File name: WEBINAR_ CE Marking Electrical Seminar (1).mp3

Moderator questions in Bold, Respondents in Regular text.

KEY: **Unable to decipher** = (inaudible + timecode), **Phonetic spelling** (ph) + timecode), **Missed word** = (mw + timecode), **Talking over each other** = (talking over each other + timecode).

Colin Graham: Good morning everyone. My name is Colin Graham, and I work in the technical advisory unit with Invest Northern Ireland. So, I'd like to welcome you to our webinar this morning, our CE Marking Electrical Engineering webinar. As some of you will know, I've been running these events for many years, and we're very pleased to be able to continue to do this, and they offer them free of charge since we've moved it online some years ago. So, this morning we've got about 80 people registered on the webinar from a wide range of companies from all over Northern Ireland and indeed beyond. We're going to run the webinar this year as a half day event. So, we're hoping to finish off about 1pm therefore, and we're going to have a break around about 11 o'clock. So, as we go through to this morning, we'll give you an opportunity to pose any questions, so, if you want to enter any questions you can put those into the question panel at the side of your screen, and we'll round those up and try to address them for you at the end of each section, and before the break. I think a question everybody normally asks is, 'Can we get a copy of the slides?' So, just to let you know we will be recording the webinar, and we hope to send out a link to that, plus the PowerPoint registration as soon as we can get all that packaged up and out to you. So, keep an eye on your email for that in due course. Our presenter today as with the global technical webinar last week, is Simon Biltcliffe (ph 01.35), Simon works with Element Materials Technology who are a global testing, inspection and certification company.

Simon's a chartered electrical engineer with over 35 years of experience in product testing, assessment, and certification, he's got extensive technical compliance experience, and he's uniquely able to combine knowledge of global compliance affairs with knowledge of further requirements of SMEs in Northern Ireland, as he's helped many companies in Northern Ireland over the last 25 years. So, we're really pleased to welcome Simon back to present this webinar this morning. So, it's time to get started and I'll hand you over to Simon to get things underway.

Simon: Thank you, Colin, and, hello everybody. We're going to talk this morning about CE and UKCA in the context of electrical, electric technical equipment. So, we're going to cover a range of topics, but particularly we're going to look at product safety, product EMC, product radio, compliance, and then just briefly touch upon reach, (inaudible 02.52). So, protection of the environment and human health. We'll-, please do ask questions on the chat, I could be very happy to try and answer those for you either during the webinar, or after the event from there. So, who are Element, as Colin said, we're a global compliance company. So, we are active in over 30 countries, we're headquartered in (audio distorts 03.30), over 8,000 experts, 40,000 customers, and 200 locations. So, (audio distorts 03.36) as you can see from the (audio distorts 03.38) in front of you. So, what is it that we do, we have a range of services that we offer, and it covers the full gambit of what you need to do as manufacturers and designers, (audio distorts 04.02), for

meeting your regulatory obligations. So, whether that be incentivising (audio distorts 04.07), looking at regulatory affairs, looking at what testing you're gonna do, the testing itself, and the range of disciplines including safety EMC and radio, or whether you need global access-, market access help, or product certification for a techs electrical safety EMC, radio, or telecoms. We provide all of those services as needed, but it's really good to be working again with Invest Northern Ireland to talk about the framework that we operate in for, as I said, those three key areas, or four key areas, safety, EMC, radio and environmental health (audio distorts 04.55). So, let's have a look where we are, UKCA and CE marking, UKCAs are a relatively recent thing, CE marking has been around for many, many years, since the early 2000s (audio distorts 05.19), 20 odd years worth of CE marking, UKCA is smaller than that. Very, very similar sets of rules, because UKCAs effectively a GB implementation of the CE marking regulations. So, there's a lot of commonality because we were subject to the EU regulations before. So, EU directives and regulations read across to UK regulations to statutory instruments, harmonised standards in the EU called Designated Standards under UKCA, but notified bodies in the EU, approved bodies in the UK, and we have a UK declaration conformities opposed to an EU declaration conformity.

(mw 06.07) regime was supposed to take over for CE within the next couple of years depending on which directive, however rules were changed this year to allow the CE marked products to be accepted in the GB market indefinitely, obviously, in Northern Ireland you stay within the CE regime, but effectively CE marked products will be accepted across the whole of the United Kingdom for an indefinite period, noting that UKCA never applied in crown dependencies, only in the GB market. So, what that leaves us is an effective use of CE marking, so, we've got the EU 27 countries, and the whole of the UK again now by default. So, although you can use UKCA for the GB market (audio distorts 07.11), if your CE marking anyway, (audio distorts 07.13), only need to CE, and if you do CE it's relatively easy, paperwork exercise to move onto UKCA. So, it becomes a bit of a choice, and I think also on this map we've got in front of us, it's worth noting that although it's not marked in as an area that uses CE, Switzerland and Turkey recognise CE marking to a greater or lesser extent in those markets. So, I actually, it's not just the 28 one here, it's at least 30 countries, if you begin looking at, if you include Norway in that where CE is also recognised, that's 31. So, again, a huge area which you can now use CE marking. So, today really, I'm not going to talk about UKCA very much because you can read across as UKCA, meaning the same thing as CE, it's just a matter of choice. So, EU directives and regulations, there's a whole host of them that apply, the basic rule of CE marking is if there's a directive or regulation that applies to your product, then you need to apply the rules for that, it's not a pick and mix in that sense, you have an obligation as the manufacturer to work out what applies to you and then apply those rules, and we'll pick up some of these themes as we go through the presentations this morning. So, what's common on these-, all of those directives and regulations, is the 3 pillars. So, all of them to some extent have technical requirements which in general are supported by (audio distorts 09.10) standards, EN standards, to help you meet those requirements. They all have some form of evidence pack that you must compile. So, it's a mandatory technical documentation that you must put together, that documentation is largely harmonised across directives. So, when you're compiling your documentation pack, it's effectively one pack of documentation for each of the directives, for all of the directives and regulation. Some people do do separate files, but actually it should be one file, because it's a file per product or closely related product family, and then the third pillar is a system for ongoing compliance. S

o, production, control, and quality processes, now some have directives and regulations, that's a really minor thing, it just says the manufacturer shall have a system for ensuring ongoing compliance, in some of the directives or regulations it goes further than that. So, if you're in a higher risk areas like potential exposed atmospheres, ATechs (ph 10.17), or medical devices or dangerous machinery, then the production process may be controlled by a third party by a notified body as well. So, we're going to focus on the first 2 pillars, the standards of documentation, but the third one it is there, and at the basic requirement it says, 'All manufacturers shall have a system for ongoing compliance,' to ensure that whatever is manufactured conforms to the documentation pack, that evidence pack on the way, and we'll touch upon the testing and assessment of products, because the role in standards all of these directives is really important, and how you assess, what you assess, how you use standards within your electrical CE conformity. So, what does CE actually mean, well, the CE mark is a manufacturers self declaration. So, it's saying, I, the manufacturer, by putting the CE mark in this product, I'm declaring that I have met all the requirements, the essential requirements of all relevant directive and regulations, it's supported by the declaration (audio distorts 11.37), (mw 11.37) and EU declaration conformity that lists those regulations and directives that you have applied, also identifies clearly the product, and also any standards that you use in support of that compliance. So, the rules say that the CE mark must be placed on the product before it's placed on the market or put onto service on the first time in the EU. So, where these regulations apply, and CE mark rules apply, you are under obligation to go through the CE process, mark the product after you've completed declaration conformity, but you complete the declaration conformity after completing a file of technical documentation. So, the CE mark is that self declaration based upon different rules, but it's not supposed to be a mark of quality or safety, it's a mark for trading purposes only. So, it's not a consumer mark, it's there for border control and customs officers, health and safety inspectors to determine whether your product is compliant or not, and suitable for use or sale within the European market. So, I've mentioned notified bodies earlier, and for some directives where product risks are high, or where there are no standards onto which to base compliance, for particularly the complex areas, then self declaration is not permitted.

So, the CE mark is a manufacturers self declaration, but under some circumstances the directives or regulations require the use of technical experts called notified bodies, who conduct third party assessment of the product or production. So, self declaration is first party, the manufacturer does it under their own volition, compiles a technical file, where a notified body is involved, the manufacturer does all of those things, but then a notified body then attests to the fact that it's been done, and that may include assessment of production. So, factory inspections on a routine basis, and that, again, has to be done prior to application CE marking, and if a notified body is used you need to include the details of that notified body on your EU declaration conformity. So, an example of high risk areas, medical devices, equipment for explosive atmospheres, and dangerous machinery, and certainly those of you who are involved in the machinery CE talk a week or so ago, will have come across the annex for the list of machinery in the machinery directive, or the new machinery regulations. For EMC, safety, and radio, we don't classify anything as being highly dangerous. So, under normal circumstances it's manufacturer declaration based upon a technical file and supporting evidence without use of notified body, there are some exceptions to that, but that's only where there are no test standards for the product, for EMC and radio. So, we'll cover those later on, but basically, I think most of what we're talking about today is going to be manufacturers compiling technical documentation, gathering the evidence prior to do that. So, if we look at the EU and UK legislation, what's mandatory is the compliance with the directives and regulations, or for UKCA the

statutory instruments (ph 15.09). It's really important to say that the standards, whether it be harmonised or designated, are not mandatory, none of these directives and regulations say, 'You shall apply a standard,' what they do is they point you via essential requirements, or essential health and safety requirements prince (ph 15.29) of objectives.

They say, 'These are the basic criteria that you'll apply when you are designing your product,' and, one way of demonstrating compliance is to use harmonised standards in that process, but it's not mandatory. The caveat on that, if you look at the EU Blue guide, which is the guide to how all directives and regulations should be applied, you're required to assess risks within a product, and then you take those risks, and then you apply mitigations, and then you prove that those risks had been eliminated. If a harmonised standard exists, whether it be for safety or for machinery or EMC or radio, if a standard exists and you haven't applied it, then you need to justify why. Why did you think that you didn't need to apply it when the, sort of, collective knowledge of industry across Europe has said that the harmonised standard is the best way of doing it. So, normally it points people back to the use of harmonised standards when meeting CE regulations. So, CE marking, a declaration of conformity is filled in before that, before that all of these directives and regulations have rules with regards to establishing documentation, largely the same wording used, but the requirement and the intent is the same, and they're, sort of, summarised in what we're going to talk about now. So, one of the aspects within the technical documentation is an adequate analysis and assessment of the risks. Now, there is in the back of all these directives an annex of technical documentation, and there's a list of-, so, there's 6 items that you would expect, (audio distorts 17.30). Just above that list, in the, sort of, opening statement, it says, 'Shall include an adequate analysis and assessment of the risks.' So, your technical file includes not just the, sort of, 6 bulleted items, but also your initial starting point of analysing an assessment of the risks associated with your product and compliance with either the electrical safety, EMC, radio or machinery safety, whatever it might be, you still need to do this risk assessment, to determine where you are about. Then you get to the bulleted list of what needs to be in a file. So, your file needs to describe the product, a general description of the equipment, suitable for-, so, that anybody reading the file can identify and be quite clear what the file is referring to. Now, baring in mind, these files are for customs officers, and health and safety inspectors, border officials. So, they have a product in front of them and they need to be able to, if they have a suspicion of the products compliance, they can ask and require you to provide a technical file, when the file arrives it needs to be quite clear that the product in front of them is covered by the file.

So, it's a general description of the product. Conceptual design and manufacturing drawings, schemes of components, (mw 18.52) assembly circuits with descriptions and explanations necessary for their understanding. So, it's the basic high level manufacturing drawings and circuits, bills (ph 19.05) and materials, explanations to enable you to say, 'Yes, technically, this is what the product is, I'm a television set, and it's a television set that has these broad design principles in it,' doesn't mean you need to put absolutely every drawing and every bit of technical detail in the file. But, you do need to put enough in there so that the person reading the file can get-, he's confident that you have that information available, even if it's, you know, perhaps the second question to ask you to provide more detail if they want it. Then, there's a list of harmonised standards, or other relevant technical specifications and descriptions of the solutions adopted to meet the essential requirements, where (audio distorts 19.47), very long winded. So,

the essential requirements of each of these directives and regulations tell you what you need to do. So, for safety it might say, 'You shall not cause dangerous sparks or high temperatures,' for EMC it might say, 'You will not emit harmful RF radiation that causes, interrupts or upsets the performance of other products,' for radio it might be, 'You don't, you know, disturb the radio spectrum to the detriment of other products.' Very, very broad requirements, and the machinery directives even more detailed, that's got pages and pages of essential requirements going down into, you know, 'You shall have guards and stops.' When you come to work out how you prove you meet that requirement, then you generally, as I said, end up back at harmonised standards, and the official journal of the European Union lists standards that can be used with those directives and regulations to help you prove compliance. So, this is the tie in with standards here, and as I said, harmonised standards are the preferred route that they would like you to follow. Then, there's results of design calculations made, examinations carried out, and that can be-, no, that's (audio distorts 21.08), you've done as the manufacturer things that you've (audio distorts 21.11), as a consultants or test laboratories to do (audio distorts 21.15). But, it needs to show what you have done to verify compliance. So, it's not just a matter of, 'Oh, I've designed it meet the standards,' what have you done to validate it actually does meet those requirements. Then, also in this list is test reports, if you apply these standards there is testing required, inspections, measurements to be made, and they need to be put into test reports, and within your (audio distorts 21.44) technical file.

Whilst, you are not-, if you are not using a notified body, there's no requirement for you to use a third party for this for some of the testing, it's most likely you would need some form of third party to help you do this, unless you have the facilities in house. So, that, sort of, bulleted list, and there's a 1, 2, 3, 4, 5 lists there, but in fact, you know, the conceptual design drawings is a merging of two requirements. But, basically, those are the six bullets that you find commonly in the standards, and in addition to that, the declaration and conformity needs to go in the file, because that's your summary of compliance. So, it says, 'I've done the risk assessment, I've compiled the file according to the bulleted list, and I've made the declarations of who I am to make the declaration, what I'm declaring against in terms of the products and standards and regulations.' (audio distorts 22.44). Last but not least, who's the responsible person in my company (ph 22.49) (audio distorts 22.50), who is making the declaration on behalf of the (audio distorts 22.54). Also, most of the regulations have some measures to ensure ongoing conformity, and you would expect your technical file to deal with that as well. So, whilst it's not in the bulleted list, there is a requirement in all these directives, (audio distorts 23.12), to maintain conformity for all of the products that you make to the best (audio distorts 23.17), would be in your technical file (ph 23.20)(audio distorts 23.20). That might just be if you're a larger company, an ISO 9001 certificate, or for a smaller company, what, sort of, quality or production processes do you do, or a reference to those processes. So, risk assessment, I mentioned that before, what approach do you take to risk assessment? Well, anything that's worrying, and a bit uncertain, you know, (audio distorts 23.53) close our eyes and pretend it's not there, if you don't look it's not there, but as we all know, in the case of (audio distorts 24.02), you can't get away from it just by closing your eyes. So, you have to ask yourself all sorts of questions in the risk assessment, how do you-, how is the product conforming? So, if it's a radio product, if it's got multiple transmitters, Bluetooth, Wi-Fi, do they operate simultaneously, or do they only operate one at a time, in which case when you're testing and assessing your product, how do you configure it into worst case configurations. If I've used pre approved modules or parts, so, CE mark compliant parts, having installed them in my product, do I need to test them again, how do I assess the risk of their compliance or non compliance in my (audio distorts 24.45).

