He pushes all the necessary what you call pipes inside, he joins everything together, tightens it, opens, evolve and goes on. He need not even check whether it is cooling.

So, you have seen that important thing is why I am mentioning it here is the compressor part is hermetically sealed. You cannot find a better compressor. I mean better more hermitically sealed thing than that compressor which is used for compressing the refrigerant while that is sealed. Similarly, you have the evaporator which is inside generally not so bad, but then these two are joined with a copper pipe.

At the end of the copper pipe, you just have a tapered conical some joint. You just have to push it inside. I will use the word collate and something is straitened. I call it hold onto that and then, he applies, he puts maybe a little bit of tape, applies this specified amount of thing on one wall opened and you have a working air conditioner which generally if it is done properly keeps working.