**Electromagnetic compatibility, EMC**
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**KTH Royal Institute of Technology**
**Module 7.2**
**EMC requirements and standards, testing and difficulties**

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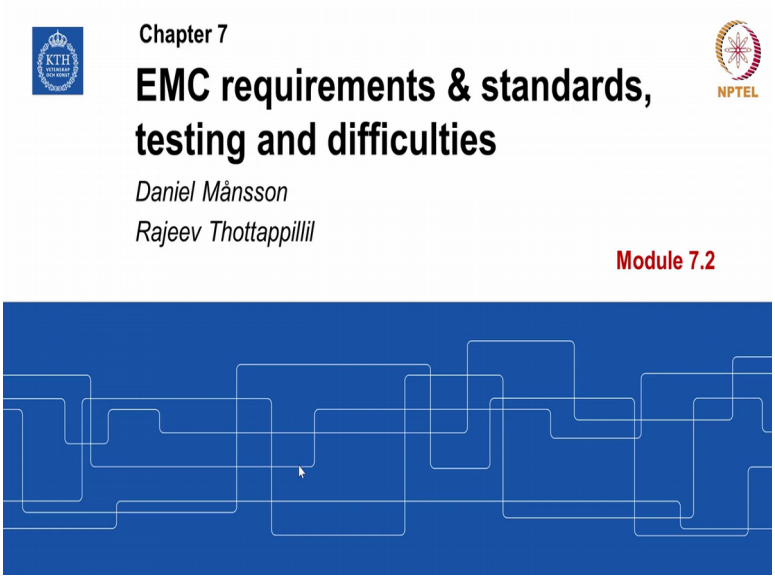