Are there really no product safety risks just because it isn't a mains powered equipment or it hasn't got chopping blades on it, is it perfectly safe, are there really no product safety risks. Again, how do I know that I've met all the essential requirements, have I identified those applicable requirements to my product, have I looked at the risks associated with my equipment, have I documented my thought process as to why I think these things, these elements apply, then what's my mitigation. So, your risk assessment says, 'These are the risks, these are the hazards, what's my mitigation,' and, now you're (audio distorts 25.27), this standard here and there, and that's helped me mitigate my risk to an acceptable level. So, the manufacturers risk assessment is really important, you identify the risks, you analyse them, you action them, you monitor them, you control them, and then you go round that cycle, it's an ongoing process. So, risk assessment is a continuous process, and hence, really, when you're doing CE compliance for any directive, it's the first document you open, you start with the risk assessment, it's the last document that you close, because you need to go through this process. Once you've identified, analysed, actioned, monitored and controlled, when you go into production processes, you need to think, 'Well, okay, what's the risks associated with availability of parts? What happens if I change a part? What happens if I change a component or material? What impact is that going to have on my ongoing compliance?' So, your risk assessment is product focused but then extends into your quality system as well as to how you meet those requirements. So, it's the place you start again once you've completed the process, and as the product evolves, your CE marked technical file and assessment process is a snapshot in time, but no product stays the same, and every time that product changes you need to go back to your risk assessment, and go, 'I've changed this, does it impact the product?' And, if your risk assessments detailed enough, you're going to be able to say, 'No, I've looked at the risks, the risk was covered, the change I've made doesn't affect my (audio distorts 27.06),' as before, or it says, 'No, I need to do something to update my file, my testing, my test reports, to keep the product in compliance.' And, that brings us to the last aspect here which is the declaration of conformity. This is the summary document, effectively it's what the CE mark is declaring against here, you know, we've said that the CE is a statement that you meet all requirements, but it's just a little mark on the product, what backs that up is what you put on the declaration of conformity.

So, your CE mark says, 'I've applied all the rules, go and have a look at my declaration of conformity to see what rules I've applied.' So, quite often, even if the regulations or directive don't require you to include the declaration of conformity in the file, your supplies will ask for it as part of their obligations under the regulations as distributors or suppliers or retailers. So, a declaration of conformity, again, identifies the product, identifies who you are as the manufacturer, if you need an authorised representative in a particular EU country depending on what the rules are, what the product is, what legislation you are complying with, what standards or other technical specifications you used (audio distorts 28.35) to (audio distorts 28.36) compliance, and then any other additional information like notified bodies route (ph 28.39), and then finally who signed it on behalf of the company. Now, the person signing this, it's just like any other legal signature, if you're a legal entity company, it's not you taking personal liability for this, you are signing on behalf of the company. So, it's in the offices of the company who take responsibility going forward for the accuracy of it. So, really (ph 29.04) anybody who can parole (ph 29.06) the content of the file and production, is a suitable person to sign the declaration of conformity. So, the CE mark or the UKCA is your passport to (audio distorts 29.20) free trade, any product baring the UKCA mark has met all of the appropriate provisions of the relevant product legislation, and then can be sold in those 31

markets that the EU, and it's associated countries that (audio distorts 29.35) CE marking, work, (audio distorts 29.39), very powerful tool for us to use. It's all part of that making tomorrow safer than today (audio distorts 29.52), but we'll run through what we're talking about as we go through (audio distorts 29.57) more detailed presentations looking at product safety, EMC, radio, and (audio distorts 30.05) reach.

The next presentation I'm going to look at is going to be looking at safety, but before I do that, Barry, have we got any questions at this point?

Moderator: Yes, we've got one persons asked just for a clarification. So, I'll read that out and then I'll bring up the next slides. So, it says, 'You said third party assessment is needed for dangerous machinery, does this apply, or does this mean all products within the scope of the machinery directive regulation, if not what is the definition of dangerous machinery requiring third party assessments?

Simon: Right, okay. It's within the machinery directive there's something called Annex 4, an Annex 4 equipment is a list of equipment that's considered to be dangerous. So, it's things like open bladed saws, industrial presses. It's quite an esoteric list of products. So, most products don't fall in the scope of it, but it's Annex 4 of the machinery directive, I don't know what the annex is in the machinery regulation, but there will be an equivalent list in there which details products that require a notified body under the machinery directive.

Moderator: Super. That's it for now, again, just a reminder if you do have any questions you can just pop them into the questions function at the bottom-, or at the right hand side of your (mw 31.33) panel, and we'll be stopping at the end of each presentation just to cover any questions submitted, but other than that, we're back to you, Simon, for a second session and hopefully that will be you now with control of the slides also.

Simon: Thanks, Barry. Yes, so, this is the first presentation where we're going to-, into detail, so we're going to look at safety of electrical equipment in the (audio cuts out 31.59) CE marking. So, safety of electrical equipment principally for CE marking, this is the Low Voltage Directive, which is directive 2014/35/EU. It's not called the Low Voltage Directive, its official title on there is, on the harmonising laws of the member states relating to the making available on the market of electrical equipment designed for use within certain voltage limits. So, hence why it's, it's shortened down for that and its voltage limits are 50 to 1,000 Volts AC or 75 to 1,500 Volts DC and anything with an input or an output within that range falls within the scope of the Low Voltage Directive. Now, in the GB market and also equivalent in the-, in Northern Ireland, there are consumer protection health and safety regulations that apply.

They historically have mimicked the Low Voltage Directive and still do. The current GB legislation refers to UKCA with the option to use CE and as I said earlier on, effectively you can use CE as an alternative to UKCA, but there is an equivalent national legislation for reflecting all of these directives and regulations. So, consumer protection, health and safety in, in, in GB and equivalent Northern Ireland regulation that adapts that slightly to your special requirements there. So, that's for the safety of general electrical equipment with some exclusions. So, it excludes military equipment, equipment for potentially explosive atmospheres, medical devices, which are covered by their own regulations. It also fits-, sits alongside the Machinery Directive, machinery regulations, in that the Machinery Directive takes precedent if it's a machine within the scope of the Machinery Directive, but when you come to the electrical part, you end up applying the rules of the Low Voltage Directive even though you don't necessarily declare against it, certainly not in a-, in a UK sense.

The second type of equipment and we'll touch on radio equipment in a separate presentation in terms of radio compliance, but there's also safety compliance for radio (audio cuts out 34.40) under the Radio Equipment Directive and the radio equipment regulations in the UK. The reason we call it up here is article 3.1(a) of the Radio Equipment Directive actually says, 'For safety of electrical equipment, refer to the Low Voltage Directive and the rules applied for that,' but no with no lower voltage limit applying. So, in other words, as soon as you put a radio in a piece of electrical equipment, that lower 50 Volts AC or 75 Volts DC limit disappears. You basically go from zero, so effectively, battery-powered product, if it's got a radio in it, now is covered by the rules and principles of the Low Voltage Directive and I suppose more significantly, the safety standards that are called up by the Lower (ph 35.38) Voltage Directive, to help you meet compliance.

So, radio products effectively are extended range of the Low Voltage Directive in terms of electrical safety. So, principles, basic principles. What does the Low Voltage Directive say? Well, to paraphrase, shall not cause death or injury to persons or domestic animals, nor damage to property due to (audio cuts out 36.05). So, it's very, very broad statements. So, this is legalese. What can you be prosecuted for nonconformity with the Low Voltage Directive? Well, there's technical violations of paperwork, but in terms of serious violations, if you've caused death or injury to persons or domestic animals or damaged property due to fire, you could be in, in, in breach of the Low Voltage Directive. And it brings us real-world issues. I mean, these are consumer issues I've got on the screen here, but we'll look at some examples in a minute of non-consumer items, well, there's both industrial, commercial and domestic appliances. We've got real-world issues, lots of issues in the newspapers regularly about, you know, washer-dryers overheating, because they've got lint stuck in them that catches fire, burns people's houses down. The dreadful Grenfell fire disaster. Whilst the, the extent of it was, was caused by the cladding and the poor fire safety rules, the start of the blaze was in a domestic appliance, a freezer going wrong, they believe. And then you'll remember a few years ago the Samsung Galaxy phones, batteries bursting into flames, to the the extent they were all-, they were banned from going on flights.

So, there are real-world issues to the Low Voltage Directive. You don't need to look very hard to find that

there are issues which impinge upon us in our daily lives. The Office for Product Safety and Standards in London, part of the DTI, Department of Trade, maintains lists of products that have been recalled or have been subject to recall notices within the-, within the (audio cuts out 38.03). So, there's an example here of a main circuit breaker, which contained a non-conforming component, which meant that the breaker didn't trip when it was supposed to. Obviously, when you're using an MCCB, you want it to trip. It's a safety device. If it doesn't actually do what it's supposed to do, then, you know, you're in trouble. Now, this was a CE-marked product produced by a very reputable manufacturer, (mw 38.28) Electric, but something had gone wrong in the production process or procurement process and they were required to take the following measures. One was to notify all direct customers of the risks and offering to replace on-site the potentially non-conforming component or to just replace the MCCB. Huge consequence of that commercial-, of that technical non-conformity, apart from reputational damage, actually the cost of replacing those MCBs would have been huge.

Second example here, this is again fairly common, lump in line power supplies were used for laptops, all sorts of appliances, and in this case, this adaptor posed a serious risk of electric shock, because when it was dropped, the case burst open. That's not uncommon with mains adaptors. There is a test in the standard to make sure that that doesn't happen, but if it's not tested properly or not tested at all or there's an assumption of conformity or something changes during production and the risk assessment hasn't addressed it and it hasn't been caught, you can end up with problems. And in this case, the case split and the distances, the creepage and clearance distances, so the hazardous mains parts inside weren't maintained. So, there was a risk of electric shock and in this case it didn't have any safety information or suitable instructions. This was an online Amazon product and the, the listing was removed from the marketplace.

Another example here, this is not a mains power product at all, but a battery-powered product. High risk of fire, because the battery pack (audio cuts out 40.19) to protect from overcharging, overheating, it ignited. Again, lots of examples of power tools, electric bikes, vapes, electric cigarettes catching fire and if you've seen some of the things on electric bikes, it's quite devastating when, when the batteries on those go. For this case, listings were removed from an online marketplace, but these things would still be in the market and it's very easy to inadvertently end up with a product. You can just see the bottom of this label here. There is a CE mark on this product. All of those products we've been talking about have been CE-marked, declared to be compliant where the manufacturers believe them to be compliant, but they haven't been, for one reason or another.

So, what factors do we need to think about to define product safety? Well, there's three things. We need to think about who is using the product? What the product's function is? What do you intend as the manufacturer (audio cuts out 41.21) and where is the product used? All parts-, forms part of your risk assessment, actually and that leads us to the how in determining compliance. So, once we know who is using it, what it's used for, where it's used, it points us down to the, the relevant risks, the level of those risks and what mitigations that we (audio cuts out 41.44). If we look at the who, so, the Low Voltage

Directive covers work, it covers when we're out shopping, it covers when we're in the home, when we're in, in, in school and it covers clean environments like offices, dirty environment like factories. So, the who is important. When we are shopping or when we are working in an office, we don't consider those to be dangerous environments. We don't expect to injure ourselves on the photocopier or when we're reaching into a, a, a freezer to take frozen peas out in a supermarket. So, we're a very, very low-knowledgeable user in those scenarios. When you get in a factory environment, if you're operating machinery, driving forklift trucks, you can be expected to have a higher degree of training to mitigate those risks. If you're the cleaner in a factory environment, then again you need to be protected as an uninformed user. So, you need to look at the environment, say who is using, who am I trying to protect with the regulations?

Then, what's the function of the product? You know, washing-machines for domestic environment are precisely that. People, you know, use washing-machines for all sorts of odd functions, if you-, you know, to make amusing videos on the internet, but what's the function intended use? There's a clear function intended use for a washing-machine. Manufacturers' responsibility extends to the limitation of that function and, and the use. Laboratory equipment, again, where is it being used? What's the function? It's got dangerous chemicals, it's being used by trained people. You know, there are certain mitigations that you can put in place. Fire panels, and in this case, this is some sort of emergency kit, which is basically a radio device on the end (ph 43.50). So, we need to define, who uses it? What is its use? What's the function? What does it do? Because that will determine some of those risks and hazards that might approach the equipment.

Then, the where, the environment it's being used. Factory, kitchen, supermarket, outdoors. You know, if, if you've got a control panel, like a telecoms panel in the street, a street box, when it's closed it's a completely sealed environment. When the engineer is working on the panel, they've got the doors open in weather. We've all had weather in the UK, in this last few days it's been horrendous. When something breaks under those circumstances, people still need to go in the panel. So, does the panel remain safe for the maintenance guy under all of those conditions? And then we've got things that are used outside, like electric car chargers. They're by definition used in a very different environment to that we find, say, in an office. So, we need to think about where the product is used, because that will determine the risks we have to consider (audio cuts out 45.01).

So, before we move on any further, what, what do we learn when we apply the three factors? Well, we take the example of my mobile phone there. Who would be using it? Well, anyone. A mobile phone can be used by anyone, including children. So, you would need to think about the risks of children's use and misuse. What does it do? Well, it communicates, it connects, so there's radio frequencies involved and it connects to the-, through-, via an adaptor for charging. That charging might be plugged in or it could be inductive charging these days. So, we need to think about the risks associated with the charger that's used with this. Where is it used? Well, this tends to be used indoors. If it-, it can be used outdoors, we all talk on (ph 45.57) our phones out, but they're handheld devices, we don't like getting them wet. We don't tend

to leave them outside, so it's really an indoor device that needs some degree of protection against weather. And obviously, (audio cuts out 46.13) and whether that's a safety risk or a functional risk, you could determine, but these three factors now help us determine what conformity assessment we're going to apply to determine compliance of the product.

