Enclosure Design of Electronics Equipment
Prof. N V Chalapathi Rao
Department of Electronic Systems Engineering
Indian Institute of Science, Bangalore

Lecture - 14
Materials used for construction

Good morning. I would like to continue with where I left off regarding making an enclosure for an electronic equipment, say two levels are the initial level it is only a prototype enclosure, by which you pack all your whatever electronics your circuits with the functionality in in mind and to make sure it works well.

If you remember in the previous presentation I told you a minimum of probably three iterations are required even for a good workable prototype. It is such not a lab demonstration it is not a lab exercise, it is not a simple you know one of what you call one of type of a in equipment you need to show to the intended user this one. No one it is expected you will have a nearly perfect object like this, you seen this know I think all of us are familiar with this.

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This is once upon a time hard disk and right now with the new technology it is possible for you to make a few numbers of this in a small contrives, and then now put it for a beta test and eventually go for the ultimate final production. But then the way this things are made even for you to do the initial testing you probably need something which is very

professionally packaged so that it will not base acceptable to your normal routine, handling routine vibration and all that.

So, bear with me with a little bit of you may find a little bit of repetition, and the core or the focus of the whole thing is you figure it out yourself. Unlike high level abstraction in a mathematic correlations or relationships you cannot represent anything by a simple variable and then play on the variables, and then in the end you try to have an optimum descent right away because things are changing all the time. So, even this same thing it is with materials, right now this is current to the extent that in case you are in a small thing like a lab or you have access to a vendor, you will be able to make use of thing.

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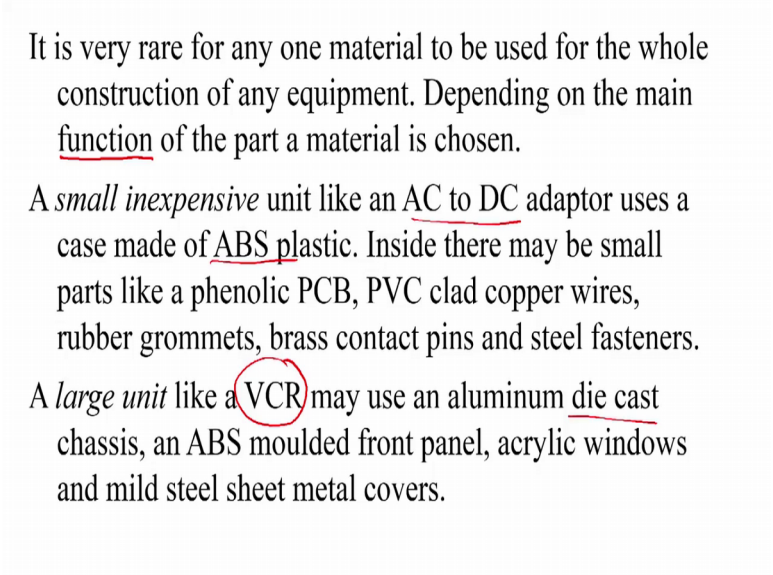

One away first thing about this is kindly if you can read along with me, depending on the main function material is chosen. Looks obvious is it not it is common sense, but sometimes we forget a rather I am sorry we can get carried away by looking it a piece of equipment, which is already in production and try to see whether we can make a thing like that at one extreme, we end up with having a very cheap plastic box my own thing is saying fit everything into a red box or the other extreme take another unit and try to modify it somewhere in between we have. A inexpressive unit like an ac dc adopter, uses a case made of abs plastic. Inside there may be a small parts like a phenolic printed circuit PVC clad copper wires rubber grommets brass contact pins and steel fasteners.

A large unit like a VCR right now VCRs are obsolete, but then you have probably a blue ray ply over are now 2 k and 4 k players may have a big die cast chassis. A moulded front panel acrylic windows and mild steel sheet metal covers. Sheet metal covers are because it is flat by definition even now anything flat and wide and which has to occupy a very small space, you cannot beat metal and it is common places to call you know a sheet metal of any steel. So, by default if somebody is refer think into sheet metal let us probably main steel, otherwise any metal in a sheet form example aluminum or you can have brass sheet and all that know generically they come under that.

