Enclosure Design of Electronics Equipment
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Lecture - 32
NEMA and related

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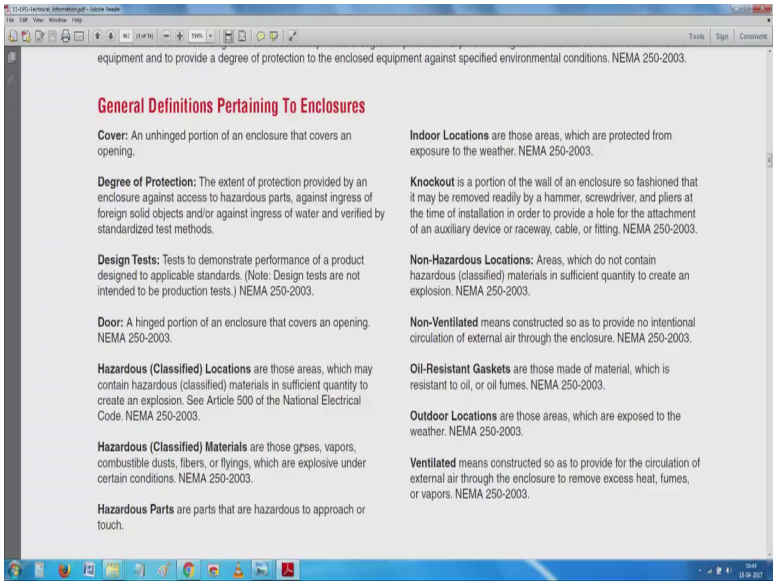

Things related to that equipment at the back, we had an enclosure, a rhombus, there is a nice box with some lower slick thing in one side, one is on the front panel directly and another one is in the rare for the vertical lamination in the centre. Because of various constraints, we are not expected to operate it directly from the centre because all three sides we need access. However, for the horizontal machining centre which is basically a simple trainer for turning things are visible directly on the top.

So, both are possible. Two things you will notice here is in the place where using it though in principle, it is used in a workshop and indoor equipment itself is not necessarily indoor because the equivalents there is oil, there is always, then you have this machine chips which get splattered all over the place. So, the equipment should not give out any of these things nor get affected by adjacent machines or the operators or by its own thing.

So, if you see here we have this thing about non-hazardous location which do not contain to create an explosion. It looks simple.

When we talk about non-hazardous areas which do not contain hazardous materials in sufficient quantity to create an explosion, we all know about gases or occasionally even liquid. Typically when you talk about a gas, it could be thing like petrol or diesel and we talk about I am sorry. When we talked about gases, we mean LPG or CNG or other flammable gases and when we talk about liquids, we talk about this various types of oils and fuels and some of them we never know that a simple thing like flour or flour as you people call it. That whitish starch stuff you get from a mill is explosive. Difficult to believe is not it? So, whenever you have any rice or other flour mills, we also need to protect it from inherent explosion. We will not think about it like that we will not think that a dry starch is capable of exploding, but it does because it is also fuel depending on the content and depending on the other things about it, it is flammable absolutely. If you go down, we have non-ventilated cabinets, no intentional circulation or external air through the enclosure while let me get into the gaps.

Ventilated means constructed as to provide a circulation of external air through the enclosure to remove excess heat from furnace or vapors. If you remember the introductory or the 2nd lecture, I talked you about three things we need to think about when we are thinking about a product enclosure. One of them is related to the usage esthetics and so on. Another is related to their economic point of view.

Third is as a part of this structure, the technical thing, this thing about how to cool thing comes and finally, we come here outdoor locations which are exposed to the weather. So, you see here what looked obviously is very relatively simple. Simple definitions, we come down to what is called Type 1, Type 2, Type 3 and so on.

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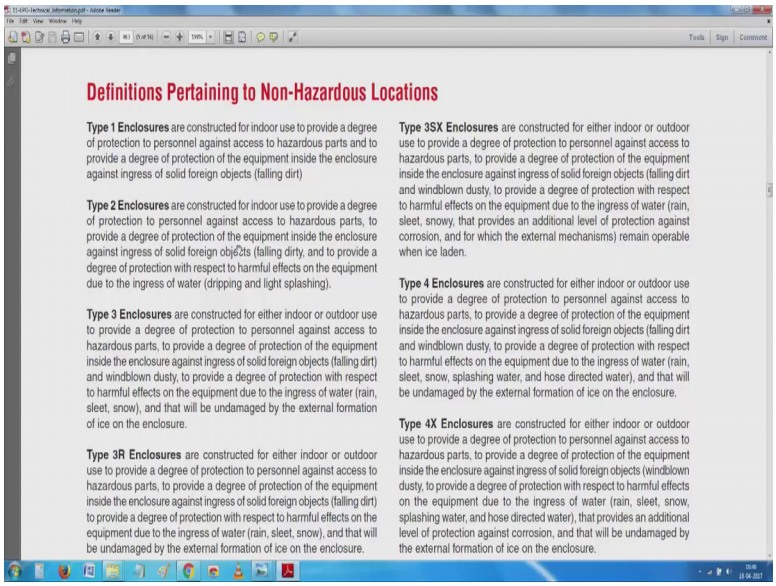