So, in the first instance, let's have a look at what the Low Voltage Directive now asks us to do. So, the, the how. Now, the Low Voltage Directive has something called principle objectives for safety and that's because the Low Voltage Directive was written in the late 1960s. They didn't use the term essential requirements or essential health and safety requirements, which is what was used in more recent directives and regulations, but it means the same thing. It's essential requirements. So, we look at these, the general conditions to start off says that we need to mark on the equipment or any accompanying documents any key instructions. The equipment should be constructed in such a way that it can be safely and properly assembled and connected and that it must be robust enough and it must be designed so that the protections set out in the rest of this principle objectives safety list is met. So, that's points 1 a, b, c.

If we look at protections against hazards arising from the equipment, again these are general principles here. It says, 'Measures of a technical nature shall be laid down in accordance with point 1 in order that,' so in other words, you need to have suitable instructions, you need to have a way in (ph 47.56) manufacturing this, you need to ensure compliance, to ensure that persons and domestic animals (ph 48.01) are adequately protected against the danger of physical injury and other (mw 48.04) which might be caused by direct or indirect contact. So, direct contact, touching the equipment, touching a live part. Indirect contact, being connected to something that's connected to a live part. So, when your mobile phone is being charged it's indirectly connected to the mains supply, so you need to have something in your design that separates the mains supply from the Low Voltage phone.

2(b), you need to protect against temperatures, arcs (ph 48.37) or radiations. (c), non-electrical dangers. So, the Low Voltage Directive means the safety of electrical equipment. It's not the electrical safety of equipment. So, it means that all other hazards in a Low Voltage Directive product need to be protected, so that can include mechanical hazards, fire hazards, chemical hazards. Then (d), the insulation is suitable for foreseeable conditions. Foreseeable conditions means how the equipment is being operated. So, we, we've identified the who, what-, you know, the who, what and where, but it also means that the products needs to consider its use. not just under normal operation, but under foreseeable conditions of use or misuse.

Item 3, external influences in the equipment, so in other words, expected mechanical requirements. So, our example of the power supply where, when you dropped it or it was bashed, the case came open. That's an external influence. (b), resistance to non-mechanical influence in environmental conditions. So, is it being used in a wet environment, a cold environment, a hot environment and (c), what happens when the equipment is overloaded? Overload in the sense of being used beyond its normal means. So, we said, you must define the function of equipment, what its normal use is, but then you do need to consider what a

reasonable extension of that normal use, which could be considered to be overload, because you need to protect that, as well.

So, those are what the objectives say, so the basic rules of compliance. How do you meet those requirements? So, the Low Voltage Directive, as with the other directives and regulations we'll talk about today, best practice and guidelines to meet are in the harmonised standards. There are hundreds of these listed in the official journal to help you meet these requirements. Now, the directive regulations says the standards can be applied in full or in part. What that means is that CE declaration doesn't mean that the product's complied with every requirement of the standard. Someone may have just done a risk assessment and just applied some parts of standards. Now, that being the case, that needs to be stated on the declaration of conformity. So, when you fill in a declaration of conformity for a any of these directives, if you list a standard on there, it means you have applied every clause from one to thirty or whatever, to the product. Really, really important.

So, you need to be cautious of what you list on your declaration of conformity. Don't put standards on that you haven't applied or sometimes people put them on and they haven't even got the standard or looked at it, just because it's what somebody else has done and that's the weakness of self-declaration, declaration of conformity. You've got no way of verifying as the receiving party as to whether what they've done is proper, but the how is about applying standards. So, as I said, it's more than just electric shock. Electric shock, fire, are all are related to electricity, but trap, crush and pinch aren't. Heat can be radiation as a result of applying power to something, but there might be optical hazards, biological hazards, chemical hazards, hazards due to batteries which are not electric shock related, but are still quite dangerous or poisoning due to materials or processes.

All of those are hazards-, must be covered and addressed under normal operation. So, it needs to be safe when operated as the manufacturer intended and in accordance with the instructions. So, your instructions are really important about saying who uses it, what it's intended for, where it's going to be used. You're setting the boundaries as the manufacturer. It's not reasonable to take a product designed solely for indoor use and installing it outside. You can't expect the same level of protection, but it must be clear to the user that there's no ambiguity with that. So, if my laptop computer is suitable for use outside and, you know, in the sunshine and could get wet, then the instructions should say that. If my laptop is not suitable, because there's some risk associated with it, the instructions should say for indoor use only, as an example. And if (ph 53.28) it goes beyond normal operation, the product needs to remain safe in the event of a fault or when accidentally misused under foreseeable conditions, overload conditions.

So, it's not just about normal operation. When you're considering the risks, you need to consider what happens when the equipment is going (ph 53.49) wrong or when it's misused (audio cuts out 53.53) and the misuse now comes back to how are you defining the original use and the competence of your user. If

your user is a highly-trained person, a technician. The photograph of the maintenance engineer by the telecoms cabinet, they are trained. So, then you can expect a higher level of competence and, and risk avoidance from a trained person than from somebody who is not trained, like in a domestic environment. So, how do we do this? Well, the standards that this, this concept we're looking at now comes from a, a (mw 54.32) media standard (mw 54.33) one, which is a hazard-based standard, but it applies across the board, regardless of what safety standard you're applying. If you have a body part or a material, then you need to separate that from a hazardous energy source.

So, that could mean (audio cuts out 54.50) an electric shock, a fire risk. You would, in order to avoid a risk to a person, you apply a safeguard and in fact what it means is, that the safeguard is there to protect you. The safeguard is only needed if injury or damage to the part occurs as a result of a failure of that safeguard. So, a safeguard is only needed if injury would result, but equally, you can turn that round and say where injury or damage to the material, fire, is affected, then you need a safeguard. Now, we've said that we need to think about normal operations, so a single safeguard is fine for normal operation, but what happens if that safeguard malfunctions? Well, in this case you need-, you follow the concept of two levels of protection where you have two safeguards between the body part or material and the hazardous source and what that means is, in the event of that safeguard failure, the body part or material doesn't come into contact with that hazardous energy source. So, effectively you're protected under conditions of foreseeable failure.

So, let me give you a tangible example of that. Thinking about the humble mains flex, this is an orange one. It's a (mw 56.24) often seen on, when you're using on power tools and what have you outside and in this case it's a three-cord cable, a live, neutral and earth. It's constructed with a really good symmetrical cross-section, such that each of the live wires, and you consider the neutral to be live here, (audio cuts out 56.45), that each of the live and the neutral wires has separation to, from the outside bit, the hand, and the copper live part in between. In this case, two levels of protection. We've got the supplementary outer sheath and then we've got the basic insulation on the live wire or on the neutral wire. So, if the sheath gets damaged, gets cut, grazed, breaks, which they do, so underneath that single failure situation, we are still protected against that hazard.

Now, in the case of where it's being used with things like a hedge trimmer, it's very difficult to protect the cable from being tripped in two (ph 57.37), in which case an additional measure might be needed like (audio cuts out 57.43) leakage trip (audio cuts out 57.45) for example, would be part of an additional safeguarding measure, because of the additional hazards associated with that. But if you're thinking about your laptop power supply or a washing machine or a kettle, something where you haven't got blades which are going to slice through the cable automatically, then this two levels of protection are really good (ph 58.07) that. So, this principle is not just about electric shock. Two levels of protection against any hazards.

What hazards do you need to protect against? Well, you need to protect against reasonable and foreseeable use and misuse. So, what's a reasonable use of the product? Is it consistent with the intended function of the equipment? And is it something the manufacturer could foresee? Now, that foreseeable might be something that the manufacturer didn't foresee when they started selling the product, but as a result of feedback, complaints, products being returned, service calls, it becomes apparent that there's a defect here. Then, that now becomes a foreseeable situation, the manufacturer is legally obliged to deal with those foreseeable issues in its designs, its instructions for the product. So, reasonable foreseeable is a test of, has a product been used properly? Was the act of the user both reasonable and foreseeable? And if it was a reasonable and foreseeable act, then the manufacturer has an obligation to protect against that.

So, let's look at some examples. Now, first of these, it's a domestic clothes iron where customers were cleaning the electric iron while switched on or just after it switched off and were burning themselves, but was this a reasonable and foreseeable thing to do? Whilst it's a foreseeable thing to do, because, you know, people get bits of dirt and stuff on, on an iron, they might want just flick a bit of dirt off or clean it, it's not a reasonable act, because common sense tells us from when we're small children not to touch hot things like the face plate of a clothes iron. In this case, it's not a reasonable thing to do. Common sense prevails. You should not be touching the hot (audio cuts out 01.00.09) in that way. So, the manufacturer of the iron isn't responsible for injuries caused in this way, because it's not an un-, it's not a reasonable act for the consumer to be doing this, even if it's foreseeable by the manufacturer. Now, manufacturers might put something in their instructions to tell you to unplug before cleaning and let it cool down, but their obligations are mitigated by the fact that it's not a reasonable thing (audio cuts out 01.00.35).

The second example, this is a domestic oven where there were cases of serious fires, more than one, and despite warnings in the instructions, users of the oven have been taking out the removable shelves and trays and you can see on this example here, well, this isn't the model that caught fire, there's a tray in the base of the oven just above the floor. They were taking out removable trays and shelves and placing items directly on the oven floor. Quite seasonal, often for Christmas dinner when you buy the turkey it's too big, you cram it in. You have to remove the things, but this was causing fires. So, was this a reasonable and foreseeable thing to do? Well, the oven really should not have caught fire. It's a reasonable thing for customers to expect that, you know, if they overfill the oven, it isn't going to catch fire and burn their (audio cuts out 01.01.33). Was it a foreseeable thing to do? Well, yes, because we all have experience of this. Never mind the faults that are coming back for broken ovens.

Now, in this situation, what the manufacturer hadn't done on this model, was put some form of thermal cutout to protect the overheating. They'd relied on ventilation in the bottom of the oven to keep the heating elements cool and to stop them from melting the wiring and causing fires and they'd assumed that putting something in the instructions that said don't block these vents was adequate. But this is an, an uninformed user that does silly things. You can't mitigate the act of an uninformed user, which is working in a reasonable way, just by writing in the instructions. So, in this case the manufacturer was at fault.

Third example, this is a shock risk. Cylinder vacuum cleaners, where customers have been lifting the device by the cord for staircases. So, pulling it along by the nozzle, as you do, and then when they get to the staircase, instead of picking it up by the handle, were picking it up by the mains flex, which was damaging cables and exposed live wires. So, a potential shock risk. So, in this case, whilst lifting up your vacuum cleaner by the cable is not a sensible thing to do, it's not an unreasonable thing for a consumer to do and it's foreseeable that they would do it. So, in this situation the manufacturer was at fault. So, even though the standard for vacuum cleaners, you know, didn't necessarily require the vacuum cleaner to be hung by its chord, it's something that the manufacturer in their own experience should be expecting their consumers to do and they need to mitigate it, even if it goes above and beyond what is in the technical standard. So, this is why, you know, part of the reason that standards aren't the be all and end all. Just because you comply with a standard, doesn't meet the regulation, regulation, you need to consider all risks and then mitigate those risks using the standard wherever you can, but if the standard doesn't cover a risk and you identified it, you still need to meet it by some other measure. So, those are examples of reasonable and foreseeable. Let's have a quick example of something that's foreseeable but definitely unreasonable. Barry. (Noise from video 01.04.22-01.04.30). 'I don't care mate, yeah? I feel like jumping-,' (Noise from video 01.04.37-01.04.47). Thank you, Barry, and all that goes to prove is you can put all matters of barriers, flashing lights, hooters into a process but it doesn't mean that you are going to prevent unreasonable and stupid things to do. Okay, let's go back to full screen. So, how does this affect principles of designing for safety? Now, this, sort of, inverted triangle will be familiar to people designing machinery. It's called the hierarchy of control, and it's the process you need to do to eliminate hazards in-, with, with equipment.

So, at the top of this you eliminate, so you physically remove the hazard from the design, so you change the design so it does something else. You substitute the hazard, you replace the hazard with a lower risk way of doing things. You take engineering controls, where you isolate people from the hazard, so now we're into safeguarding under those scenarios, which we've talked about already, and then you have administrative controls, so you change the way people work or use the equipment. So, this is instructions and warnings, and then at the bottom you've got PPE, you provide the worker or the person with personal protective equipment so they can use the equipment safely. So, this hierarchy of controls, you can only move down the hierarchy when all of the practical options at the current level of exhausted. So, you start by eliminating, and when you can eliminate no further you substitute. When you can substitute no further, you isolate people from the hazard, so you put-, design in, engineering safeguards. And only when you can't do anymore do you now put administrative controls in. Now, it may be that there are-, you don't need to isolate people from the hazard as greater an extent in an industrial or commercial environment with trained people, and then you perhaps can fall on administrative controls, and then you can give them PPE. You can't assume the same thing in a consumer environment. What you can't do is say, 'Actually, I'm going to use an administrative control instead of an engineering control.'

So, the example of the oven, where the manufacturer of the oven decides to save themselves a few pounds by not installing a thermal cut-out and instead said, 'We'll take the cut-out out, save ourselves a few

pounds, make it easier to make, but we'll just put something in instructions to warn people not to block the vents,' that's not acceptable. So, this design principle here which runs through from the Machinery Directive applies to all product safety. So, engineering controls, equipment safeguards, components, insulation and fire barriers, guarding, instructional safeguards, instructions, warnings, labels and training, and finally personal safeguards like gloves and safety glasses. And you can think of examples from that slide I showed earlier of pieces of equipment, the, the laboratory equipment which had chemicals and moving parts in it. The design should basically be safe with equipment safeguards, and then in terms of adding fluids, taking warnings with chemicals, some sort of warning or labelling would be important, and the last but not least if there's still a risk, perhaps due to the chemicals, poisons, you know, biohazards, you might need to use gloves and safeguards. So, they all have a role but you can't just say, 'Protect against electric shock. Just wear, wear rubber wellies or rubber gloves,' that's not acceptable, you have to design it out first, then instruct it and then provide personal protective equipment. So, let's have a look at hazards in a product. So, we've got a typical product here, we've got a, a laptop computer with a power supply, looking very similar to the power supply that was in my example earlier on actually, which is a bit worrying (audio distorts 01.09.00) .