Then we have this acrylic windows; acrylic has a an advantage the mu are the optical index is very close to air and little close to water, by which it will continue bit it transparent and the properties can be modified such that if you want you can have a higher index or otherwise you can have a lower index and so on first priority is it clear nothing to worry about it is as clear as glass, without the chance of breakage and easy mouldability. So, any windows you see any small thing and including a thing called a light pipe is probably made out of a acrylic moulding, but then acrylic is not yet scratch proof. So, they use abs and various other things to see them better.

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The construction of a *portable stereo* player may include a load bearing chassis made of mild steel sheet, covers made of ABS plated with nickel, transparent parts made of acrylic, internal electro-mechanical items like levers, pulleys and gears made of nylon, polycarbonate and various acetal co-polymers.

Hand held devices like *cell phones*, calculators, cordless handsets and the like will have most parts made entirely out of various modified versions of ABS and simpler Polystyrene.

If you take a stereo portable stereo player may include a load bearing chassis, in this case a stereo player this particular thing refers to a mould chassis player. So obviously, the chassis could be made out of mild steel sheet covers made of abs you see here slowly we

are coming into a very very interesting thing. Advantage of this new moulded or injection moulded parts plastic can easily be platted, and in fact, if you look around your house all the tabs or facets which have a fancy shape, are all probably made of plastic. One give away is that there will be a sticker on it saying do not use any material you know which is likely to scrub, use a non scoring pad and then use mild soap and all that because the thickness of the coating is very very small of the order of a couple of a microns, it does not what you call stick very well to the base the first you know fault it will come away.

So, most of the things you see around which look a little bit metallic or probably all made with abs which is plated with nickel that is a process itself. So, we have abs with nickel transparents parts made out of acrylic internal electro mechanical items like levers pulleys and gears, made of nylon polycarbonate and while various acetal co polymers. This acetal co polymers it slightly difficult to mould, but still that is the strongest; so, you have a very small gears with the modules have the order of even 0.3 0.2 mm, they are all mild with this acetal polymers which will maintain the shape without any problem. Things which do not have (Refer Time: 08:12) or probably I continue to get made with other plastics where the ones that need to have good tongs miscibility of force have all this plastic.

Hand held devices like cell phones; calculators, cordless, handsets and the like will have most parts made entirely out of very various modified versions of abs and ps polystyrene. So, it is cheap; polystyrene is what your soap cases are made of and depending on the cost. But if we are into cosmetics let us say you want a compact powder or you want a that you know multi color rust box there well the use even a expensive this thing because the field is very very important it should look valuable. So, you do not go and buy you know really valuable any item which is not packed properly and not packaged outside properly, because the packaging is part of the use and listen when you when you receive a gift you expected to be gift rapt.

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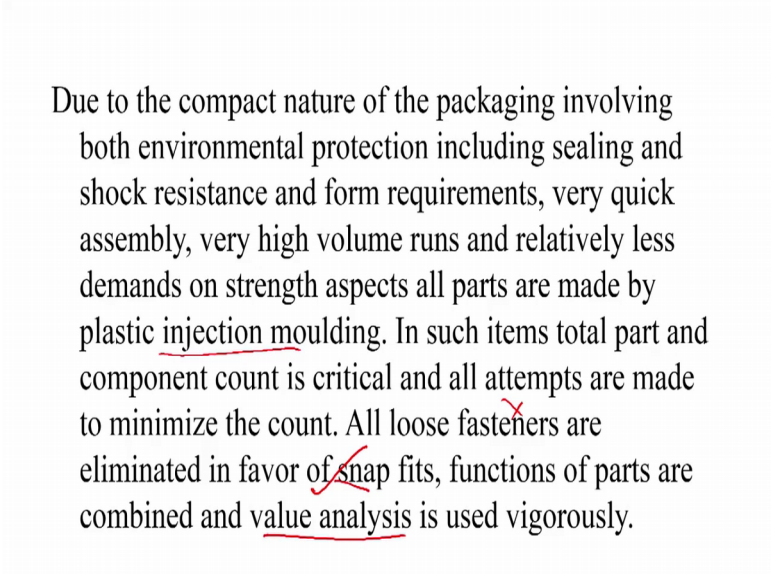