Definitions Pertaining to Non-Hazardous Locations

Type 1 Enclosures are constructed for indoor use to provide a degree of protection to personnel against access to hazardous parts and to provide a degree of protection of the equipment inside the enclosure against ingress of solid foreign objects (falling dirt)

Type 2 Enclosures are constructed for indoor use to provide a degree of protection to personnel against access to hazardous parts, to provide a degree of protection of the equipment inside the enclosure against ingress of solid foreign objects (falling dirty, and to provide a degree of protection with respect to harmful effects on the equipment due to the ingress of water (dripping and light splashing).

Type 3 Enclosures are constructed for either indoor or outdoor use to provide a degree of protection to personnel against access to hazardous parts, to provide a degree of protection of the equipment inside the enclosure against ingress of solid foreign objects (falling dirt) and windblown dusty, to provide a degree of protection with respect to harmful effects on the equipment due to the ingress of water (rain, sleet, snow), and that will be undamaged by the external formation of ice on the enclosure.

Type 3R Enclosures are constructed for either indoor or outdoor use to provide a degree of protection to personnel against access to hazardous parts, to provide a degree of protection of the equipment inside the enclosure against ingress of solid foreign objects (falling dirt) to provide a degree of protection with respect to harmful effects on the equipment due to the ingress of water (rain, sleet, snow), and that will be undamaged by the external formation of ice on the enclosure.

Type 3SX Enclosures are constructed for either indoor or outdoor use to provide a degree of protection to personnel against access to hazardous parts, to provide a degree of protection of the equipment inside the enclosure against ingress of solid foreign objects (falling dirt and windblown dusty, to provide a degree of protection with respect to harmful effects on the equipment due to the ingress of water (rain, sleet, snowy, that provides an additional level of protection against corrosion, and for which the external mechanisms) remain operable when ice laden.

Type 4 Enclosures are constructed for either indoor or outdoor use to provide a degree of protection to personnel against access to hazardous parts, to provide a degree of protection of the equipment inside the enclosure against ingress of solid foreign objects (falling dirt and windblown dusty, to provide a degree of protection with respect to harmful effects on the equipment due to the ingress of water (rain, sleet, snow, splashing water, and hose directed water), and that will be undamaged by the external formation of ice on the enclosure.

Type 4X Enclosures are constructed for either indoor or outdoor use to provide a degree of protection to personnel against access to hazardous parts, to provide a degree of protection of the equipment inside the enclosure against ingress of solid foreign objects (windblown dusty, to provide a degree of protection with respect to harmful effects on the equipment due to the ingress of water (rain, sleet, snow, splashing water, and hose directed water), that provides an additional level of protection against corrosion, and that will be undamaged by the external formation of ice on the enclosure.

These are all meant for you should read it for yourself. You have seen this we have two options here. One is they are ready and they remain operable when I slide in this is because often because of the choice of materials, because of the choice of insulation things tend to freeze or lock up.

So, we make some arrangements to these things later down more in detail is given here.

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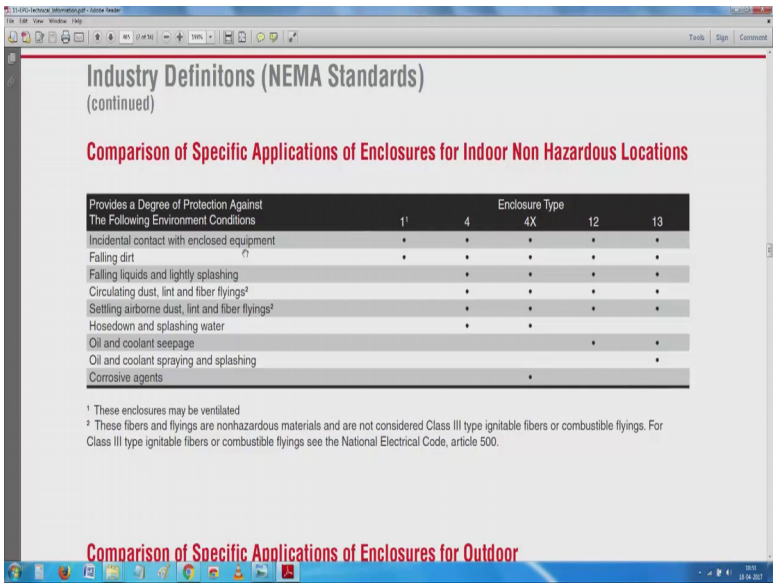