So firstly, there's an electric shock risk in the power supply. There's a fire risk in the power supply that needs to be mitigated. Within the laptop itself it's not without risk. There's quite a large lithium battery in your laptop. We, we want to have a long battery life, so we've got quite big batteries in there, which is a fire risk. There's a, a radiation risk potentially, albeit very low power Wi-Fi and Bluetooth in that laptop, but certainly could be present and we do need to consider the risk and mitigate that. So, that's an example of hazards and risk assessment. Two levels of protection, normal and abnormal operation, reasonable and foreseeable, the whole range of hazards. That is the Low Voltage Directive's principle summed up, regardless of what standards that you apply. The standards will give you solutions to, how do you demonstrate the power supply's not going to electric-shock you? Well, as I've said, there's a drop test, there's impact tests, there's material tests on the enclosure, there's tests for the effectiveness of screws. There's effectiveness of barriers and insulation. There's protection against overheating, things catching fire, and if they do catch fire, does the fire propagate? It's in the standard. There are tests for batteries, both in the battery standard and in the laptop standard. It tells you how to make the product safe. Then there's radiation requirements there. We'll look at that again in a minute, but let's just, just step aside and look at another aspect of, of, of safety of electrical equipment, functional safety. So, this is a control system that's safety-related, in other words it's using some form of electronic control, or sometimes software, to provide one of those levels of protection.

It's a common concept used in machinery, emergency stops, light curtains, that sort of thing, but it's also used in, in standard electrical equipment. So, a safety-related control system may fail, but it should do so in a safe manner, so it's that two levels of protection again. So, we've seen this in machines but it's becoming more common in things like domestic appliances, so a lot of the times functional safety is, is used to prevent things like hairdryers or curling irons from overheating. It's used to stop you from opening the door of your washing machine while the drum is spinning. Previously that would have been a, a mechanical bio-metallic strip to do that, but these days it can be a software-operated solenoid. So, if we're looking at functional safety, what do we do? Well, there's a couple of standards which are called up

by the Machinery Directive, they're harmonised with it, and that's ISO 13849 dash 1 and 62061, two, two appropriate standards. And the-, for, for switch gear, so the Coordinating Committee for the Associations of Manufacturers of Switchgear (audio cuts out 01.12.27) European group, noted that the existence of these two standards are now very similar in their 2023 and 2021 editions. Which can be confusing as to which one apply, particularly as some machinery standards will call up one or possibly the other, when there is in fact the possibility to use, use either of them. So in fact, the core principles apply between them these days, so it doesn't really matter, but of the two, 13849 is often used as the easier to follow in terms of the safety system (inaudible 01.13.04) and machine builders.

So, in terms of machinery context, 13849, the easier, but if you looked at 16061 you would find very, very similar principles, calculation methods have been used. There's a series of terms here that define what we're looking at. What sort of safety level or performance level are we looking for? What sort of architecture of the circuits do we need to provide the level of safety, and then how do we qualify, prove, validate that those circuits are effective in what, what we're doing? I won't go through these definitions in detail at this point, but we will-, I will use some of these terms as I go forward. So, in the context of machinery, but this could equally be the context of a, a-, of a piece of medical equipment, or a domestic appliance, or a scientific or measurement equipment that was using functional safety, the end user of the product, or in this case the machine builder, performs a safety control assessment, typically using ISO 12100, or it might be in the Machinery Directive Standard, and they identify the risks, allocate the performance level required, which would be the (ph 01.14.29) PLR under ISO 13849. In other words, what level of safety measures are needed, so we're back to risk assessment again, (audio distorts 01.14.40) before, and then the control system design, and this might be the same company if it's an electrical machine, but if it was a control panel for an industrial machine it could be two different groups of people, the control system designer then designs a system architecture with a performance level that meets or exceeds the required level defined by the risks to the machine, and then they validate the designs. So, here's a nice, simple risk assessment model. It's in 13849. It's been used for years and years and years. It helps us define what the, the PLR required level is.

So, if we take an example here where we assess the risk of a-, of a-, of a piece of equipment or machinery and we determine that there's a, a serious risk of injury in this particular example, we then look at the-, so that's a seriousness test. Then we look at all the severity of the injury. Then we look at the frequency of exposure, because it can be a very severe injury but if you're not exposed to it very often the risk is lower. So, frequency of exposure could be long or it could be short. In this case it, it, it was determined to be short. And then you look at the possibility of avoidance, so can the user avoid a hazard? Well, if they can avoid, if it's possible to avoid it, it's obviously lower risk if you can't avoid it, and in this case you end up with a, a required level of C, which is somewhere between the high and low. Low is-, low is A, E is high. And that has direct correlation to SIL. Now, PLRs are used in 13849, SILs are used in functional safety both in 62061 and 61508 standards, so perhaps more familiar with PLCs having a rating for SIL. So, you can read across PLRs and SILs. Now, this scenario here, it's given us a middling, a SIL 1 or a C level. If we were to alter the parameters here, so if we were to go back to our frequency and say, 'Actually, we were going to be exposed to this risk more frequently,' then we would move along the F2 path, and then the F2 P1 would give us D, a higher level of, of safety required and a, a SIL level 2. Equally, if the risk of

avoidance was changed so that if we were on our red path but when we'd got to determine the possibility of avoidance we decided that you couldn't avoid it, then our C would again become a D PLR or a SIL 2. System architecture, these are defined in the standards. There are four or five really, cat B and 1 are, are the same architecture-, cat 2, 3 and 4, all with different levels of protection. So, the basic level, you have an input, you have logic and an output for low or very low risk.

When you go to cat 2 you have some means of testing whether the logic is working properly, and so you have some form of test equipment or test process and an output for that that now enables you to determine that the logic process is working properly. That might be an automatic test or a manual periodic test. When you get higher risk down to cat 3, more complicated systems, you use parallel processes which are interlinked, with the little dot C being cross-monitoring between the logic, so in other words you have two separate channels doing the control function and you might have some sort of cross-checking of one logic to the other to make sure the whole system continues to work. When you get very, very high risk, the category (ph 01.18.30) four architecture, where there's continuous monitoring between the two channels, so you've got a double level of protection built into the, the logic process. Then, you, you can use in 13849 what they call a simplified process, where you look at the architecture that you-, that you-, that you, you, you, you might want to use, or what's available to you. So, if I take an example here, if I take our C, PL C (ph 01.19.00) example that we talked about with the (ph 01.19.02) flowchart before, what this is telling me is that I can't use a cat B design because it's not in the scope, but I could use a cat 1 design if all the components had what they call a high mean time to failure for that assembled system of components. Or, I could go to a cat 2 design, something with some sort of testing, and then I've got a broader range where I could use effectively a less reliable system mitigated by external checking, or I could go to a cat 3 design, a two-channel design, and still meet the requirements with a medium mean time to failure, so where there's a less well-defined system but two channels.

So, you can see the various mitigations give you the same level of protection, and again if you look at the standards you'll find guidance for this as you go through. So, in this next section we're gonna look-, use that IEC 62368 IT (mw 01.20.07) equipment, multimedia equipment standard, of how common LVD hazards can be addressed. Not all the LVD standards follow the exact approach, but the principles I'm gonna talk to you about are the same. So, example of energy source limits, so this is just a summary table really, it's just saying, 'You can define the risks low, medium and high risks depending on voltage levels, current levels.' For electric shock, 'til 30 volts is safe, anything over 60 volts is considered unsafe. Anything under fifteen watts is unlikely to cause a fire. Over 100 watts would do, and then for thermal injury, you're holding a handle, anything less than 48 degrees C is gonna be fine, anything above 58 degrees C is gonna cause you burnage (ph 01.20.55) . So, this builds in from an electric shock viewpoint into how your power supply is built. So, in a power supply, a bit like our mains cable, you've got basic insulation over the hazardous mains part and then a supplementary level of insulation to the invent of a-, in the event of a failure here, you just never get the hazardous voltage on the (mw 01.21.20) . And in this case, the (audio cuts out 01.21.21) double thick, what they call reinforced insulation, in it. So, that's a good example of electric shock. Other power sources, the battery power sources, big batteries are now very common, so we've got that battery there is an e-cycle battery, will provide 36 volts at seven amps continuously, 159 watt-hours of, of, of power, so a huge amount of power built into it.

Old, sort of, little, sort of, flatpack batteries quite used in, in, in electronic products, you know, typically the 1,000 milliamp or the one amp-hour battery at 3.7 volts, fairly innocuous, but the example there with a 10,000 milliamp-hour battery, a 37 watt-hour battery pack, and some of the rechargeable battery packs (inaudible 01.22.21) might have two, three, four or even five of these batteries, so can provide over 100 watts for an hour. That's under normal operation, that's continuous. Under fault conditions they are much, much more likely to provide higher, higher rated currents, and that needs to be considered when batteries are being used, and battery approval's really important as well. You need to know that your battery power source is good and it isn't gonna catch fire spontaneously, so there's UL, Underwriters Laboratories American standards, and IEC standards that apply to batteries. These components are so safety-critical, really we need to have third-party approval on these devices because the risks are so high when you don't have that. We can see those risks in this next video. Barry. (Noise from video, any speech not audible 01.23.31-01.24.30). Thank you, Barry. As you can see and, and hear from that, even though they were doing a test on a battery they were shocked by the-, by, by the, the, the initial explosion, and then the fire extinguisher had to be used because it continued to burn afterwards, and that's just an example of what was a relatively small, small low-power battery by modern standards. So, there's a serious risk associated with that, and if we look at fire injury risks, as I said, anything less than fifteen watts is not likely to cause a hazard but doesn't mean that it won't. There are examples of less than fifteen watts causing problems.

Certainly anything more than 100 watts is likely to cause ignition and cause rapid growth and spread of the fire. So, we need to be really cautious with, with anything over 100 watts, but even at lower levels, particularly with battery-powered products that can sustain energy for, for quite a long time, you know, we need to-, we've got to be careful. So, it's not just mains-powered products anymore, we do need to think about other power sources. Also worth considering when you're thinking about fire risks is about what happens when things catch fire, and the concept of flame cones it quite useful, not used in, in, in other standards, but you, you have a, a point of ignition, the PIS, the point ignition source, and then you can consider, you know, in old money half an inch or two inches, or American money, a half an inch or two inches-, half inch-, half inch radius from the point source and two inches above it is where a flame could potentially go. So, when we're thinking about risks of things catching fire it's, how does it propagate within the equipment and beyond? So, sometimes the flame cone, cone concept can be very useful, so you can afford to have a flame perhaps for a very short space of time but it doesn't actually come into contact with anything that's, that, that's going to propagate the fire. Now, we've said worry about mains, worry about batteries, but it's worth thinking about, you know, USB power sources. Not so long ago, USB, when we were down at USB 2.0, was very, very low power, five volts, 2.5 watts, not going to ignite anything.

Steadily over the years that power delivery's got higher and higher and higher. As we've demanded more from low-voltage power supplies, you know, quite often we, we run lots of things off USB ports, there's a drive towards a DC-, a DC-powered society rather than an AC-powered society. So, not so much mains, lots more DC. Lot-, much more demand, and things like tablets and laptops, computers, a lot of audio-visual equipment, now runs off USB. It, it, it, it won't have a mains port to it, it'll have a USB-C port to it.

You may not even get the USB adapter sent with it in future. But to deal with this, and to deal with the demand for ever-increasing more powerful technology and more powerful chips, the power limits of USB has changed, and the latest USB standards will deliver 100 watts, programmable levels of power output of 100 watts or even more. So, the USB port which you used to be able to consider was safe may not be, it may be sufficient to provide enough energy to cause a fire. So, an interesting change in standards, so something like the, the, the USB mouse I've got on my desk, I assume my laptop is providing low power, so there's very little risk of that catching fire, but at 100 watts there is a potential risk, and it would change the design of the-, of the mouse. This mouse is going to be designed with plastics and very, very-, of a low level of flame retardancy on the plastics, but if I can get 100 watts through it it effectively is a much higher-risk product, and you might need to change the design of the PCBs or the plastics used. So, don't assume that just because it's USB it's not dangerous, just like you shouldn't assume just because it's battery-powered it's not dangerous.

There's more risks for fire caused by non-mains sources than there have ever, ever been. Thermal injury, burns, we did touch a bit on, on earlier on. This is just to give you an example of, of how risks change. If we look at the top line there, handles, knobs and grips which are likely to be touched or worn against the body in normal use for more than a minute, then there's a, an overarching 48 degrees Celsius maximum limit that you're allowed. Now, bearing in mind in some ambient conditions, that's not giving you a lot of temperature rise on it. When you get down to the bottom row, external surfaces that need not be touched to operate the equipment, then you can get away with much higher limits because you're not likely to touch them. So, if you can say, 'I'm not likely to touch this surface, and if I did I'm not likely to fall on it or what have you, then I could go for much, much higher temperatures.' For metal at 70 degrees, it's just at the point where it might burn you, but notice that for glass, plastic and rubber and wood, the thermal conductivity of the material is such that it's not gonna burn you as quickly, and therefore you can sustain higher temperatures. So, we don't have to have everything below 50 Celsius to keep it safe, it all depends on the risk associated with it as to how it's being-, about what the part is and how it's being used. So, standards can help us with these criteria. So, the important thing here to consider with the Low Voltage Directive is the risk assessment. Have you considered all of the risks? Have you considered how those risks impact upon the people who are using the equipment? How those risks are dictated by what the equipment is intended to do?

How those risks are impacted by the environment, the indoor, the outdoor environment where it's being used, and all of those things together come together in determining what you need to protect against, and then points you at the standards you need to use to protect. So, if you are for a domestic appliance, or an appliance that's used by untrained people in an unsupervised environment like in retail or school, then the 60335 series of standards is appropriate for that. If it's instrumentation, measurement or control, or scientific equipment, six-, IEC-, EN 61010 would be the appropriate standard. If it is control gear, EN 60947 might be appropriate, if it's multimedia equipment, EN 62368. So, the standards then tailor the tests and the, the, the qualification criteria to those environments, and help you make the right conclusions. So, whereas the Low Voltage Directive says, 'You shall protect against high temperatures,' when you delve into the standard it gives you much more detail and much more contextual limits to help you prove that you meet that statement of objectives for safety. So, making tomorrow safer than today

quite literally when you're applying the Low Voltage Directive. Okay, do we have any questions on that? Barry?

Moderator: We do, we've, we've got a couple of questions. So, do you want to take them now and then we'll break after that?