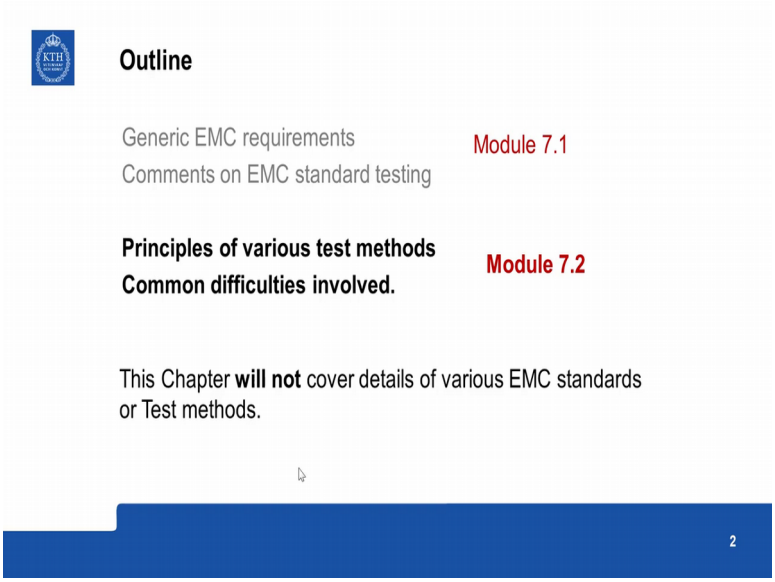

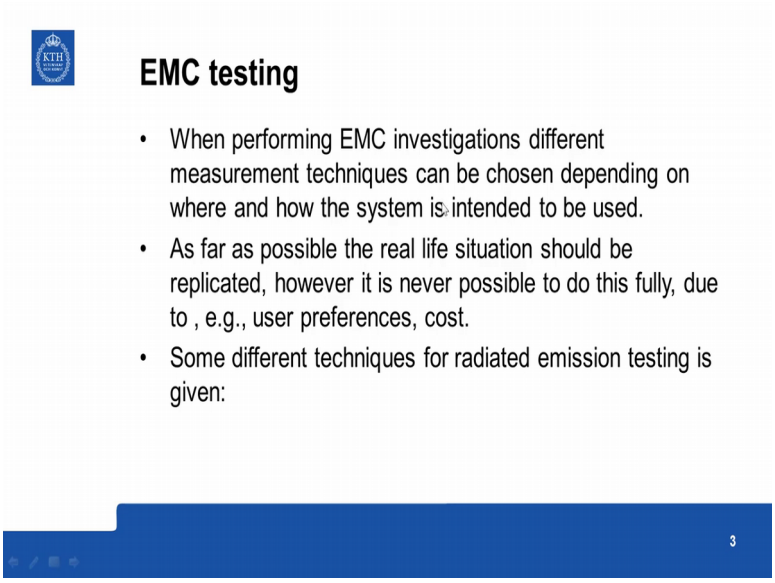


EMC requirements and testing module 7.2, in this module we will inspect the principles of various tests methods and some of the difficulties involved. By performing EMC investigation different measurement techniques can be chosen which depends upon where and how the system is intended to be used. As far as possible the real-life situation should be replicated, however it is not always possible to do this fully there can be several reasons for that cost is one reason and size of equipment is another reason say for example if you want to test an airplane or a big truck or a train you need different type of test facilities that are normally not available, however some commonly used test techniques for radiated emission testing is given in the next few slides.

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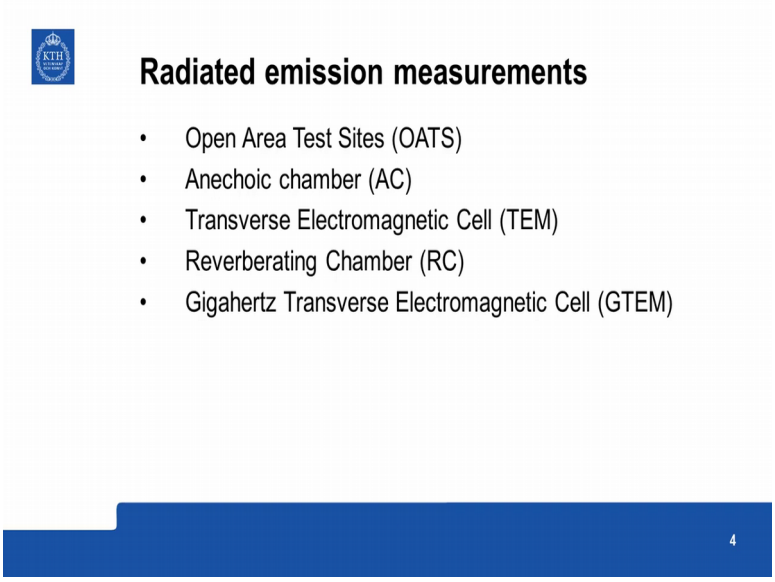

So radiated emission measurements, so some of the techniques used are Open Area Test Sites, this is more like a reference test system Anechoic chamber, Transverse Electromagnetic Cell or TEM cell, Reverberating Chamber and Gigahertz Transverse Electromagnetic Cell.

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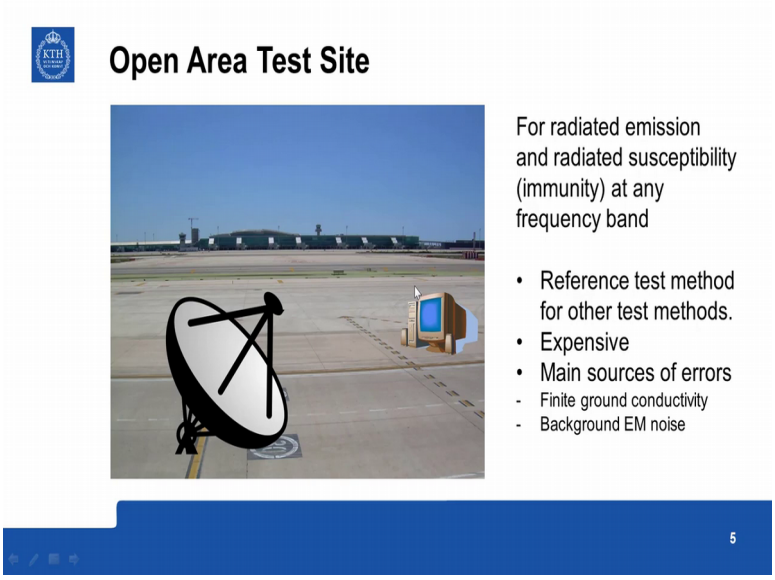


Now the open area test site, so this is the most fundamental of all the measurement method. Assume that you have an area that are plain and without any interference from background electromagnetic field, usually you have to be very far away from cities and other communication area not often very easy to find but if that is the case then you can have your equipment to be tested and you can have position your antennas, radiated the equipment you can calculate how much of the fields falling on the equipment by taking into account the reflection from the ground, so this is the most standard kind of test sites.