Industry Definitons (NEMA Standards)
(continued)

Comparison of Specific Applications of Enclosures for Indoor Non Hazardous Locations

Provides a Degree of Protection Against The Following Environment Conditions	Enclosure Type 1[1]	4	4X	12	13
Incidental contact with enclosed equipment	•	•	•	•	•
Falling dirt	•	•	•	•	•
Falling liquids and lightly splashing		•	•	•	•
Circulating dust, lint and fiber flyings[2]		•	•	•	•
Settling airborne dust, lint and fiber flyings[2]		•	•	•	•
Hosedown and splashing water		•	•		
Oil and coolant seepage				•	•
Oil and coolant spraying and splashing					•
Corrosive agents			•		

[1] These enclosures may be ventilated
[2] These fibers and flyings are nonhazardous materials and are not considered Class III type ignitable fibers or combustible flyings. For Class III type ignitable fibers or combustible flyings see the National Electrical Code, article 500.

Comparison of Specific Applications of Enclosures for Outdoor

I suggest you go to the now coming back to as we go down, what they were talking about are NEMA standards, Electrical Manufacturers Association Standards. So, we have here enclosure types and so on and Type 3 are 4 index and whether to be ventilate it or not.

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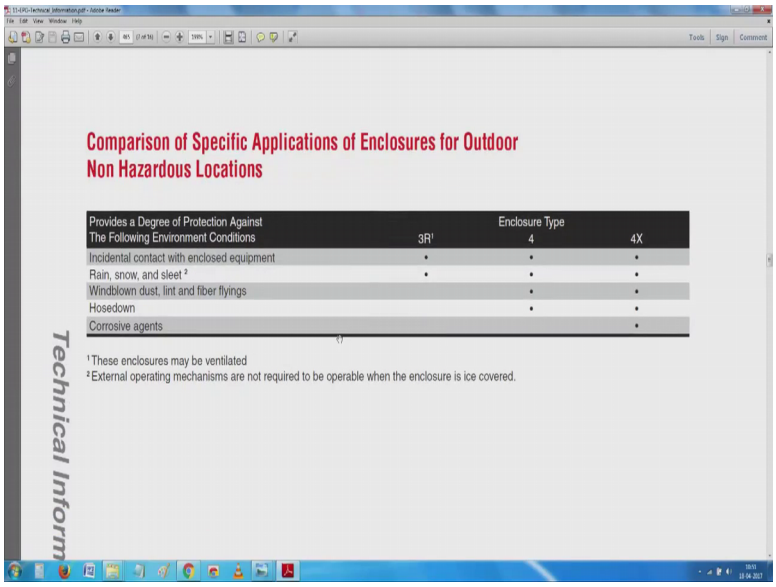

Similarly, there is a cross this thing about Canadian CSR is a Canadian cross reference underwriters.

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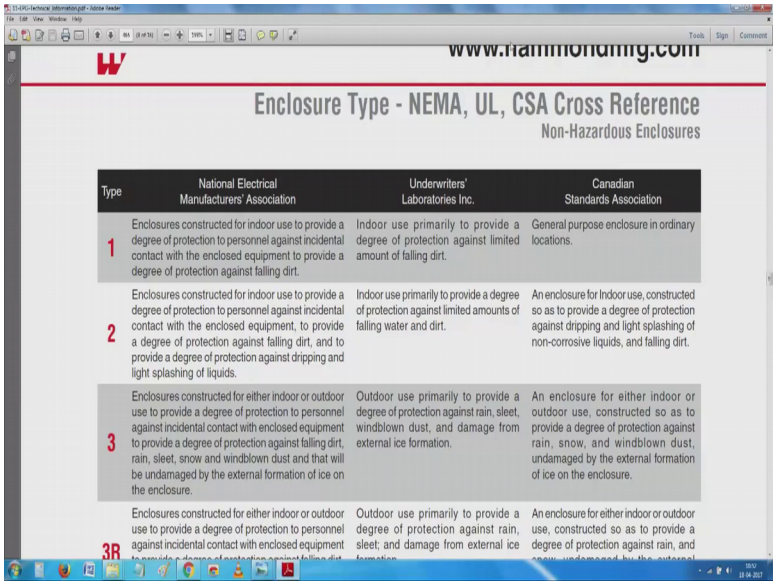

Then, NEMA and then type of enclosures minor difference are there because of we slowly come to old 529, one of the earliest standards related to enclosure design.