Simon: Yes, that's probably a good idea.

Moderator: Okay. So, the first one is, do you not need to also to consider foreseen misuse of a product as part of a risk assessment?

Simon: Well, that's in reason of what I would say was, was, was reasonable and foreseeable use and misuse, so that's normal and abnormal operation. So, abnormal operation is foreseeable misuse on it, so yes, you do, you definitely need to take into account how it might be misused as well as actual conditions of misuse, and that's where the risk assessment comes in. You need to consider all of these things.

Moderator: Okay, and just one more. So, would large batteries such as EV batteries or stationary energy storage systems in houses fall under the Low Voltage Directive, or is there another directive that would apply, so that's large batteries?

Simon: (inaudible 01.34.00) . I mean, they would fall under the-, the-, there would be-, the Battery Directive would apply to the batteries themselves. When they were connected into a pack, you'd have to ask yourself, 'Does it provide an output greater than 50 volts DC?' And if the answer is yes then yeah, I would presume the Low Voltage Directive would apply to that, but yes, no, again, developments in technology. You know, we'd been having that conversation five years ago, that question wouldn't have arisen, but now it's, it's quite common to have battery packs. I have to say, I've got no idea what my battery pack in my-, for my solar panels in the loft outputs, but I'd presume quite a lot more than, than 50 volts DC, certainly by the protection measures of it, it, it, it is, but yeah, yes it would potentially, definitely.

Moderator: Super, and we've just another question, just snuck in there. So, if a product has a Bluetooth connection, does it need to be third party tested?

Simon: We'll cover a little bit of that later on, but not necessarily, no. Not for the EU or UK markets. CE marking it's a defined technology, so you won't necessarily to, retest, but it depends on what you do with the, the Bluetooth module, and what's it's going into, and we will cover that in the fourth presentation. So, thank you for that nice advanced lead in for that.

Moderator: Tee up to what's happening later on.

Simon: Exactly.

Moderator: Perfect, well, Simon, you've had a run of it this morning already, and we've had quite a few questions in, so thank you for that. We'll take a break now, I think, because we're a little behind, but we're still doing okay, so do you want to still take a full fifteen minutes, Simon, and give yourself a-, (talking over each other 01.35.42)

Simon: I, I think so, I, I, I could do with, with a drink just to wet my throat.

Moderator: (talking over each other 01.35.45) not a problem.

Simon: Yes, so if we come back at, what 25 past? Would that be alright?

Moderator: I think that-, yes, I think that sounds absolutely perfect, 25 past, I'll come on a couple of minutes, just to give everybody a heads up.

Simon: Brilliant, thank you very much. See you shortly.

Moderator: Thanks folks. Okay, Simon hopefully the, the correct presentation that's up next, and you should have control of the slides, okay? Just the usual click on the screen, etc.

Simon: Right, so this presentation, we're going to talk about EMC, electromagnetic (audio cuts out 01.36.35). This is again, a, EMC it's a directive in place across the EU, (mw 01.36.47) sure this to work, there we are, relating to electromagnetic compatibility, there is a corresponding UK regulation with, with NI content in that. It's been around for quite a long while, while in a previous incarnation of this one since 2016. Like the Low Voltage Directive, these are the C directives, they do now reflect options for UKCA. For those UKCA options effectively mirror the CE and CE now is allowed anyway. So, we'll just talk about CE, read into that UKCA unless I say otherwise . The other thing to note with the EMC Directive is it has that common framework we talked about, including the technical documentation, so all the things about-, that we have-, we, we thought about at the start, which would have applied to the technical file of the Low Voltage Directive also apply to this. There's also the element of risk which comes into, into EMC Directive in exactly the same way it does for Low Voltage, so you need to consider the, the, you know, the, the who's using it, where it's being used, what's its function, as part of that risk assessment for EMC, as part of your technical file.

So, what does the EMC Directive do? Well, it, it, it literally means electromagnetic compatibility, so it's designed to assess a device's compatibility with its operating environment or emissions and immunity. So, emissions is, the basic rule says the equipment must not interfere with other equipment including radio and telephony equipment with a level set by the relevant standard, (mw 01.38.39) monitored in the UK by Ofcom and in different countries across the EU. So, levels are set, put into standards, which if you keep the amount of unwanted electrical or unintentional emissions, because we're talking here about not radio transmissions but just electrical noise, that the electrical noise emanating from equipment must be kept below certain levels. Those levels are in standards, so there are no levels in the directive at all, it just has these basic principles of, 'You will not interfere or, or be interfered with.' So, in that scenario, you have to refer to standards for those levels.

For immunity, equipment must continue to operate as intended, and you, you determine what intended use is and operation is, under expected interference with the level set by the relevant standard. So, once again, standards are really important with EMC, because they are determining the limits that apply, both in terms of what noise can be emitted from equipment but also how resistant to noise from other sources, other equipment, lightning surges on the mains that come into the piece of equipment itself, so it's a two-fold requirement. It's worth noting that the EMC Directive is unusual in that it has requirements for both emissions and immunity. If you look at the rules in Australia or the United States and Canada, for example, they're only interested in limiting emissions, and presume by default that if the emissions are low enough then immunity isn't affected, but the European rules go a step further and look for immunity as well as emissions.

So, the EMC Directive applies to single functional units supplied, to use a bit of a technical firm-, term, but it, it, it basically means complete equipment rather than part-complete equipment or parts because you-, because they're-, because they're not fully functional and you can't assess or test them for EMC. So, it covers apparatus, electronic modules and plug-in boards, like Raspberry Pi boards. For fixed installations, you don't CE-mark or declaration of conformity, but you apply the same good engineering practice, all of the standards that, that you would for general EMC. For products for self-build or for prototypes, you need to comply with the protection requirements, but the technical file and CE-marking aspects don't apply. So, the important thing is for most apparatus that's ready for non-technical use, for use by the end user, and most modules you would expect the EMC Directive.

We've talked about compatibility, so that's the ability to operate in your environment without negatively affecting the performance of other equipment or being affected by the importance-, performance of other equipment in your environment. So, in a domestic situation where we have a common mains system, you can have televisions, audiovisual equipment plugged into the same supply as motor-driven equipment like, like vacuum cleaners. So, in this situation, we're looking at effective interference, so in this case you could have radiated interference, so radiated emissions from the vacuum cleaner become a potential

source of interference for the TV set. In this case, it's switched the TV on automatically without actually us wanting it (audio distorts 01.42.24), and there's a second type of interference which is conducted, and that's electrical noise going through the common mains supply and interrupting the performance of the processes in the TV set, as shown in the example.

So, how is this interference caused? Well, when we switch on the main-, a mains supply somewhere, we're wanting a nice clean square wave. The reality is you don't get that because we don't-, we, we work in a, a practical world not a theoretical world, so when switches are flicked, power is switched on and off, you don't get a clean zero to 2.30, you get oscillations and spikes and surges caused by inductance, capacitance, general impedance in the apparatus, and you get noisy wave forms. Now, you can argue a lot of that noise is wasted energy, it isn't actually powering the equipment. It's, it's not at the right level, it's not at the right frequency, so it's wasted noise, but that's how interference gets there, it's imperfections in the way that, that equipment and its component parts work cause electronic noise, which, when it gets out of one appliance and affects another, becomes interference.

(mw 01.44.02) the purpose of electromagnetic interference tests and electromagnetic compatibility tests is to ensure that equipment can operate properly and can coexist in their intended electromagnetic environment. This ensures a, a number of things, that they can operate without interference, so we don't want our TV coming on when it shouldn't, and when it is on, we don't-, we want to be able to see the picture. You can see the effect of EMC legislation in the fact that whereas years ago, you know, when a motorbike went past your house your TV picture would wobble, when you switched on, you know, your mobile phone, you could sometimes, again, get (audio distorts 01.44.43) TV, these days, much less so. So, it can operate without interference (audio distorts 01.44.50) comply with regulations and standards, because you don't want too much electromagnetic noise in the environment, and electromagnetic interference, as you-, as we can see, can have safety impacts as well, improves reliability and safety, less wasted energy, less products being switched on when they shouldn't, are compatible with other devices in the environment, so, again, that's the lack of wasted energy, and happier customers. Customers do-, don't want to buy a product and find that it doesn't work properly or it's noisy or it, it-, its performance is, is sporadic because of interference from other appliances. Neither do you want to be switching on your microwave in the kitchen and find that your Wi-Fi at home packs up, so all sorts of things to do with airborne interference that, that we all really want to avoid.

Then there's this issue of safety-related electromagnetic interference. So, within the Machinery Directive we looked at in the last, last presentation, they use safety-critical electronic controls. These need to have functional safety but also need to be immune to EMI to ensure that you can't override the safety function, say, of a remote control for a, a, a, a digging machine or a drill or a lathe or you can't override or interfere with the operations of a safety curtain or a safety switch or a PLC. So, there are requirements in the-, in the Machinery Directive to ensure that safety systems, that safety control systems, are immune to electromagnetic interference, and both common standards include EMI requirements. EN ISO 13849 less specifically, more general guidance, but 62061 has specific requirements. So, 62061 pulls up an IEC

standard, 61000-1-2, and also other standards, 61326-3-1 and also 61000-6-7 for immunity levels for functional safety. These are quite high-level limits which the standard recognises. So, you can design your system architecture, your, your, your common cause of failure, but you also need to think about the risks from a safety perspective of electromagnetic interference. As I said, 13849 doesn't have the same detail, but it does have recommended routes (ph 01.47.39) in the form of an annex. The principles are the same, so when functional safety systems and control systems are present, you need to think about the impact of electromagnetic interference.

Outside the realms of machinery, there are other applications. So, many domestic appliances and medical equipment need to be protected against electromagnetic interference. If you-, for medical equipment there's a specific standard, EN 60601-1-2 for EMI, EMC performance of medical equipment. In this case, the EMI phenomena are key parts of the safety assessment, so in the risk assessment that we talk about, we need to think about EMI and its impact as our risk assessment when we're looking at the safety requirement, so there's a link here. So, electromagnetic compatibility is about equipment operating in its environment, whether it be domestic or industrial. Electromagnetic interference, the EMI concept, kind of impacts the safety.

So, what's EMC testing about? Right, well if you've got equipment under test, in this case we've assumed it's AC-powered, then you need to think about over-the-air and through connected cables situations, and then the slight outlier which is electrostatic discharge directly into the enclosure of the equipment. If we think about over-the-air, we need to think about radiated emissions and radiated immunity, so that's radio, EMC waves leaving the equipment and then being susceptible to those arriving. Then we have conducted emissions, which is harmonic emissions, voltage fluctuations and, and flicker emissions, so in other words the impact, impact upon connected cables, so that's mains cables as well as low-voltage data cables. Then we have conducted immunity, which is the impact of transients and surges, dips and interrupts, other conducted noise coming into the equipment via the mains cord or by other interconnected cables. Then, as I said, last but not least, the effect of electrostatics on the enclosures of equipment, you know, getting into equipment and ceasing (ph 01.50.22) sensitive electronic devices from working properly.

Now, we said before that the directive doesn't give any limits, it just says, 'Shall not be susceptible, shall not emit,' but what limits do you apply? Well, there are different limits to different environments. An industrial environment has more noisy emissions but potentially less sensitive equipment than, say, a medical environment or a domestic environment, so you have different limit levels depending on the application of the product. So, where do you get those from? Standards. So, standards have a real role with EMC because they are the ones where the limits are set. So, we've got IEC here, and the reason I'm talking about IEC is most of the electrotechnology EMC standards are written by-, at international level, and by international I mean the European Union and people in North America, South America, Asia, Australasia, non-EU countries, all involved with the IEC standards writing process, and you can see the framework here for standards writing. That framework for IEC feeds directly into the European Norm

standards. A lot of the European Norm standards we use for CE-marking are-, these days are EN IECs, they're European implementations of IEC standards. So, much of the detailed work for EMC standardisation is actually done at international level rather than just at European level.

So, if we look at the CISPR group, and CISPR are just a standards writing group within, within the IEC, a special committee in the IEC looking at EMC matters, and they help write the standards for emissions test methods, we'll look at some of those shortly, so that would be, for example, the EN or IEC 61000-4-XXX series of standards would be emissions test methods. Then we have the product standards people and the, for example, instrumentation scientific measurement CISPR 11, which in a European context becomes EN 55011, for multimedia equipment CISPR 22 becomes EN 5522, for household equipment CISPR 14 becomes EN 55014-1, so there's a, a direct follow-through here. Then for immunity product standards we have subcommittees 77A, B and C and they're (ph 01.53.20) developing standards for the different operational environments that we-, that we need to, and so you'll find the EN 61000-6 series standards largely covering those areas.

Now, the emissions test range we looked at, it's a wide range, conducted and radiated, and actually the number on the left-hand side is not right, that should be 0.009, 9kHz not 90. At the bottom end, 9kHz all the way up to 6MHz frequency test range, and, and that's across conducted and radiated, with it basically (ph 01.54.13) cut off at around about 30MHz. So, this is a basic test set-up for conducted emissions in this case, where we've got an artificial mains network situated between the equipment or in the mains supply to the equipment in-between the equipment and, and the receiver that's measuring the conducted emissions. What this, this AMN does, it stabilises the impedance feeding into the equipment and allows measurements to be taken without artificially impacting upon the-, upon the results. So, this is a standard conducted emissions test set-up. It varies depending on which emission standards you're applying, but effectively it's the-, it's a standard set-up.

Then there are limits that you would then apply to these conducted emissions tests. Now, this one is taken from EN 5522, I believe, and this is showing two limits, the quasi-peak limit, which is the-, that-, the higher one of the two, and that's a weighted peak measurement which is based upon the repetition rate of those, those peaks, and then you've got the average level, which is average amplitude, so, again, lower levels on here. Now, these limits are for different classifications, so this is the non-industrial limit, what they call class B. So, you have class A industrial limits and class B non-industrial limits, so this is the non-industrial limit on, on this particular chart.

If we superimpose some real-world results on that, then what you can see there, you can see, again, the two-, the two limit lines, the quasi-peak limit being the higher dotted red line, the dotted, sort of, purply line is the-, is the average level, and then you've got recorded emissions levels, conducted emissions levels, there on the trace (ph 01.56.42), so you can see on this particular example it's well, well with-,

within the limit. So, the testing you carry out is designed to get a, a test set-up that is whereby the measurement system is isolated from the equipment you're testing so it's not affecting the results. Then you go through a series of tests depending on its environment. So, if it was-, as I said, this is a class B, non-industrial series of tests and limits, there would be class A limits, perhaps to different standards as well, depending on whether it's, you know, IT equipment or industrial measurement, etc.