So there are no particular limitations on the size of the equipment, so you can both to radiate immunity as well as initial testing also can be done using this method and there are no frequency limitations either, however it is very expensive to this type of test because you need to find relatively (())(3:32) free noise area far away from other sites and you need to have the power requirements for conducting the tests, so this is not often done however open area test site are used in calibrating the equipment or standard equipment that are tested using the other methods.

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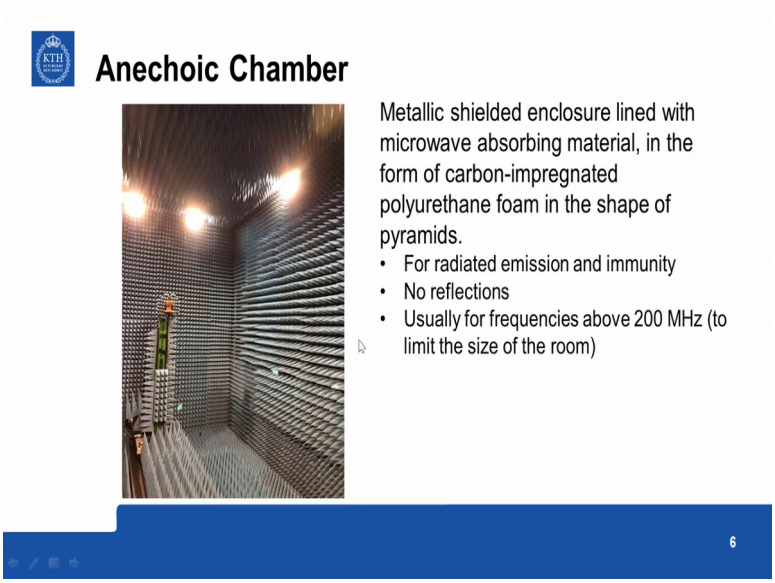


Anechoic Chamber, this is a metallic shielded enclosure lined with microwave absorbing material in the form of carbon-impregnated polyurethane form and these form are shaped like pyramid, so basically you have a shielded enclosure on the outside and the shield will prevent other electromagnetic fields from entering into the test area, so you are looking out all the external fields. Then the cones…the microwave absorbing materials will make sure that there are no reflections.

If you have just this metallic enclosure it will reflect electromagnetic fields when you have an antenna inside but the cones of carbon-impregnated material will absorb all the microwaves and the cone shape is used because it will…even if there are some reflections that will be again absorbed within the cone between the cones and it will minimise all the net reflection that is coming out from the walls, so you can consider that there are no reflections.

The term Anechoic come from sound engineering for some (())(5:53) also you use similar kind of principle, so if you enter into a Anechoic chamber and shout it may feel strange because you do not have any echo even for the sound it is quite good. Usually this type of chambers are used for frequency above 200 megahertz and there are no real upper limit for frequency up to several gigahertz it can go, however a lot of frequencies are limited by the size of the room, if you want to go lower in frequency then you have to increase the size of the chamber and becomes more costly.

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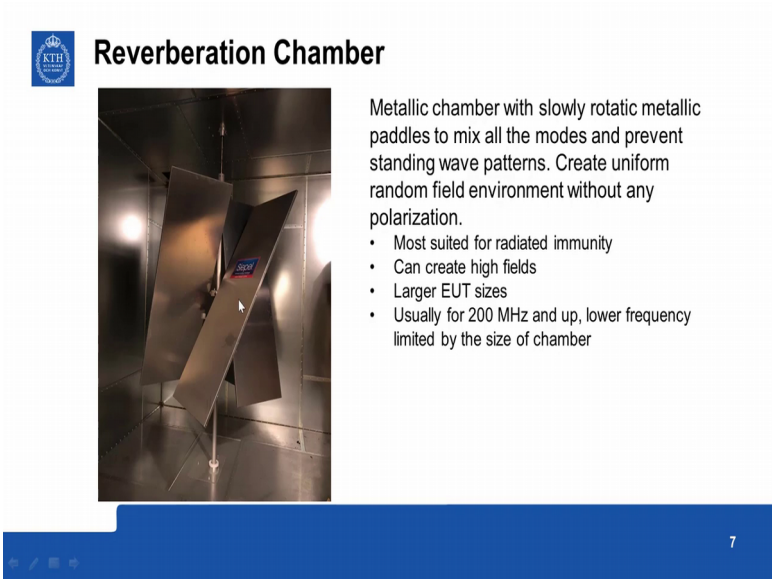