So, we have this problem of due to the compact nature of the packaging involving environmental including sealing and shock resistance and form requirements, very quick assembly very high volume runs and relatively less demands on strength aspects all parts are made by injection moulding. In such items total part and component count is critical and all attempts are made to minimize the part count. All loose fasteners are eliminated in favor of snap fits fasteners no snap fits yes. Functions of parts are combined and value analysis is used very vigorously intensely, otherwise we cannot meet the target cost product cost has to be kept low.

So, the only way of making a product cost low is; obviously, to make things manufacturing cheaper. While a lot attention has gone into making the electronics inexpensive the same amount of you know this thing is slowly coming into manufacturing. So, that the enclosure also is there.

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Large instruments like say invertor housings, Oscilloscope and signal generator enclosures, power management hardware, convertors and drives involve the use of heavy and rugged components like IGBT modules, large heat sinks, blowers, heat dissipating components, heavy transformers and bulky filtering capacitors. In applications for housing these items only mild steel and special alloys of Al-Si-Mg are common. Even here cost considerations often result in the use of only variants of mild steel.

So, we go back here to check about large instruments like say inverter housings oscilloscope and signal generator enclosures power, management hardware convert and drives involve the use of heavy and rugged components like this IGBTs. IGBTs are power modules insulated gate transistors large heat sinks blowers heat dissipating heavy transformers and bulky filtering capacitors, all this stuff in applications for housing these items only mild steel and special alloys of aluminum silicon magnesium are used. Even here cost considerations often result in the use of only variants of mild steel.

So, as of today if you now go and inspect your system unit of the computer you have, the main housing is invariably made of mild steel; mild steel sheet lot of expensive of operations are done and overall the cost of modification of the raw material into this is the lowest say continue to use this mild steel in the large this thing. Here what in the initially in the lecture I was talking to you there may be a little going backwards and forwards. So, some of this may be repeated in the later slides, but it is for you so, that in case you are watching it on the video maybe you should go back and check and just see with things make sense, still now the issue of mild steel is still there.

You also have plastic hinges if you have a specs case of where you know you keep your this spectacles, it has what is called a living hinge often we open it and the corner if we see, it is made out of a what is called a living hinge. The whole thing is made moulded

like this after that it is snapped in place, and then it just is like that and then a few hundred operations nothing happens with this.

However if you come to the specs themselves or I can see here if you can make it next time go and examine this things.

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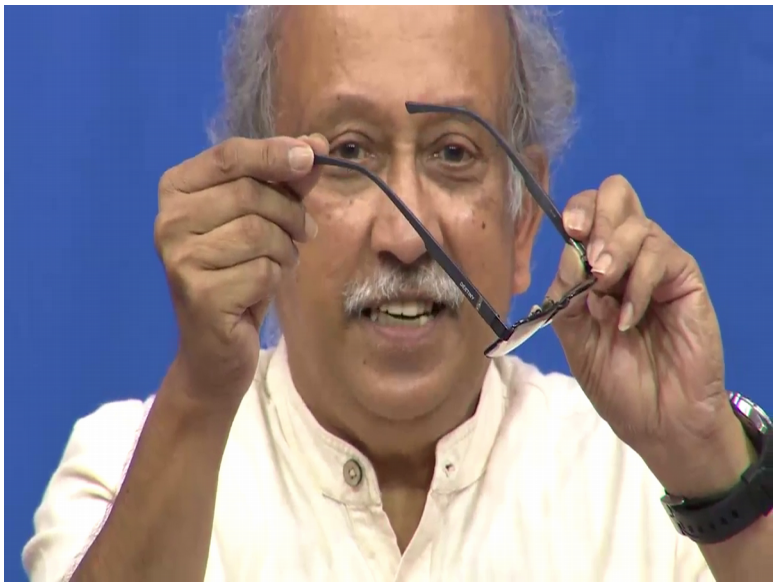

You see here there is a beautiful; this frame is probably moulded plastic with a small spine made out of steel and then you have a hinge as of now nobody has been able to replace the hinge automatically with a plastic, not yet being replaced and then inside this as if it we are not sufficient to make it more usable they have even put a small spring and all and made a very elaborator arrangement and then you also have a bridge support here.