So, that's conducted emissions, which is the lower frequency. Once you get to higher frequencies, we're looking at radiated emissions, and in this case there's no direct connection between the receiver, the test and measurement equipment (audio distorts 01.57.36) test. You have a set distance, depending on the standard, between the equipment and the antenna, and generally this test is conducted in a chamber which minimises reflections so that you're actually getting the emission as it's transmitted from the equipment not something that's been bouncing off the walls, and also it eliminates external RF emissions so that in fact all you're measuring is what's coming out of the equipment. So, these, these chambers, EMC chambers, are very, very specialised, very, very expensive, and enable you to make these measurements in a, a, a, a controlled and repeatable manner.

So, like before, we have a, a set of limit lines which are determined by the standards, and there's a bit of a mismatch here. The sort of blue, turqouisey, cyan line at the bottom is the, the line for domestic, I think it is, the domestic line, I can't read my notes on the slide. It's a-, it's a-, the domestic line for IT equipment, whereas the sort of purply, sort of snake-y, Loch Ness monstery type thing, line there, is the limit for industrial measurement and, and test equipment, so different limits depending on what type of equipment that it is. So, here we have a practical example. We have the-, a-, the class-, you have-, have the, the class B line here which is allowing a 40dB limit at the lower end, and you can see in this particular scenario the emissions are exceeding the limit for that particular non-industrial environment.

So, for immunity we've got a different range, in this case 150kHz up to 6MHz with a dividing line at 80MHz for conducted and radiant, radiated emissions, (audio distorts 02.00.24) and because it's immunity, we have to have different, different acceptance criteria. So, in this case, we've got three types of, of criteria. Quite often this is left up to the manufacturer to decide what criteria (audio distorts 02.00.55), sometimes the product standard will say what is acceptable or not. So, these acceptance criteria are not to be confused with the class A, class B industrial and non-industrial applications. So, in the first sense, in acceptance criteria A for continuous interference, in order for it to pass, the apparatus must operate as intended and there's no degradation of performance below the manufacturer's specification. So, you as the manufacturer can say what you set as the specification level, so you might accept flickering of a screen temporarily as being a minimum specification. If it's a piece of medical equipment, you want to make sure that its life-support functions, for example, are always maintained.

Acceptance B, which is for transient interference, a degradation of performance which is within the

allowed performance level but with no unintended change of operating state or stored data, so you can't get a mains spike that suddenly makes the equipment malfunction or forget, you know, lose data, etc. Then, C, which is for manual, anything for manual operation where there's a temporary loss of function which could be manually reset. So, these criteria occur in, in, in, in (audio distorts 02.02.13) give you guidance as to how you can determine a pass/fail criteria. So, just because a product is susceptible to interference doesn't mean it fails, it just determines what acceptance criteria are applied.

When we look at radiated immunity, that's almost the reverse of radiated emissions, where you're firing set levels of radiation. Again, radiation levels are determined by whether it's an industrial environment, a non-industrial environment, whether it's for domestic or scientific or multimedia-type applications. The limits, again, come from the standard, the test set-ups are detailed in those-, in those standards or in some of those subset 61000 series standards, but the principle is the same. For conducted immunity, a similar sort of thing. You've got an interference generator that goes through a coupling, decoupling network that allows you to power the equipment and then you can feed some of these transient immunity effects into the product. So, you can get surges which can come through the, the main supply, electrostatic discharge caused by people touching equipment when they've been, been charged up, or you can get things like fast transients, bursts coming in through signal and control cables.

Depending on what standard and what environment you are-, industrial environment you're operating, or non-industrial environment you're operating in, will determine what levels and what, what tests are applicable to you. So, for example, ESD would be governed by the EN 61000-4-2, voltages and surges by EN 61000-4-5 and fast bursts and transients by-, perhaps (ph 02.04.19) by 61000-4-4, but your-, effectively your location standard, what EMC environment you're working in, will determine the sub-standards that you-, that you need to apply. Then, just to give you some examples of what ESD wave forms look like, so ESD spikes, you know, bursts of-, and fast transients, which are little bursts of pulses coming down, you know, communications cables, for example, and then mains surges with different, sort of, rise times on that, so your product needs to be designed to all of these things. Immunity is very complicated and, and-, so the rules for CE are, you know, are quite demanding, say, compared to, as I said, in the US, where they don't bother with immunity so you don't have to bother with all of these things, you just need to make sure that every product is low-emitting.

So, testing problems. Okay, so there's, there's-, we've said that a lot depends on standards, but standards do change quite regularly. They also give little to no help to enable design to compliance, it literally sets a test, tells you how to set the equipment up, what equipment, what test environment, test chambers you need to do (ph 02.05.48), how to perform the test, it doesn't really help with, with design for compliance, or, more importantly, when things go wrong at the end. It needs calibrated, specialist equipment which is often very expensive and it-, to produce that stable environment and give you reliable and consistent (audio distorts 02.06.07). Unless you're-, you do these tests in the-, in the required way, it's very difficult to get (audio distorts 02.06.14) and hence EMC testing is expensive (audio distorts 02.06.20). It's also true that all-, nearly all newly-designed products fail the EMC test when they go for pre-compliance

testing. Things need to be done to bring them into compliance, so even with best endeavours there's always some tweaking because of the complexity of EMC design. Even when they do market surveys of CE mark products, failure rate of about 30%, which is very high, is, is, is often found when market surveys are done. So, it just demonstrates how difficult it is, not only to get things to comply in the first place, but also changes of components, minor changes of design, can make you non-compliant relatively easily. When you do get into that situation, non-compliances can be simple as a, you know, half a day re-test, addition of some ferrites, some capacitors, some inductors, it could cost you less than £1 to the (audio cuts out 02.07.22). On the other hand, it may need months of testing, total redesign, changes over to multi-layer PCBs, additional filtering, software fixes, compromises and sacrifices to the performance of the product in order to get it through the-, through the testing and to get a compliance report.

So, there are some things that you can do. I mean, certainly in terms of PCB layout it's important to understand the relevant EMC tests and (audio distorts 02.07.58) re-test to understand what levels are going to be applied, what tests are going to apply to you. So, that's about looking at risks, it's looking at the EMC environment you're going to be working in, and the standards that are going to be applied to you. Follow the principles of filter shield in ground, so, you know, filter what you can, shield where you need to, and, and make sure that, that you make good use of, of, of, of, of ground plays and grounding points to to avoid some of the more obvious hazards. If you've got complicated PCBs, use multi-layer layout, and you'll see those designs where, you know, you, you, you, you, you (audio distorts 02.08.42-02.08.49). Where you use-, you're doing fast switching using MOSFETs you can-, you can limit the, the current perhaps into the MOSFET drivers, but you also can think of the design of your leads and traces to reduce parasitic capacitors and inductors, which causes-, which can be, be a cause of, of ringing.

Don't allow different analogue and digital grounds, because then you can end up with, with unfortunate loops, and then use, you know, generous use of surface mount ferrites, because they'll remove, you know, high frequency noise over a broad range. So, it will catch things that have got into your circuit, either from the outside, or things that you're generating yourself and, and eliminate them before they begin causing you problems and permeate through the rest of the, the (audio cuts out 02.09.47-02.09.54). Segregate noisy and sensitive circuits, that's fairly obvious, ensure that power supplies are not (audio distorts 02.09.59). Again, it's good grounding, good physical separation and shielding of noisy parts from, from sensitive parts. Decouple everything with, with capacitors, particularly, you know, across power rails, don't leave processor pins unterminated, always terminate them, minimise ground, ground use, use vias wherever possible and PCBs to connect directly to the ground play, rather than creating wire or (inaudible 02.10.33) . At the front end, to avoid surge and transient, fit surge and transient absorbers, so you will-, you, you will catch the incoming surges and spikes before they get into your equipment.

If you're making control panels, there are some simple guidelines here. Use zinc-plated backplates. If they're painted then you need to remove the paint around the mounting holes, or use serrated washers. It's a common problem where people prefer nice colour-coded backplates, and then they lose the benefit of the ability to, to earth against that back (audio cuts out 02.11.13). If you're a control panel designer, make

sure that you've documented any EMC assumptions for the people connecting the wiring into the-, into the equipment, and also the people wiring the panels up. You don't want wires, you know, great long loops, you want short runs, etc. So, in your panel design, specify the wiring routing. Don't just leave it up to the assembler to do it their way. Make sure earthing wires connect to the shortest possible, 360 coverage is when, when, when you're bringing those earthing wires and earthing braids into a termination, don't use pigtails.

Thinking about enclosures, an enclosure may not be EMC, you know, tight. It has gaps and insulating seals, and so electromagnetic waves can get through those, so unless it's a full EMC-proven cabinet with, with appropriate measures, you, you're going to get leakage, in which case you may need to specify (audio cuts out 02.12.24). Then even if you do that, you need to think about EMC-compliant glands, otherwise you'll just let things in through those, those other routes. Earth screen cables for optimum EMC performance, (audio cuts out 02.12.39-02.12.45). Last of all, segregate interference sources from susceptible equipment. Route their cables so as much physical separation as possible, with cables crossing at right angles to minimise coupling, fit mains filters and ferrites to cables. You know, earthing is really, really important, particularly with inverters, to make sure you're not letting interference pass through the-, through the equipment. Good communication between the control panel design and the panel installer, to make sure that all the measures that you're putting in your control panel design aren't undone by the installer when they put that into the-, when they (audio cuts out 02.13.32) site or to the machine.

So, common problems with applying EMC directive. People fall into the trap that a CE mark part with another CE part, mark part, automatically gives you a CE mark part. That isn't always true. You need to think of the thing as an-, as an entire system. Remember that wires act like aerials, especially if they're not shielded and connected at both ends, so you can create, you know, many sources of interference within products. Theoretical capacitors on capacitors and inductors don't exist. Capacitors have inductors, inductors have capacitors. Everything resonates at some frequency, and so the presence of frequencies in your equipment, coming into the equipment or generated within it, will have EMC effects. You can't get away from it, so don't assume perfection. Look for potential issues and minimise where you possibly (audio cuts out 02.14.37). The CE plus CE equals CE fallacy is very well-demonstrated by anybody who's bought a CE-approved power supply, where they often fail conducting and radiating emissions on the bench, never mind in end applications. You get quite a lot of caveats perhaps in some of the documentation that effectively says, 'We've only done these tests,' you have to do more tests in application.

So, be aware that they won't automatically comply, and will need to be assessed for end application. Having said that, resist the urge to design, design your own switch mode power supplies, because you'll end up with a whole heap of additional pain from that. It's better to take an off-the-shelf one and take additional measures, or find one that's suitably compliant, rather than going through the, the pain of a-, of, of a full design. The plastic cases do not solve all ESD problems. Screws, for example, can allow an ESD electrostatic strike to enter the product. Metal cases do not solve all radiating problems, unless it's a full

Faraday cage. A lot of that will depend on the frequencies that you're using, and think about EMC and LVD design complex. Sticking lots of extra capacitance or filters may sort out your EMC, but it may end up with, say, earth leakage, current problems, undermine your safety compliance. So, real-world EMC testing.

Important to say that testing under the EMC directive is not mandatory, it doesn't mention standards, never mind testing, but the implementation of the directive means that some way of-, you must be able to demonstrate compliance, and as the limits are in standards, you need some way of showing that those requirements in those standards have been met. How much testing you do depend on the complexity of the technology involved in the product. While it shouldn't do, the reality is company size and market share, it's risk, isn't it? It's financial risk of non-conformity and risk to reputation. Those things will come into account. It is a reality, the larger you are and the more complex the product, the greater risk that you are at prosecution for, for non-conformity. Your customers are also going to be less forgiving as well, and we, you know, we go back to the, the, the first slide in, in this set, where we talked about customer satisfaction. So, your risk assessment needs to identify the risks, and then your mitigations need to be suitable for that process.

At some point you're going to have to collect some test data in order to validate that your product is compliant. If you do no testing at all it's very difficult to be able to fill in your technical file and say, 'I've met all these requirements.' Certainly, if you've done no testing you shouldn't be listing standards on your declaration conformity, which applies that you have tested to those products. The highest risk is if you do nothing, if there's no testing or technical evidence, and therefore no proof of compliance with your file, so you're going to need something. Now, that might be data from your suppliers, it might be data from your component manufacturers, it might be getting a technical opinion from an expert. It might be based on similarity of existing products that you-, that, that you-, that, that you have. All of these things come together to help you, you know, compile a, a file that's, that's got meaningful, meaningful use. Okay, so that's a very brief introduction to EMC. We've tried to cover a lot of ground there. Barry, any questions?

Moderator: Yes, so have one question, and it's asking does a consumer unit or a fuse box require to be EMC tested?

Simon: Good question. The, the box itself is, is probably not a functional device until it's actually, sort of, wired up and connected. The MCBs in it are more critical, so they would probably need something in them to, to show that they have some sort of-, at least some sort of immunity to it, but no, a consumer unit I would say probably is an installation, falls into the category of that. It's not a-, it's not a product per se that you would plug into. It probably comes under installation rules, so there would need to be some measures taken, but I'm not sure the EMC directive applies to it. Good question. I'll, I will ask that and follow up on that.

Moderator: Super. That's the only question we've had in, but there is opportunity later on if you want to submit any more questions just using the question panel on the, the right-hand side in the 'go to webinar panel', but other than that, Simon, that's your next set of slides up, and again, just click on the screen, that should be US control.

Simon: Okay, thank you. Okay, so this one is looking at radio compliance, so radio compliance, very similar to, to EMC in some extent, and we're looking at airborne radio waves, but in this case, whereas EMC is unintentional emissions and dealing with those, radio compliance is about intentional radiated emissions, where you are deliberately sending waves or receiving waves for communication purposes. The radio equipment directive is covered by-, is 2014/53/EU, so, and again, just like the EMC Directive and the Low Voltage Directive has a, a UK statutory implement, instrument in there with variants for Northern Ireland as appropriate. The radio equipment directive's, sort of, part of telecommunication safety. It's about protecting the infrastructure, it's about making sure that when you use your mobile phone you can make a call from A to B, that the emergency services radios will always function correctly when they're-, when, when they-, when they need to. With a range of different communication technologies these days, it's a, you know, that, that's quite a, the-, quite a task.