Then another type of chamber is Reverberation chamber, this cost much less than Anechoic Chamber it is basically a metallic chamber with slowly rotating metallic paddles to prevent standing wave patterns, so it is called mode mixing so you can have multiple reflection from all the walls then this will be reflected from the paddles but when paddles are rotating you are mixing everything, so it is called mixing of the modes. Since no waves are absorbed it can create fairly high fields for the same power of the antennas and this is mostly suited for radiated immunity where you need to use very high fields.

It can also commutative larger equipment under test sizes EUT sizes when compared to the TEM cell that will be coming later. It has got fairly high frequency, upper frequency in several gigahertz but the lower frequency is usually limited and usually this type of chambers comes about 200 megahertz because if you want to have to go lower in frequency the chamber size has to be much larger and it becomes more costly.

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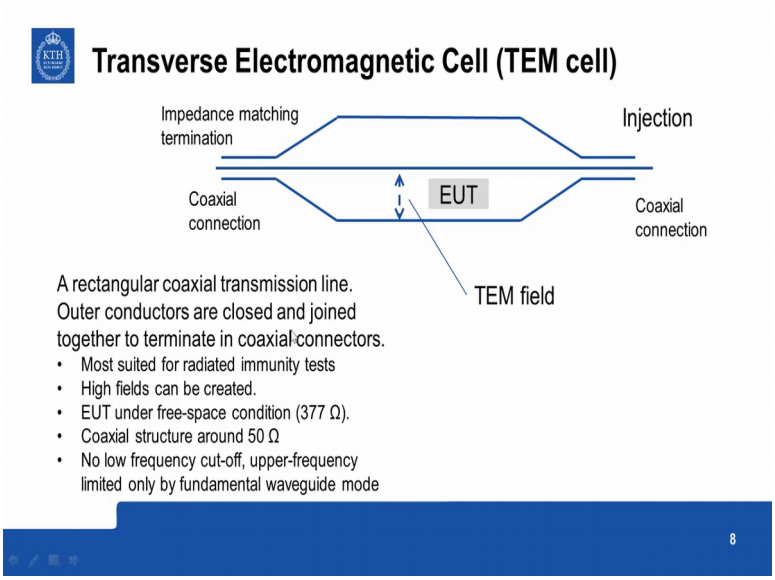


Another test equipment is TEM cell Transverse Electromagnetic Cell so here the principle is that you create a transverse electromagnetic field in a coaxial structure. We have seen what is meant by a TEM field while talking about uniform plane waves, transmission line et cetera, so this is actually a transmission line, a coaxial transmission line so this is formed by a rectangular metal chamber.

Now towards the end it is tapered it is covered all along, so it completely blocks all the outside fields and the tapered sections are terminating into round coaxial connections on both sides, on one side it is for injection and on the other side it is impedance matching termination for absorbing all the waves so that there are no reflections. So if you look at the coaxial structure then there is a matching of the impedance from the injection to the cell and the terminations and usually this type of coaxial structures are designed for 50 ohms terminations you can have 75 ohms also sometimes.

So these are the 2 impedances that are usually used by most equipment. EUT is placed in the middle somewhere so below this septum that is the central conductor or above you have TEM field and EUT is subjected to free space condition that is 377 free space impotence, so due to the confined nature of the cell you can create very high fields, so this is mostly suited for radiated immunity test. It does not have any low frequency cut-off you can go very low into frequencies in the megahertz range, however that can be an upper frequency limitations because you want to ensure that there is TEM field structure inside and if you go extremely high end frequency based on the dimensions of the cell you can have other modes also

coming in, so you do not want to go that high in frequency still depending upon the size you can achieve from megahertz to several gigahertz frequency range in TEM cell.