So, the previous slide I started with saying we will talk about little bit of the industrial racks and so, on next round when I make more presentation, I will probably take you on a small video this thing which shows that large racks which we have which are used for communication equipment. Loosely it is actually it follows that iac 5 to 9 loosely we use the word saying rack, rack refers to a vertical standing structure those racks were earlier made almost exclusively steel, but now since the progression of aluminum extrusion techniques; however, become easy and then the perforation for mounting and all is easy, a lot of them are made with special aluminum extrusions. These aluminum extrusions have special cross section by which using other hardware you can make things wider

taller can increase the depth, and then also you can accommodate other structures within them.

Now, again is where I was telling you I have take you know you need to jump backwards and forwards, otherwise it will just end up with usual examination material, you by heart a list reproduce it you pass the exam without understanding too much about what is written in the list.

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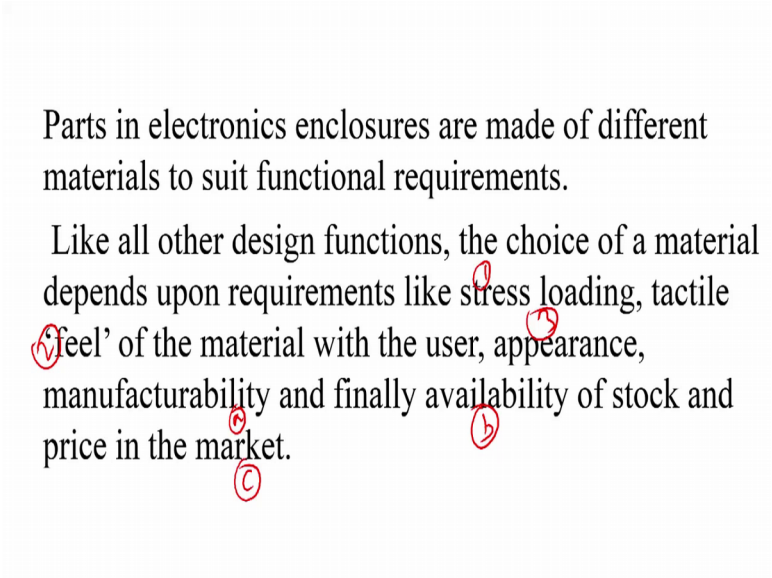

Come back to thing various electronics enclosures are made of different materials, to suit functional requirements obvious. The choice of material depends upon requirements like stress feel appearance you have seen this know these are all very important at the back what you do not see is probably manufacturability availability and price what is obvious is that you know in case the material cannot take the load it has a tendency to buckle it may not fail, but it is tendency to buckle that will spoil the filling of your whatever it is. Imagine you are going on a bridge and another heavy what you call truckers something passes, by you can feel the vibrations it is not dangerous. In fact, if they were to make a bridge very brittle chance are little crack is here.

So, it is flexible. So, all studio also know we try to isolate it as much as possible so that vibrations are not transmitted automatically this is where we have the thing about how to make a material which feels good material has to feel good.

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1. For example if one were to take an external modem, a typical example of a **professional** product, the enclosure is probably made of ABS, a common plastic. Most of the parts inside would be made of either ABS, PS, PP are even PE.
2. In contrast, an **expensive** portable stereo will use compound assemblies of ABS, Acrylic, Polycarbonate and Nylon for the external covers and will use special quality Mild Steel for the load bearing chassis. Spring steel would be used for flexible parts.

Next slide talks about small modem a typical example of a professional product; enclosure is probably made of abs at one time it is so called professional products of black boxes were not visible to the public; they all nicely stayed away in some place. But I have think progress now even on your table you are likely to find one or two modems and it cannot be a unsightly black box, and unsightly black box of a modem does not give the what you call same confidence a something which you would like to make it you know more presentable.