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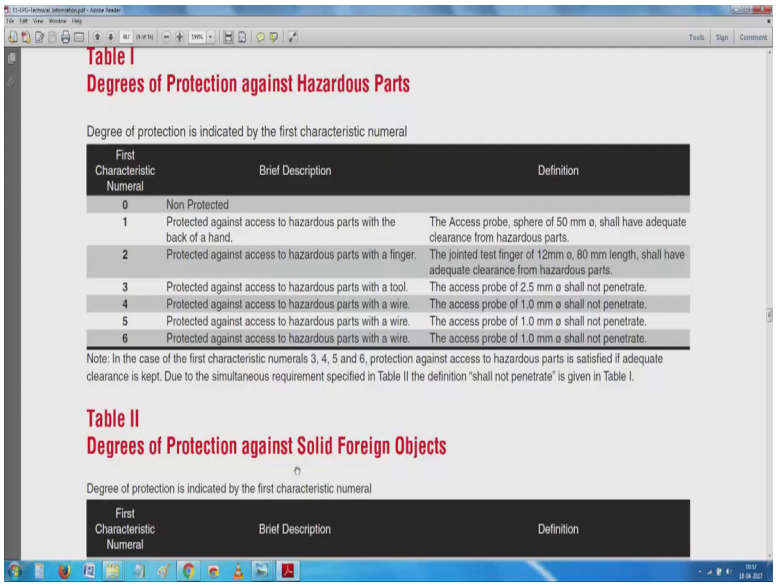

Table I

Degrees of Protection against Hazardous Parts

Degree of protection is indicated by the first characteristic numeral

First Characteristic Numeral	Brief Description	Definition
0	Non Protected	
1	Protected against access to hazardous parts with the back of a hand.	The Access probe, sphere of 50 mm ø, shall have adequate clearance from hazardous parts.
2	Protected against access to hazardous parts with a finger.	The jointed test finger of 12mm ø, 80 mm length, shall have adequate clearance from hazardous parts.
3	Protected against access to hazardous parts with a tool.	The access probe of 2.5 mm ø shall not penetrate.
4	Protected against access to hazardous parts with a wire.	The access probe of 1.0 mm ø shall not penetrate.
5	Protected against access to hazardous parts with a wire.	The access probe of 1.0 mm ø shall not penetrate.
6	Protected against access to hazardous parts with a wire.	The access probe of 1.0 mm ø shall not penetrate.

Note: In the case of the first characteristic numerals 3, 4, 5 and 6, protection against access to hazardous parts is satisfied if adequate clearance is kept. Due to the simultaneous requirement specified in Table II the definition "shall not penetrate" is given in Table I.

Table II

Degrees of Protection against Solid Foreign Objects

Degree of protection is indicated by the first characteristic numeral

First Characteristic Numeral	Brief Description	Definition

So, they have been using three numeral or two numeral designation which will ensure that first numeral talks about completely unprotected open pcb which I have shown you.

The axis probe figure of 50 mm shall have added clearance from hazardous points. You have seen that in case this is a large thing. So, if you can recollect the connector at one end and it was covered the idea being in case you put the probe anywhere inside also, none of them are likely to touch or cause damage. So, if you again recollect that heat absorber which we have kept or the conduction plate that we have by itself, even something metallic touches. Nothing happens because it is insulated from one of the connection from the series pass element.

It could be an emitter or collector or equalenter source or a drain. Nothing will happen to that. Now, as we come down to 1 2 3 4, slowly they talk about in another slide these pictures are all explained properly. So, the first thing you will see here a typical characteristic hazards with a finger. So, with a tool with a wire ends, I have a graphical also here in the next slide. You can see this. So, see here that is the beautiful 2.5mm probe. So, typically it could be anything. Let us say you have any object including a hand or anything like a pen or anything which accidentally does not go inside and then, try to short circuit things.