There's also a plethora of radio devices now, so you can ask yourself, 'When does the radio equipment directive apply to a product?' An example here, we've got a, a, a, a, a tool. Well, it only applies when there's radio function within the product. Now, but why you'd have any of these functions in a panel (audio cuts out 02.22.13), but you could. As soon as you put one of these radio technologies, even low-power radio technologies, into a device and you give it radio function, transmitters, receivers or transceivers (audio cuts out 02.22.28) frequency up to three megahertz. Does it have communication and determination functions, or is it-, is it an intentional transmitter and receiver? So, is it a radio or a radio-, or a product with a radio function inside of it? Well, according to the directive and the UK regulation, it is radio equipment. As soon as you put a radio function within a product, it, it becomes radio equipment, and therefore falls in the scope of the radio equipment (audio distorts 02.23.06).

So, if it's an electrical appliance covered by the low voltage directive, then as soon as you put a radio in it, it no longer falls within the LVD, it forms, falls within the radio equipment directive. Similarly, its EMC requirements no longer come under the EMC directive. They come under the radio equipment directive, because the radio equipment covers a multitude of sins. So, the original directive, article three, has requirements for health and safety, which as we saw in the first presentation, is related to the low voltage directive, but without voltage limits. It has EMC requirements to make sure that it isn't generating or susceptible to unintentional radiation in the environment, but also the intentional radiation, the communications technology can't cause products to malfunction from an EMC perspective either. There are specific requirements to that in RED, and then last but not least, there's the radio spectrum, so making sure that actually, you know, we're not-, our radio devices aren't interfering with, you know, other channels, so domestic cellphones don't interrupt with, with police channels or emergency services.

So, the originally-, the, the radio equipment directive just had these three parts (audio cuts out 02.24.34). Subsequently, the, there are additional article three additions to this, so interoperability, articles 3(a), 3(b) and 3(c), cybersecurity, articles 3.3(d), (e) and (f), that's coming in in August 2025, and again, cybersecurity is a big issue, not just in terms of radio equipment, but all equipment generally, and then a, sort of, catch-all, articles 3(g), 3(h) and 3(i), which cover other things yet to be specified. Then last but not least, we now have a new article 3.4 coming in in December of this year for common charges for radios. We, we, almost everybody will have seen in the press Apple being resistant to using a common charger, and wanting to continue to use its bespoke lightning connection rather than a USB-C connection. So, the radio equipment directive's gone from a very simple set of three requirements to much more complicated requirements as we go forward. Just a note on the common charger that that doesn't-, you know, an exemption for laptops until 2026 (ph 02.26.01).

So, how do you meet the RED? Okay, well, there's three methodologies, internal production control, self-declaration, type examination by a notified body, or full quality assurance at the factory, also by a notified body. So, but if you have a harmonised standard and you apply it in full, then you can have a choice of which one of these you apply. Now, obviously the internal production control is the-, is all within your remit, because it's self-declaration. You can apply any one of those if, if you wish, it's your choice. Most people go for internal production control. If there isn't a harmonised standard, you're not allowed to do internal (audio cuts out 02.26.45) and you have to go for type examination. So, there's lots of product-specific standards for radio equipment, and so most products fall into the green category there rather than the RED. What does that mean? Well, it's all leads to a CE mark or a UKCA mark, but if you need to use a notified body, which you do for either type examination or for quality assurance, then you need to add the notified body number (audio distorts 02.27.16) one number after the, the CE-, the CE mark under those circumstances.

So, a range of requirements, but this is one of the directives where they consider products which don't have a designated or harmonised standard to be a risk to the spectrum, the radio spectrum, and hence manufacturers can't self-declare, they need to use a notified body to determine compliance. That also stops people from producing devices with the wrong-, the wrong frequency balance. So, if we look at the assessment, patterns between radio equipment regulation for UKCA and EU RED, (audio distorts 02.28.09) technology, harmonised standards and designated standards are the same, notified bodies and approved bodies are the same, but article 3.3 does not apply in the United Kingdom, or in Great Britain. It will apply in Northern Ireland, because if, if you're following CE route, and RED article 3.4 for common charges doesn't yet apply. So, there's a divergence between the UK and the EU. However, if you meet the requirements for CE marking for radio equipment directive, that CE mark is valid also for the United Kingdom.

So, you are doing more things for Europe than you are the UK, so I think back to the original slide, de factor CE will cover you for the requirements that you need to apply. Obviously for the whole of the UK market we, we can use slightly different frequencies to the rest of the EU, so we always need to make

sure that the, the, the frequencies that radio equipment operates in is acceptable in the-, in the marketplace. So, the question we've asked about standards of testing, do I need to test radios? Most likely, again, not mandated, but most do test as the best way to prove (audio cuts out 02.29.31), and as I've said, there's those standards available to you to enable you to prove conformity. There are lots and lots of them for different products, so for example, EN 301 489-5-2 for cellular equipment, 301422-1 for wireless mics, so there's a standard for everything. The good news with ETSI EN standards is they're free for anybody to download, so I'm not sure how helpful that is, at least you don't have to pay for the privilege of checking out what the rules of compliance are.

So, testing for radio compliance, the transmitter tests, we're looking for power and frequency levels to determine whether our product is transmitting within appropriate band. The bands are specified by regulation. Within those bands you're going to get different channels. Those channels need to be distinct and separate. They shouldn't be overlapping, they should have the correct power levels, they should be the right bandwidth, and when you get to the end of the band it should not overlap into adjacent bands, causing spurious emissions. So, it's about making sure that the intentional transmission falls within the scope as specified by this regulator and the standards. Then what you get is patterns of radio frequency emissions that look something like this, with intentional transmission frequencies that can be clearly seen when measured. So, receiver tests, so receivers, you have to have a transmitter, what you're aiming to do is to say, 'When I transmit, does anybody receive what I say?'

If I haven't got enough power in the device, or my transmission parameters that we saw on the earlier slide aren't correct, then the receiver may not receive it because it may not recognise the signal. If I make the signal stronger and I make sure that it-, that, that it-, it performs to the specification, and the radio receiver is tuned to receive that specification of transmitted wave, at the right power levels, communication is complete. So, that's the intent of a communication device. There's also some radio compatibility. Radios of one particular manufacturer are seldom used in isolation. Others will be around them, so you need to make sure that the emissions from one radio device doesn't adversely affect the transmissions of another device, and I think everybody continues to work without interfering with adjacent (audio cuts out 02.32.40). When you're doing receiver testing, so something like a, a, a Wi-Fi router, then you need some way of making the, the, the, the measurement, so you're connecting to the receiver to, to be able to inject appropriate frequencies, simulation of the-, of the radio waves.

Then you're going to need something to be able to say, 'Did I receive the message or not?' so some sort of communications device. So, relatively easy with a Wi-Fi router to connect to an external port. There'll almost certainly be a port available to it, some sort of tweaking to enable you to apply the, the radio frequency to the device in a controlled manner. More difficult when you've got tiny devices like Wi-Fi or Bluetooth-enabled peering devices for mobile phones and such like. Very difficult to make the power connection, the connection to the monitoring device, and some way of injecting the wave form into it whilst, sort of, maintaining the integrity of the product, so it's not always as easy as it looks. That's important because it's a wireless world that we live in. We want more wireless devices, we want more

Internet of Things, more machine-to-machine technology. The manufacturer of the Internet of Things aren't always radio experts, so it's a big challenge as to, 'How do we connect our non-wireless products wirelessly?' even if it's the silly power drill at the start.

So, one of the solutions available is radio modules, which are produced by radio experts, and then the equipment manufacturer then installs the module and creates a, a wireless device. So, an example would be a washing machine, not a radio device, manufacturer decides that they want to have some sort of a wireless capability, perhaps to enable you to set the start and finish times of the device remotely, check the progress of your washing. As soon as you've put that radio module in the product, it now becomes a radio product, like the power drill at the start, this washing machine now has changed from being a low voltage directive and EMC product to a radio equipment directive incorporating safety in EMC within the requirements of that (audio cuts out 02.35.19). Now, as we said before though, it's not sufficient to CE mark the, our washing machine on the basis that the radio module also came with an, an approval.

Life is not that simple, and if we look at ETSI guide 203 367 on modules it says, 'If the conditions in which the radio product is used in combined equipment deviate from the assessment conditions, then the manufacturer should reassess the combined equipment in compliance with article two,' so the radio spectrum bits. It's noting this isn't just a European thing. Similar rules apply for overseas markets like US. So, a third-party module may introduce a number of things. It may be subject to resonance on, you know, unwanted frequencies resonating on PCB tracks within the host, so it's fine when it's on its own or when it was in a PC, but if you take it out of a PC and stick it in a washing machine, all sorts of different criteria. You can get reflections of fundamental or unwanted emissions, which, which impacts power and field strength levels. You can introduce shielding, whereby you block the receiver, so the receiver, because it's in a metal-, earth metal washing machine can't receive the, the incoming signals, and you could get a noisy host.

Putting a, the radio module in something like a microwave oven, which, which is using radio frequency as a heating element, you know, can be quite a noisy device. What does that mean? Well, if we look at the original radio module, and, you know, lots of radio module manufacturers will give you these traces or give you details to enable you to make some decisions on it. (Audio distorts 02.37.21) get nice, clean trace on the radio, if you install it in a host product, you could end up with all sorts of, of, of noise or different emissions appearing. So, in this case, it's demonstrating unwanted resonating frequencies, which aren't compliant, it's got reflections causing increased field strength of unwanted emissions, and in this case shielding is lowering the power of the transmitter in this particular case as well. So, it's going to be more difficult for it to transmit from your washing machine to your Wi-Fi router into your control system or whatever you're, you're trying to do with it. What you're looking for is a pattern like this, where there's no significant difference in radio emission level when used in a host.

Now, unfortunately, it's going to be very difficult to determine whether you're this scenario or one of the interfered scenarios without making some measurements. So, you need data from the-, from the, the, the module manufacturer, and then you need to find some way of validating that in your appliance, otherwise you will end up with poor performance issues. There's also issues when you get multi-transmitter products. Mobile phones are classic examples of multiple radio transmitters exist in the product, and you need to consider the effect of intermodulation, so in other words, the effect of each of these radios on each other within the appliance, unless of course you can only use one of these at a time. In a mobile phone that isn't the case. We quite often use Wi-Fi (audio distorts 02.39.07) NFC cellular simultaneously. So, when you've got multiple radios in products it becomes more complicated as to how you install those. The key criteria in this case is you need to think about the transmitter plus the receiver plus any transceivers.

All radios must be reviewed, even not-, even if not to all of the RED articles. So, again, it's about compatibility, so it may be that your compatibility is just about (audio distorts 02.39.44). So, radio modules, they're great, really good solutions, particularly if you're not a radio expert, but you need to consider about how you authorise use of that module in your product to maintain compliance with the-, with the direct (audio cuts out 02.40.02). The final product must meet all those, those requirements. If you're the manufacturer of the final product, the washing machine or the power tool in the examples I've used today, and signing the declaration of conformity, then you're taking responsibility for the compliance. The radio module manufacturer has no liability there. This is down to you. So, it adds to the complexity. So, CE mark is essential, 'cause at least you know that it, it was fully compliant before it started, but the module manufacturer will usually not know the end installation. Sometimes the module will have been tested in a specific application like (audio cuts out 02.40.47) and that doesn't necessarily mean it transfers to a control panel or (audio cuts out 02.40.52) or to some scientific measuring equipment.

So, the module test results are important to the installer, and knowing how those test results were taken will help make a decision as to how much validation testing you need. So, the CE mark is less important to you as an installer. What's more important is that you have access to the test results, so you can see-, you've got a starting point to compare what the module's compliance level is to what it's going to be compliant in your product. If you're lucky, you get a CE mark product with lots of test results, and you can validate that there's no impact by placing it in your product, you've got an ideal world. So, common mistakes in RED. Inconsistency of information and the way that the product, you know, product specification (audio distorts 02.41.46), incorrect results because measurements aren't taken properly, or, you know, appropriate risks haven't been followed. Missing testing, because, you know, that intermodulation, the, the, the effect of one transmitter over another has to be considered.

An assumption that the module manufacturer will continue to take responsibility, even when the module is installed in the product, remembering the product manufacturer, the end use manufacturer, has the responsibility. Document (inaudible 02.42.23) , like with all CE directives on the-, on the (audio distorts 02.42.26) conformity. More importantly is, is an incomplete risk assessment, where the risk assessment

has not been-, not taken into, into account the operating environment and the essential fact (audio cuts out 02.42.39). The option of not using a notified body to interpret results instead of ploughing on with lots of testing, testing is not necessarily required. You can use a notified body in lieu of testing to assess what you've been given to give you an opinion, which you can put in your file. So, notified bodies serve a purpose. Sometimes using a notified body can be more effective than, than going through lots and lots of testing, and also ignoring difficult issues, you know, ignoring the wolf and just closing your eyes, not testing things to their full (mw 02.43.18).

So, before we finish on RED, let's just touch on one of the hot topics of cybersecurity. So, cybersecurity is relatively new, and there are lots of factors to look at. So, for EU markets, articles 3.3(d), (e) and (f) are applicable. There's the EU Cyber Resilience Act, which has just come into force, and will-, you know, sometime in 2027 will be fully enacted. There's already within the UK, the UK Product Security and Telecommunications Infrastructure regime or PSTI, which is already in force, and due to the speed of the introduction of these, many aspects are not fully clear. Many people don't really have a good understanding of cybersecurity. It's all a bit mythical, and I'm partly in that camp. I understand bits of it, but I don't profess to know the detail of it. So, a lot of those requirements are very complicated and not fully clear, there are standards, some standards available, but how you apply them aren't necessarily fully clear.

Actually, for once, the UK PSTI regulations are, are, are actually quite good, 'cause they're, they're too the point and simple, so we'll come to that a bit later (audio cuts out 02.44.37). Is testing required for the cybersecurity things? Likely to be required. It's going to be difficult to prove compliance with all these regulations without actually saying, 'Well, I have tested the resilience of my equipment to hacking, I've tested the resilience of my equipment (audio cuts out 02.44.57) interference of transmitted waves (audio cuts out 02.45.02).' When we look at RED, articles 3.3(d), e and f, they cover protection of the network, which obviously the, the infrastructure's important, protection of personal data and privacy, you don't want people being able to hack the hardware, the software, or break into the transmitted encrypted signal and steal personal data or financial data, which is the latter one, protection of frauds from cybersecurity. So, really, really important aspects that are in the-, in RED. Note that not all article parts apply to all products, because not all products have personal data in them, not all products have the ability for fraud. So, not all things apply to all products. All of these articles come into force on 1st August next year and there is a new EN 18030 series of standards developed so that manufacturers can demonstrate compliance. Now, these standards are only newly out so there's still a lot of knowledge developing on how to apply the rules and the standards. So, very, very short times to get your head around this and work out what you're supposed to be doing for radio equipment manufacturers, and it, it certainly isn't easy.