Say these days thought it is typically a professional product the enclosure is made of abs a common plastic most of the parts would be made of either abs polystyrene polypropylene and polyethylene, because all of them can be moulded easily and then you can make them in millions and then only one part of it know probably the top enclosure needs to be redone, and then we are in a generic group of products are this things can be used.

So, if you go to anyhow the online retailers and just look around go to anyhow the online retailers. So, first thing that comes to us probably is the amazon, we have dozens of them ask for a modem. We surprised to see how many what you call how much of effort is gone into make them look good. It is not your powder compacts or it is not your grooming products that have all the things even semiprofessional products meant for a user experience the external appearance.

And something very very important is from the marketing point of view we need a differentiated product. So, we have market segments, say in a professional segment they probably do not work too much on the you know external appearance color and all that, but they are ready to pay a premium for something which you have a guaranteed life saying next 10 years I need not touch it will not go absolute on it is own we can upgrade it.

But if the similar function product is kept in a let us say directly in a visible area, while that is also an important thing which even if occasionally does not work well appearance seems to be critical .And other thing is can it hold your coffee it is a real spillage extental droplets all this are very real for desktop equipment occasionally they spill over, but then nothing is lost if you make in a large quantity can replace it not repairable, but replaceable.

Getting back to my slide in expensive portable stereo studio will use compound assemblies of abc abs acrylic polycarbonate and nylon, for the external covers and use special quality mild steel for the load bearing chassis spring steel would be used for all the flexible parts.

So, if you have to look at a DSLR, the costlier DSLR still come with a magnesium body inside there is a magnesium shell. Probably the costliest camera I would not know I would not know whether I should say (Refer Time: 20:44) or hassle bladder need not know what people use for all the money you pay you get a cuboid in which 5 of the sides have to be purchase separately you buy the top you buy the back you buy the lens and then you buy the bottom probably a little bit of and one of the sides the mechanism and all that are separate, but the core skeleton inside is made out of a special magnesium alloy which will make sure that it does not distort itself and any of this accessories can be fitted on to that without any problem. That is a professional thing it cause a lot of money I do not know where it cause 5000 dollars or something still a lot of money expense.

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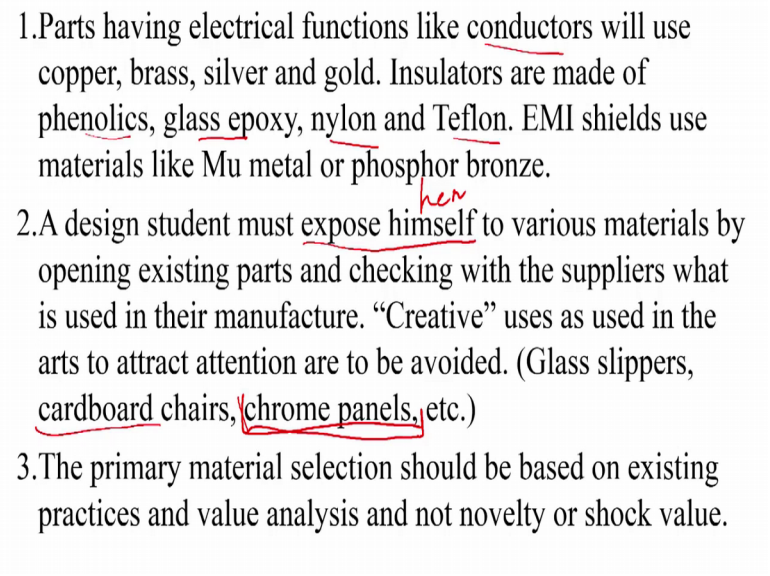

So, we will get back to my slides parts having electrical functions like conductor being conductor will use copper brass silver and gold. Gold is not the best conductor, if you go back to your physical tables and see gold is not the best conductor actually silver is the best, but the advantage with gold is that contact between two gold patches table it will not change your work time or with a minor corrosion and all that. In contrast copper and brass have a tendency to corrode very quickly copper forms an oxide, brass also have I do not know what all colors it has and silver is better to the extent that it has a lowers conductivity, and the oxide have silver is not bad something which gets oxidize is no problem at all.