So, going back again when we made IP20, that cover has openings which are typically little less than two and half millimeters. So, it protected against access to hazardous part

with a tool access probe of 2.5 millimeters shall not penetrate. So, the advantage being that by mistake it does not go inside. Now, if you go back to the probe set which comes with your multimeter, you have a probe set which comes with it. One end is made with a banana plug which instantly just little more than the two and a half millimeter. The other end you have 1 millimeter probe and depending on the voltage rating, sometimes I have a disk which ensures that flashover does not occur or accidently the finger does not slip. Very high voltage have a fat holder and a large disk because the flashover you can avoid. Small ones is more of a something to prevent your finger from slipping and then, you have a probe depending on the dust, you can have a sheet in front of it.

So, as you go back here, you will notice that slowly again this hazardous point against solid foreign objects.

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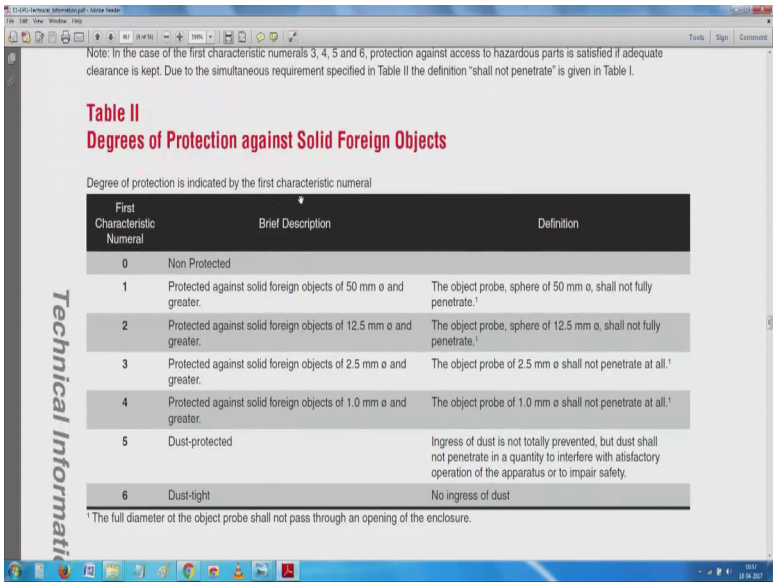

Note: In the case of the first characteristic numerals 3, 4, 5 and 6, protection against access to hazardous parts is satisfied if adequate clearance is kept. Due to the simultaneous requirement specified in Table II the definition "shall not penetrate" is given in Table I.

Table II
Degrees of Protection against Solid Foreign Objects

Degree of protection is indicated by the first characteristic numeral

First Characteristic Numeral	Brief Description	Definition
0	Non Protected	
1	Protected against solid foreign objects of 50 mm ø and greater.	The object probe, sphere of 50 mm ø, shall not fully penetrate.[1]
2	Protected against solid foreign objects of 12.5 mm ø and greater.	The object probe, sphere of 12.5 mm ø, shall not fully penetrate.[1]
3	Protected against solid foreign objects of 2.5 mm ø and greater.	The object probe of 2.5 mm ø shall not penetrate at all.[1]
4	Protected against solid foreign objects of 1.0 mm ø and greater.	The object probe of 1.0 mm ø shall not penetrate at all.[1]
5	Dust-protected	Ingress of dust is not totally prevented, but dust shall not penetrate in a quantity to interfere with atisfactory operation of the apparatus or to impair safety.
6	Dust-tight	No ingress of dust

[1] The full diameter ot the object probe shall not pass through an opening of the enclosure.

Technical Informati

So, we have this once again know against solid foreign objects 60 millimetres pressure against 12 and half and then, against this thing and finally, dust protected and dust tight. This is where you would have heard about IP55, IP56, IP65, IP66 and so on. This refers to the first digit in that. So, both we have seen from inside to outside and outside to inside also.

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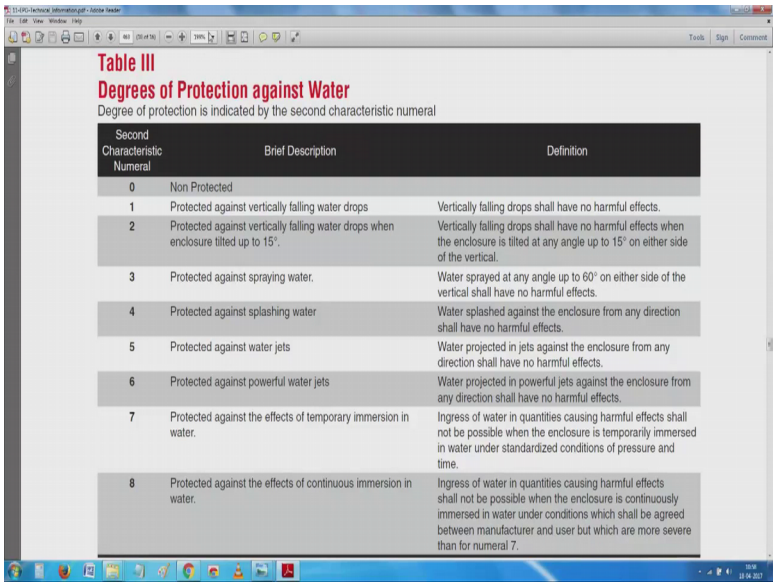