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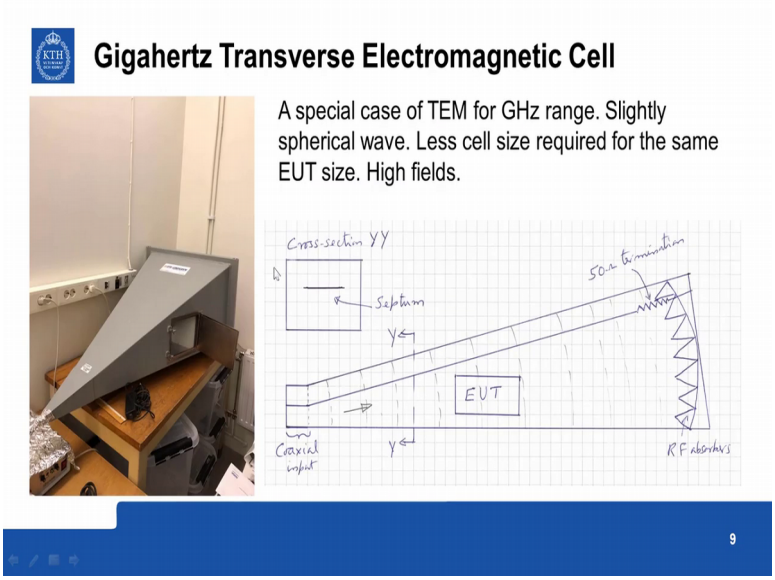


Gigahertz transverse electromagnetic cell, so this is a special case of TEM cell especially suited for gigahertz range, so if you are mostly interested in extremely high frequency you can have much smaller size for the cells and this is kind of half TEM cell in the sense that you have a coaxial terminations here, so this is from our lab KTH, so you have the source connected to the coaxial termination and device under test can be place by opening this window and put it inside, so inside you have a septum, contacting septum that is terminated and this are (())(12:45), so what the cell create is a slightly spherical wave and this is a cross-section as taken from here, so EUT will be under this so small devices like mobile phones or small equipment can be tested easily using this type of cell, so same comments that are made for TEM cells are applicable to this also it can create extremely high fields that is one advantage.

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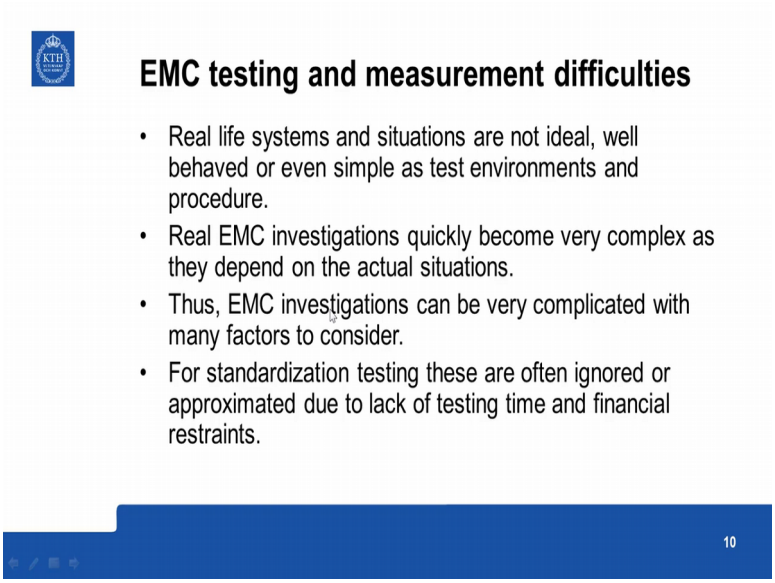


Some general comments on EMC testing and some of the measurement difficulties, EMC testing is required to make sure that the devices that are put into market are tested as per the specified standards and you want to have repeatedly of the test, so that is why we use this standard test methods, so you have something to compare with her from one product to the other, however just because these tests are passed does not mean that the equipment or the device are without any interference or without causing any EMC issues in all kinds of environment because test environments are of ideal and they may not correspond in reality to the actual situation where equipment are working or devices are working. So EMC investigations are much more complicated and there are many factors to consider. A standardise testing ignored (())(15:03) those conditions.