So, even the costliest thing like know huge contactors which carry lot of amps, but I will stick to may be 100 amps, the actual contact button inside is probably made out of copper, but the part which makes a contact the pressure contact the last portion of a is a silver. The copper takes all the current to the last bit have a contact and the last contact button is made of silver and that also use some special alloy. So, that guaranteed million operations or couple of million operations nothing will happened to that.

Getting back here insulators say while that is all about the conductors, insulators are made invariably of phenolic epoxy nylon and occasionally Teflon. Teflon flows Teflon is not a stable strong material it use a tendency to flow say a things like phenolic glass

epoxy nylon and then the these days there unbelievable amount of plastics you should go and check on the plastic.

So, typically even your commercial switches probably they have a poly phenylene sulfide or a some ppo pps I do not know all the materials, all those materials are even used in your commercial modular switches. That is lot of money and thing has spent into it and then the advantage is saying they are not disturbed by temperature and in the very unlikely case of failure they do not add to the hazard that taken be done.

So, this you call sulfide and this ppo and pps materials are chosen in a special function. So, these days if you are to build an equipment, especially with supposed to be reasonably ragged equipment you are not expected to meddle with the ul listed parts including the connectors, including the cables and in case you have a power switch because all you proved and then it is made for a fire rating. So, now it is gone to ROHS restriction of hazardous substances the movement there approves much easier for you otherwise you have to sick approval for everything.

Second point is what is actually the core of my whole series of lectures saying a design student must expose him slash herself to various materials, by opening existing products and checking with the suppliers what is used in their manufacture. Creative is use as used in the arts to attract attention are to be avoided. You know glass slipper fits only one person it does not slip when fit others only recently you had a chance to see one more variant of the Cinderella; though I do not know probably the what you call a step mother takes and shorter is the remaining glass slipper. So, understand know.

So, somebody cannot know pair it and say this is the same the only other slipper is gone. So, still the prince comes back with it and fits and all that the moral of the story is first of all it is easily crushable, you can shutter it. Secondly, it is made for a single function for a single use you almost like a thumb print. So, it will fit only one person and then may there can even walk in it. It is available now I should not use the word now, but I will say we have the glass slippers available and in fact, their some in which you can walk I am talking about the people would like to wear them.

So, these are all generally you also have a cardboard chair, we do not have many cardboards chairs around your house is it not you have normal polyethylene or even I do not know modified poly I do not know what this chairs are made with probably, lose lot

of them are made with abs see how plastic chairs, but cardboard chairs as he had know continue to be a novelty, then people have built houses.

And then if you look at the equipment that is shipped and comes to us often, you will see we have load bearing recycled cardboard packaging that is used inside except the very core things all other places you have this behave structures, you have this panels, in which he you have support structures where the cardboard is used a compound material; it is used on edge such that it supports the whole thing. Advantage they are being contrary to our normal expectation something which gives or which takes a shock is more desirable than something which does not give.

So, it is not correct if you if all the gaps you have you fill it up with your ps form; such thing is not very good, but if you see a carefully moulded thermocol or polystyrene from product, skin outside is there and the part which is held inside in between it is corner covered with are connected by various ribs, which will fail or which will buckle and take the shock that seems to be a very important issue. Otherwise if you bang something on the outside it should go and bang itself go and bang the things inside.

So, typically a honey comb panel is a reasonable what you call a compromise; it is just strong enough and then it remains flatter. So, you still have cardboard panels which are used you can even build a house with it and I do not think your cake boxes are made with anything, but cardboard it has lot of coatings and so on.