Table III

Degrees of Protection against Water

Degree of protection is indicated by the second characteristic numeral

Second Characteristic Numeral	Brief Description	Definition
0	Non Protected	
1	Protected against vertically falling water drops	Vertically falling drops shall have no harmful effects.
2	Protected against vertically falling water drops when enclosure tilted up to 15°.	Vertically falling drops shall have no harmful effects when the enclosure is tilted at any angle up to 15° on either side of the vertical.
3	Protected against spraying water.	Water sprayed at any angle up to 60° on either side of the vertical shall have no harmful effects.
4	Protected against splashing water	Water splashed against the enclosure from any direction shall have no harmful effects.
5	Protected against water jets	Water projected in jets against the enclosure from any direction shall have no harmful effects.
6	Protected against powerful water jets	Water projected in powerful jets against the enclosure from any direction shall have no harmful effects.
7	Protected against the effects of temporary immersion in water.	Ingress of water in quantities causing harmful effects shall not be possible when the enclosure is temporarily immersed in water under standardized conditions of pressure and time.
8	Protected against the effects of continuous immersion in water.	Ingress of water in quantities causing harmful effects shall not be possible when the enclosure is continuously immersed in water under conditions which shall be agreed between manufacturer and user but which are more severe than for numeral 7.

You see as we come here, we come into 5 and 6 talk already about something being dust tight air coming into liquids not protected completely.

The first thing is saying the ingress of water, nothing is taken care. That ingress of water should some water fall inside. Nothing will happen. Now, you may be wondering why I showed you that studio and myself sitting there at one point. Why it was shown is while it looks like in a way relatively safe benign environmental, you will notice that these air condition cooled specifically and not heated where we live.

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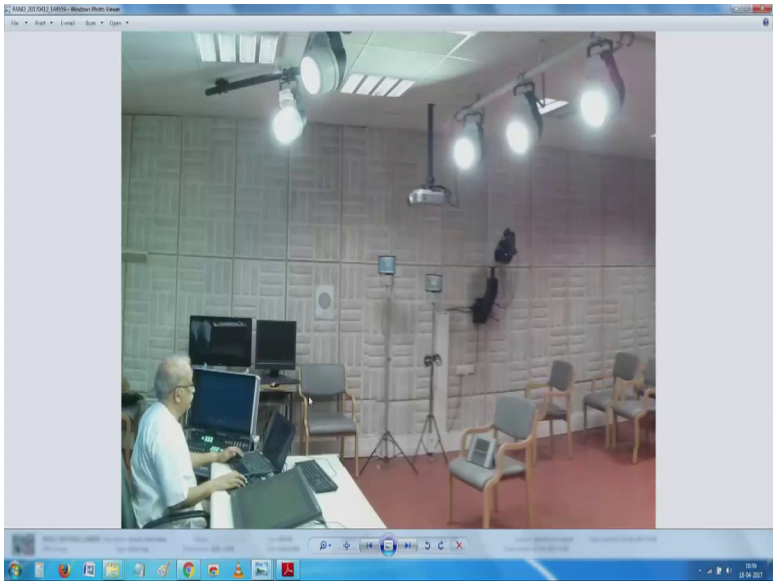

So, the moment you have this air conditioning, you end up some serious issues. My bad luck it does not show we have directly on top of us. Here I have what is called a cassette air conditioner.

What the cassette air conditioner is, it is what you call a square, rectangular or certain square box, where we have the condenser inside and it is not an oval unconventional air conditioners. It is directly a walk in the middle chances are when this cold air from it meets any moist air, condensation can take place and this condensation can affect equipment like this. We have you see here we have a projector here. So, chances are it will get affected by the projector. I will see I have one more slide. No, it is same slides. So, everywhere as such I will have to go back to this.