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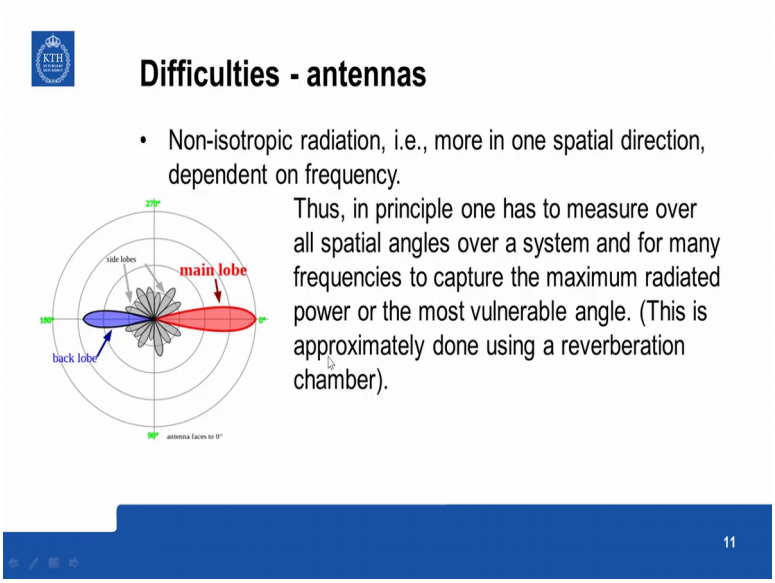


To give certain examples you know any radiating structure or receiving structure can have specific radiation pattern or receiving patterns and radiation is non-isotropic. So depending upon how the equipment is placed you can have different perception or different dimensions, to some extend this kind of variations are tried to be cover during testing by operating the device under test in various angles and try to find the most venerable radiation lobes, however this is not full proof. In anechoic chamber by mixing the different modes you are achieving this, in anechoic chamber by physically rotating the equipment under test you are achieving this variation in the lobes, radiation lobes.

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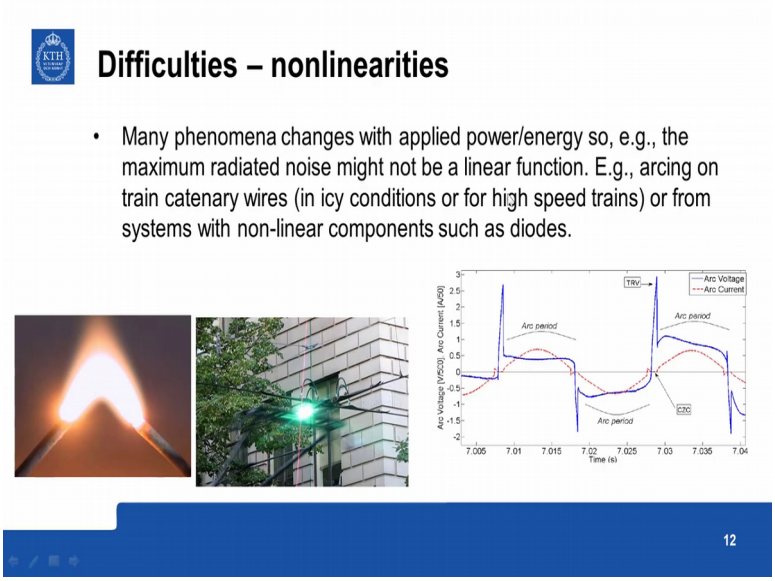

Then there are several nonlinearities which cannot be captured say for example if you have arcing say the catenary of a tram or a railway line you can have lot of arcs under icy conditions or due to the mechanical jerk you can have gaps created in arcing so this is shown over here current and voltages, so these type of things are very difficult to capture in the laboratory whereas for the outdoor systems you have those types of situations. In Sweden it is very common during the winter to have icing on the catenary and due to that arcing on the catenary which creates a lot of EMC problems to the trains as well as to the nearby systems which are very difficult to predict.

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So that gives you a (())(17:44) for some of the test methods and some of the standards of thank you very much.