Now, we get this other thing know do we do we nearly need so much of chrome everywhere. Instantly that chrome bumpers and all what you have been what you seen old automobiles are not chrome as such. The core of it is still a mild steel except their muck stress pressers which will deform things into that shape and then later on it is coated with copper, because copper base plating is required. Then on top of it they put nickel everywhere know nickel only in some very occasional cases you have a chrome on top of it nickel is the one with the bluish and things looks good and if you see the chrome it has a slightly non bluish appearance, it is as a more natural whitish appearance.

So so called chrome bumpers are actually not chrome bumpers, they are nickel with chrome on top of it. do you need it everywhere some places it is expected. I have shown you that virtue phone know I am sure there some places they have actually used metal it has a dual function first of all it is stronger much more stronger if you have a metal.

Secondly, it very easy to chrome plate those things say even in the case of our electronics it is used. You have seen this know material selection should be based on practice and not novelty or shock value.

It makes sense a sometimes in some places more than shock the new use of it is very very what you call a novel use of an existing material, is still people you know take that there is an intelligent designer here. He is been able to use it we are happy about such a thing.

So, as I said glass is good no issue about it you can may be replace it with know polycarbonate, you can replace it with anything or can go back to quads, quads glass is glass absolutely are why not.

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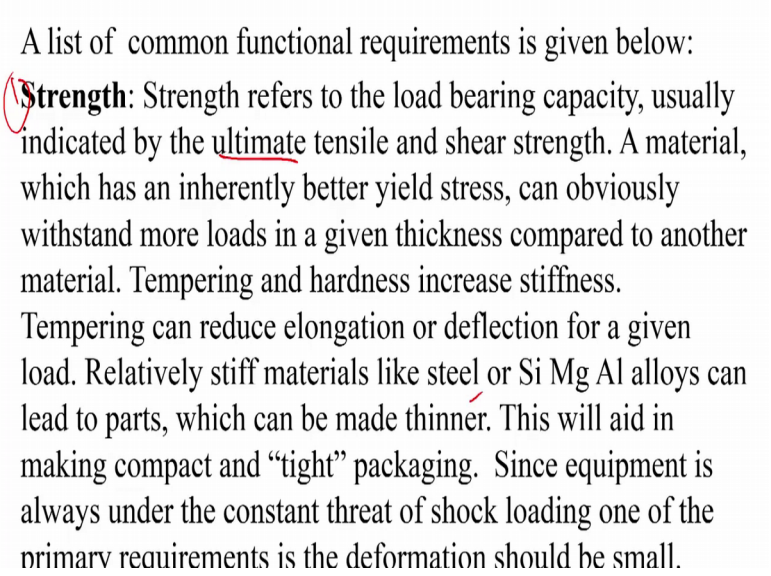

This is just a listing not as filler, but I expect that the student should be able to see what is going on here.

Normal functional requirements are it is starts with strength; to the load bearing capacity usually indicated by the ultimate tensile and shear strength material which has an inherently better yield stress can; obviously, withstand more loads in a given thickness compared to another material say if you remember yesterday I had shown you a power supply where I have opened the cover and showed you that they use a very thin material absolutely a whole thing is made mild steel something has been done by which it does

not look good, but it looks professional thin, thin like you know a point three or 0.4 millimeters, even if you take your car of course, in the parts where I live.

You have cars which you know are little lower price probably the costliest car cost 20000 dollars not more than that and cars like what we have. I think all of you must be familiar with the 2000 dollar car or the one lakh nano. Nano refers to ten to the power of something know and then it has been made into 10 to the power of 6 rupees I am sorry 10 to the 5 rupees is to a 10 to the power of I do not know how much minus something. All cars instantly if you see that door and all that they are thin not very thick very very thin and over the edges where the door opens.

So, imagine this is the panel the fold it over in an sometimes they do some special treatment to see that edge does not gets spoiled, but; however, if you employ a shortcut next time if you take a car and if you happened to be living in the coastal places, open the door look at the edge preferably towards the bottom you will see that corrosion has set in, not easy to get rid of it because the process is such and trapped to water trapped condensation all this are fixed at thing.