So, we see here an absolutely unprotected device can get affected even in indoors because of unintended condensation, because of the change in humidity in the environment unless you have a guaranteed humidity control. Chances are water can condense rather moisture can condense into water droplets and something very much intentional with. That is the good old coffee cup. We carry water around, we carry water bottles, we probably carry coffee and by itself you may know it spill coffee. Next time you notice what happens if you take a hot liquid and keep it on a surface, condensation takes place and if you have a cola or any soda bottle which is cooled and taken out of a refrigerator, the condensate is there all around it.

So, unintentionally we have brought in just about to condense water and then, it will drip everywhere. So, it will happen to your keyboards. So, it will happen to any of your electronic equipment. So, this talk about vertically falling water drops, this is the interesting thing. We have this beautiful 15 degree tilted up to 15 degree vertically falling drops shall have no harmful when enclosure is tilted at any angle upto 15 degrees on either side of the vertical.

So, we have some plus and minus points. So, if you have to carry one of those simple equipment also, chances are it needs to work with all this. Now, as you come back here things are getting interesting. I will just remember this thing. Now, 3 4 5 6, I will start with this is number 3 protected against spraying water sprayed at any angle upto 60 degree in either side from the vertical, they will have no harmful effects that is you take a

spray nozzle and spray everywhere where is this likely to happen, just about anywhere. I have shown you examples of the vertical machining centre.

So, because of the nature of the operation, we have cooling liquids and then, you have lubricating oil. Then, occasionally we have other chips. All these that are likely to affect this, then you see starting that this is where when we talk about IP55, 56 and all that know first one is about solids from here, it talks about the liquids, water projected in jets against the enclosure from any direction shall have no harmful effects.

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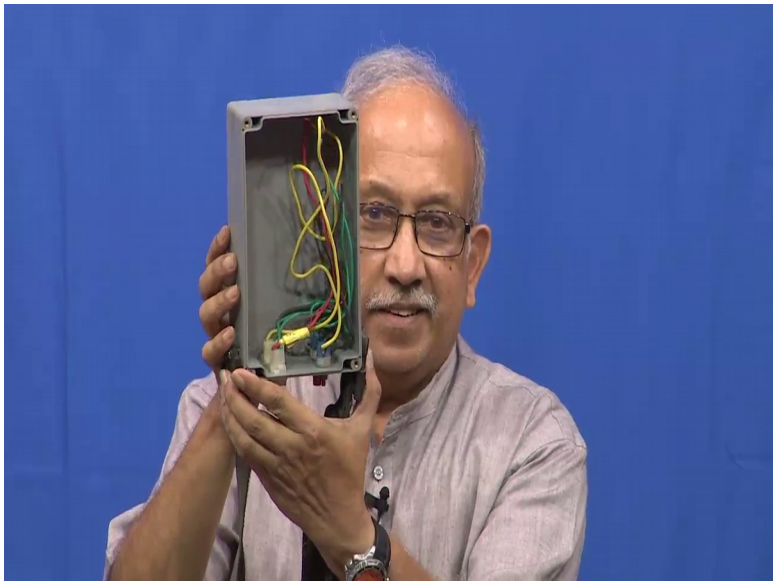

So, I will get back to this. So, if it have to be mounted like this, we have beautiful gas cutting practice and in general, things are sealed. This will what you call put upto IP1 1 or 2 3 something like that.

If you have to use proper connectors here, probably if water is flush from here also, it will work without the slightest problem.

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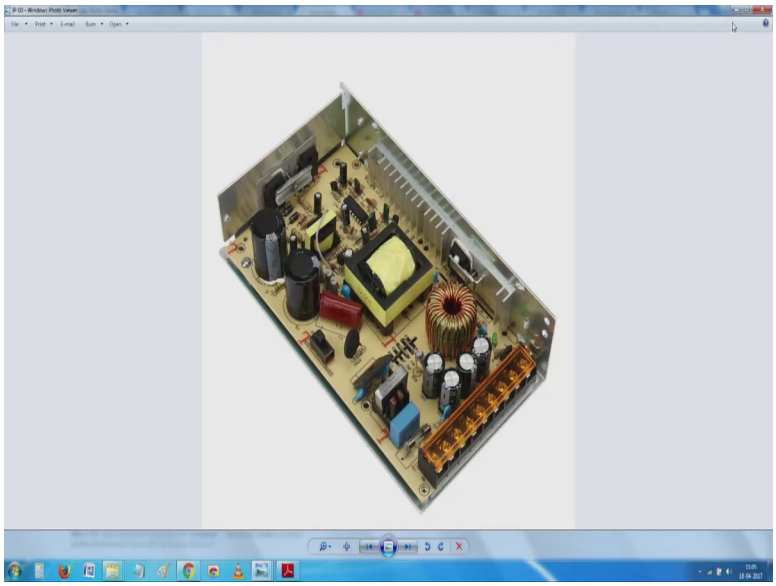

So, at this point let me quite ensure you while I am not endorsing the manufacturer. AluKOM the archetype of whole industrial was developed 14 years ago while enclosure company, its key feature consist. You have seen here this is the gas cutters trying to talk to you about why I have to depend on these sources is we have no access to this testing facilities while I can go and get conducted in a private or a military place. I am not allowed to take a video and show it to you hence, I want you to watch a video.