So, we coming back it can withstand obviously, you know strength is strong material can withstand loads in a given thickness tempering and hardness increase stiffness tempering can reduce elongation or deflection for a given load relatively stiff materials like steel or silicon magnesium alloys can lead to parts which can be made thinner. This will aid in making compact and tight packaging; it is needed because the amount of functions that these day we are expected to perform more and more you know stuff is getting packed inside there no gap between any two parts this will aid in making compact tight packaging say equipment is always under the constant threads stuff shock one of the primary requirements is a deformation should be small the unlike lickers that some shock. Comes it should not get transmitted the movement it gets transmitted failure occurs. So, if something absorbs it by taking a bit of deflection very much possible for you to accommodate the materials.

So, next part after the strength; obviously, comes this corrosion resistance. Long term it will take the equipment is a next most important consideration. So, this corrosion resistance is very very critical a little while back I was refereeing to about the corrosion around car doors. Same thing it happens everywhere if you go and check the things like

your well refrigerators at home tensionally refrigerators were all made with mild steel and condensation is real.

So, now, anything rest we cannot help it, same thing with the in the case of electronic equipment also corrosion is real. We think we are in a benign atmosphere by just putting a air conditioning in the place the moment you try to chill something, humidity goes up the amount of water present in that thing is same, but then we have cool down and the tendency for it will get more and more saturated and humidity will get increased. Moment humidity is increasing condensation starts taking place you may not see it that is the only thing.

Next time now we say what has happened to your refrigerators you do not find the condenser at the back any more and in fact, sides of the refrigerator are expected to be heated hot not long ago only about 30 years back, they said you should never have a hot surface you should have a cold surface otherwise your biting.

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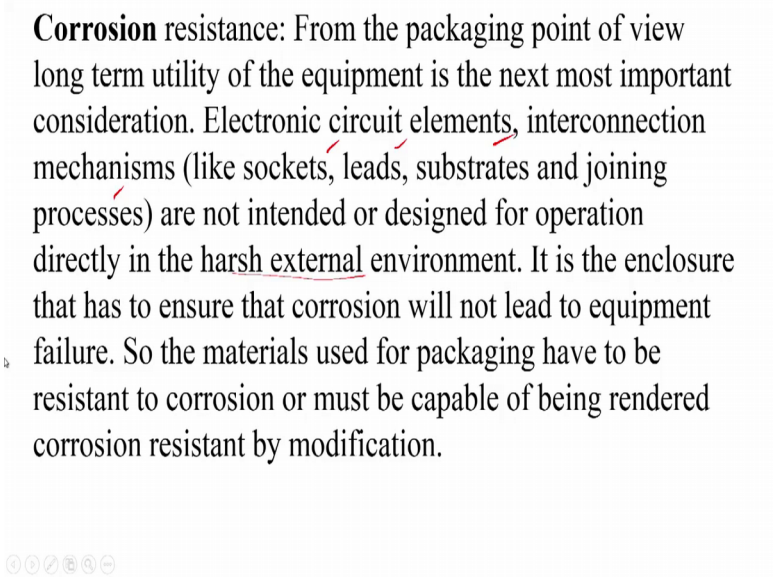

The whole system think about it little electronic circuit elements; I mean, I am sorry I could not switch it on.

So, the corrosion resistance helps in the long time utility. Electronic circuit elements interconnection mechanism like sockets, normal leads, substrates, joining process are not intended for operation in harsh external environment. It is the enclosure that has to

ensure that corrosion will not lead to equipment failure, seen that know we use common things I think I showed you this wireless mike in the transmitter I fit yesterday.

So, it had wire like mike has a connector here you seeing this there is a (Refer Time: 38:07) something and you have to turn and I would not do it now, and there is a small rubbery mute switch I was getting ready you have a spring steel clip. So, that I can clip it here I can clip it on my back or any convenient place I can put it in a pocket or it can be my closure pocket, will you see here right now in the thin form that is possible you cannot beat steel, I cannot say what grade have steel, but it is steel.

Now, look back to at your portable thing or maybe you have an mp 3 player anything know you may not find this sort of thing, instead you have a tab probably it has a spring inside and the tap closes and all that if it is very very cheap like I have this small this thing, something else has been done to make it just clamp on to my lapel.