Melting holes for the enclosures and covers, these enclosures are particularly well suited for installation at 7 o clocks and has junction boxes. These incursions are modified with complex machining to protect industrial.

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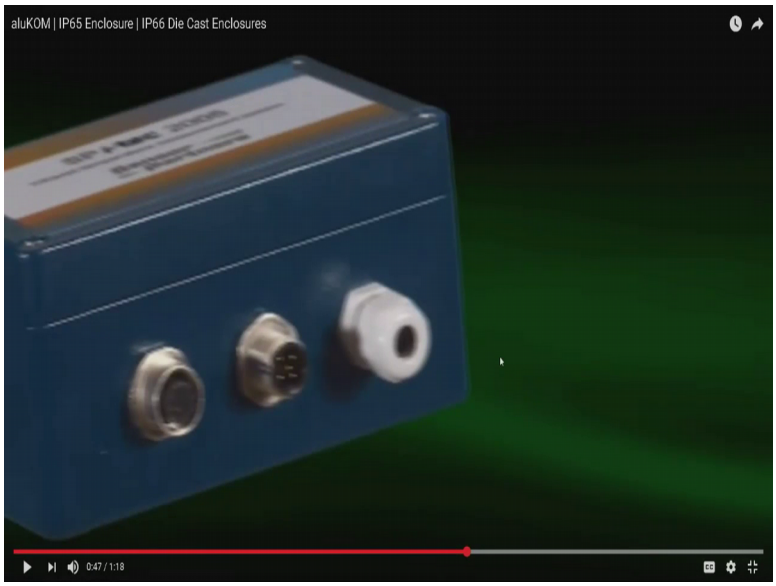

You see here there are three types of connectors. Here this one is a cable blend. We have this plug and then, it has a ferule inside and then, if you select the proper type of a rubber gasket which comes with it and then, if you squeeze it in I mean when you turn it, something is squeezed and holds it hard, there is a tapped portion and it holds it hard. Important is you must always select the correct type of a washer there, otherwise it is useless and then, again there are two types of connectors here you notice. First of all, it is absolutely watertight and this one is where you have socket contacts.

In general, socket contact means you can take power out of it. This one has plug contacts that means, you send power inside. So, both types are required and then, you have a nice beautiful thread here, then there is a flange here and behind the flange, you have that rubber mounts which will hold things in place and when this is not used, it also comes with a cap. So, it is not what you call a simple elastomer cap. It is usual threaded cup like thing which will seal it fully. So, any unused connectors and especially during storage or sometimes these connections are required for testing during installation and troubleshooting when that function is over. They are kept closed.

You see while design is at one level and how to start these upfront, how do you try to make these designs in real life. You have to subject it to the harsh environment as per the specifications that have been shown earlier.

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So, the military has its own facilities. Non-military test houses are available which conduct the test for you and give a certificate. One of them is you can specify saying what is it your equipment can withstand and another is you can specify whatever the requirements that have been given in the original IEC529.

So, left top you see there, IP65 tests are given there. The testers does not guarantee that each and every unit confirm through this because a lot depends on how you install it and the first time when you attempt to do any repair, what happens to it is however, the test house gives us certificate saying under what conditions they ran it and with the understanding saying we conducted it on the samples given to us.

I hope that was interesting for you. I kept it short. I just picked to the one. So, right side here you can you know you can see all sorts of tests here where my intention is not to show you all the possible test. My intention is just to show you how well we try to, let me go back to the previous this thing where I left off. So, here the second jet talks about how well we talk, we the enclosure is protected.

So, first one if you remember was only about solids. So, if you go up, it talks about dust protected versus dust tight. Dust protected it ensures that generally when you have a metal to metal surface, something meeting like this. Chances are dust getting in are very small, understood. Two metal surfaces joining on to each other and secondly, even if you

are to have some openings, if you provide a way of you know a difficult path chances are nothing will happen to it.