Cyber Resilience Act, approved by the European Parliament and now, actually, approved by, to be enacted in, in 2027. And, it introduces requirements for products with digital elements. So, anything that's connected within the home, so cameras, fridges, TVs, toys, need to be safe and resilient to cyber attacks. So, the new regulation (mw 02.47.09) makes the existing legislative framework more coherent, it places obligations on manufacturers and throughout the supply chain through the life-cycle of the product which is really good if you're a consumer of these products. (audio cuts out 02.47.26) will come in effect in

2025, well actually it will be (audio distorts 02.47.37) . But, we need to work out how to apply these things. Now the Cyber Resilience Act is likely to have notified bodies in it, (audio cuts out 02.47.53) to help determine criteria, but how you comply is something that's going to have to be developed as we go along. So, the principle is good but the practice, there isn't the same defined routes we have for radio spectrum or for safety EMC, just at this moment in time. So, if you're confused about cyber security, you're probably in the same place as many others. You've just got to attend a lot of conferences, follow a lot of what is going on in the technical press, and keep yourself up to speed.

Last but not least, the PSTI is talking about consumer connectable products, such as smart TVs, cameras, speakers, it wants to make them more secure against attacks. And, these rules came into effect for the UK from 29th April. And, it basically says you can't have default passwords, or easy guess passwords on equipment when it's shipped so it can't be 1, 2, 3, 4, on every single product. Products must allow those outside the company to report vulnerabilities of products and publish information about this reporting process. So, if you are subject to a cyber attack on the equipment, the manufacturer of that equipment needs to give you some way of reporting that so that they can do something about it. And they also need to provide security updates for their products and that (inaudible 02.49.16) how long they're going to do that needs to be available in the public domain. So, when you buy a product, you should know how long the manufacturer is going to continue supporting to keep it cyber resilient. It's not a great long piece of legislation and actually compliance can be based upon a few clauses of a commonly used standard for cyber security ETSI 303645 which is available free of charge from the ETSI website, I would note. So, in terms of meeting the requirements for the UK, you can use that standard. Many other countries outside the EU including Australia also use that standard. So, that ETSI standard is a good basis, a good introduction, gateway into cyber security. You'll find common elements of that in the 18030 series, as well, although it's not the same, there's more in the 18030 series than there is in the ETSI series. So, a good starting point is to meet the UK PSTI and if you are selling into the the UK market you need to be meeting that requirement already. Red requirements remain the equipment (ph 02.50.26) end of from August next year. And then, broader European requirements from 2027.

So, this flowchart which is very complicated to go through as we're doing now but when you get the slide deck it will give you some routes through how do you get through the red, when does the CRA apply, when does the PSTI apply, so start-from-start and you'll end up down in the bottom right at the end having determined which of those three sets of regulations you need to meet and then at least you've got a starting point from that. So, red compliance process, quite complicated, more complicated than it has been in recent years with the addition of interoperability cyber security and common charges. (audio cuts out 02.51.21) you need to evaluate your risks of all of these things against the directive and then determine your mitigations. So, as we said before, first document you open, use it like an assessment plan at that stage having done the, identified the risks, what do you need to test, what do you need to assess (audio distorts 02.51.40). It helps you form your test decisions and it helps you (audio distorts 02.51.47) choices and then you go round that loop again as your products change, as the regulations change, to make sure you keep yourself up-to-date. So, that's the end of red. Any questions there, Barry?

Moderator: Yes, we have one question in which says, what do machinery manufacturers need to implement on their machines for NIS2?

Simon: I don't know what that means. So, I'll have to have a look at that one.

Moderator: That's no problem. Next question that's just popped in here, is 3rd party assessment needed for all RED products?

Simon: No, 3rd party assessment is not required. The simplest option if you use harmonised standards, is to apply the standard. You don't need to do 3rd party, you can test it yourself if you've got the ability to do it. So, no you don't need, there's no mandatory 3rd party if you use harmonised standards. If you're using non-harmonised standards then, yes, you do need to use a 3rd party under those circumstances.

Moderator: Super. That is all the questions we've had in. We have one more opportunity for questions at the end of this final session but that should be your session 5 slides up, Simon, so I'll hand it back over to you.

Simon: Yes. Right, we will quickly go through this aspect, it's relatively short. So, these are protection of environment and human health. Three sets of rules, regulations, that apply, that's RoHS, REACH, WEE, all share a similar objective which is to protect the environment and human health, or users and anyone in the supply chain. So, these are overlapping rules that apply to us to some extent or another if we're in the design and manufacture of electrical equipment that's subject to the CE mark. So, if we start of with RoHS. RoHS directive restricts the use of toxic materials in electrical and electronic equipment. And, the intended (ph 02.54.13) here is to keep hazardous materials from accumulating in the environment after EE (ph 02.54.17) is thrown out. So, the idea is you don't put hazardous materials in at the start and therefore you've got less problems when it comes to end-of-life. So, RoHS is mainly aimed at the management of finished products but at the production stage. So, it's a manufacturing issue. So, what does RoHS do? Well, it restricts certain substances to generally to less than 0.1%, actually 0.01% in the case of cadmium, by weight of product.And there's a list of materials, the original ones lead, mercury, cadmium, hexavalent chromium, polybrominated biphenyls, polybrominated diphenyl ethers were the original set and they were joined more recently by the phthalate series on there. Now, the phthalates are sort of rubber and soft material things so they're quite common used but there are restrictions now in when you can use those. RoHS applies to a whole range of electrical and electronic equipment including the list there of household appliances, IT, medical devices, control instrumentation, tools, leisure and sports equipment.

And then, last but not least, the category of other EE (ph 02.55.50) not covered by any of the categories above. So, in other words, everything. So, it's a very broad reaching regulation but there are some exceptions. So, there's a list here, military equipment unless it's intended, if it's intended exclusive for military use, space equipment, all the way down means of transport, and batteries which is the one which people get confused with because they are covered by their own battery directive which has these requirements, similar requirements in it. So, otherwise, most equipment that we're talking about would fall under this scope. So, your obligation under RoHS, all manufacturers of equipment have to monitor control the use of restrictive materials in their EE (ph 02.56.35), compliance with the directive is made by retaining technical documentation on materials and bought-in parts. This has been around for a while in various forms, there's lots of documentation available. If you can't get the documentation and you can't

test materials, and there are options to do that. And most significantly for this, RoHS is part of the CE market so when you make your declaration of conformity for electrical equipment in addition to low voltage, EMC, machinery, radio, RoHS is likely to be required. Now, (audio cuts out 02.57.18) standards available and one of the most common is the IEC (audio distorts 02.57.27) and the IEC 63000 series which allowed you to perform tests on products. And, I have had examples of people actually testing, taking a whole product, taken it apart bit by bit, and testing each individual part because it wasn't really designed to meet RoHS requirements and it was only done almost after the event, so the standards quite affected (ph 02.57.49) doing that. So, RoHS in the UK and the EU, the legislations very, very closely aligned so you can treat the two rules as the same, particularly now it's a CE market (audio cuts out 02.58.06).

So, what is REACH? Okay, REACH regulation, another directive that applies across all the EU is mainly aimed at the management of chemicals used for production. So, not materials, not the finished bits but the chemicals going into it, the mixtures (audio cuts out 02.58.22), again, protects human health, not limited to EE products but applicable to it. And, again, it's keeping hazardous chemicals out of landfill, and the environment, and the water supply. So, if we look at the REACH regulation it requires chemical producers to register safety data for all chemicals produced and then experts in the EU (ph 02.58.45) determine which chemicals are acceptable and which aren't. And, there's a list of unsafe product that you're not allowed to use, of chemicals of very high concern (audio distorts 02.58.57) that are being replaced or phased out and some chemicals are completely banned. So, there is a banned list that you can't use, there are others on the way out. It's up to the manufacturer of those chemicals to register the safety data. (audio cuts out 02.59.14). So, the scope of REACH applies to companies or individuals that import, manufacture, use or place on the market substances, mixtures, or articles, to be compliant with the regulations. So, if you look at what articles are, that's an entire object which could be a substance, which could be a chemical element or compound, or it could be a mixture or a solution of two or more substances. So, it's covering most chemicals that would be (audio distorts 02.59.51) with some exceptions, radioactive (ph 02.59.52) substances, substances that are just in transit through the EU, and substances covered by other regulations (ph 03.00.01). So, what's your obligations? This is the most important part (ph 03.00.04). If you use equipment, if you use chemicals, you use these substances, then you're responsible for their use. And so, even importers have some responsibilities if they (audio distorts 03.00.18) covers all manufacturing, importing, distributing (audio cuts out 03.00.23) materials or finished products. So, it's quite wide reaching. You need to be aware of what chemicals are in the parts and materials in your product, that's the key thing in this (ph 03.00.36). Are you using any of the banned chemicals? And, part of due diligence can be just to make sure that that's (audio distorts 03.00.47) and when you're buying bits in, ensure that you're insisting on compliance with the REACH regulations. So, any individual company that imports more than one tonne of substance a year must register that substance with the chemicals agency, so they have a database, it's regardless of your company size. And, those same manufacturers must produce information on the safe use of those chemicals in the safety data sheet. So, you, once you know that materials are in your products, you can maintain the safety data sheet to show that you've assessed (audio cuts out 03.01.25). Again, the UK and EU regulations are closely aligned.

The final one of these is WEE, and this is waste Electrical and Electronic equipment. It provides the end-of-life product rules that keeps electrical and electronic (mw 03.01.48) out of the environment. So, in 2021 13.5 million tonnes of EE waste, of equipment was put on the market, of which 5 million tonnes worth (audio distorts 03.02.01), that's 5 million tonnes, it's a lot. It's 11kg for every person within the EU, that's a lot of EE waste that we're generating. The directive is about collecting and proper treatment of

WEE and sets a target for their collection (audio distorts 03.02.22) recycling. So, to some extent, WEE is the the tail end of RoHS or REACH. REACH is trying to keep chemicals out of the, dangerous chemicals out of the market in the first place, RoHS is specifying what materials are in a piece of electrical or electronic equipment so you know what's in there in the first place, and that contributes to recycling and reuse when you get to end-of-life. So, that's the relationship between the three of them. And, RoHS and WEE are very closely related. Note that at end-of-life, if you export waste electrical equipment out of the EU, it only counts towards fulfilling your obligation under the law if you can prove that the treatment that took place is equivalent to those that would have been conducted within the EU under the WEE directive. So, it's trying to stop people shipping stuff after elements in the developing world. You get those horrendous scenes of people burning PCBs and burning wire, you know, insulation off copper wire in hideous and unsafe conditions. So, we can't export our obligations, you deal with it locally or you make sure that when your waste is exported, it's being treated in the same way as though it had been done, been treated within the EU. So, the scope of WEE is a bit oddly designed which is to (mw 03.03.50) electric currents or electromagnet fields (ph 03.03.51) to work properly. So, if it's powered by batteries, by mains or electromagnetic fields or uses electromagnetic fields or transmits electromagnetic fields it's within the scope (audio cuts out 03.04.07) there is a limit on WEE of less than 1000 volts of ACL or 1500 volts of EC (ph 03.04.13). So, again, aligns with the low voltage directive (audio cuts out 03.04.17). And, the annexes of the directive has indicative lists of the type of equipment that falls under different categories. There are, as with RoHS, a list of exclusions (audio cuts out 03.04.29) from military equipment, space equipment, and then oddities and medical devices where there may be some sort of infection in the equipment in which case it can be disposed of (audio cuts out 03.04.43). So, what's your obligations under WEE? Well, as a manufacturer, the first thing you need to do is comply with the RoHS directive. So, to meet WEE, you have to CE mark to RoHS, that's the direct link between the two. You need to register with WEE authorities in each country where you, within the EU, where you distribute or sell equipment. And, because there's a correlation in the UK that's true as well. So, you need to register your product with the responsible national authorities or waste collection to make sure you have a path to safely dispose of your waste electrical equipment. You need to file a regular report on the amount sold electrical equipment so you can say how much did I put in the market and how much did I actually (mw 03.05.33) again? And then, applying the WEE mark to products. So, there's no CE marking for WEE but we do have the ubiquitous crossed out wheelie bin. So, complying with WEE, you put the wheelie bin on it. So, at the front end it's CE marking during production and then to show that you have measures at end-of-life for the product, which is mandatory for you to do it, you put the crossed out wheelie bin on it, as well. So, hence, you should see that on almost all electrical equipment. So, the WEE requires you to organise or finance the collection, treatment, recycling, and recovering of your products, plenty of schemes for you to join to that effect. If you're distributing electrical equipment or a retailer, you need to provide a take-back service where your customers can provide WEE, who can return WEE free of charge, and that's critical to there (ph 03.06.31), as well. So, when we buy electrical equipment we have to find a way of giving it back to retailers such as Currys and so forth. (audio cuts out 03.06.42) these other two environment regulations, these are largely transposed across into the UK, so the rules are largely the same. So, follow the CE rules and largely you'll meet the UK rules, as well, noting that for WEE there is that additional headache of having to provide registration in each country and that includes our own domestic market in the EU (ph 03.07.08). So, they all share a similar directive, so we need to make sure that we're complying with them to meet our environmental obligations, it's full product life cycle from the manufacturer or the chemicals to the manufacturer of parts, and components that go into equipment that's REACH and RoHS, to trying to recycle and recover materials at the end-of-life and product. So, it's important that all players in the market understand their obligations and act upon them.

Right. That's the end of that presentation and the series of presentations this morning. Have we any questions?

Moderator: We have no questions in. So, just one final shout out if anyone does have any questions so Simon that was a great series of presentations and kept perfectly to time. So, I can't see any questions coming in yet. So, that's obviously covered everything. But, thank you for everyone who did submit questions throughout the session, it made it a very interesting morning. So, I think what I'll do is maybe just hand over to you Colin if you're happy enough to wrap up.

Colin: Yeah, thanks Barry. So, just to finish off everyone, thanks very much to Simon for the excellent presentations today and thanks especially to Barry for the, from Eventful for hosting the event for us and for posing the questions. Thanks mostly, obviously, to all of you who have participated today, we hope you found it worthwhile. That's the last in our series of Autumn 2024 CE Marking and Technical Compliance webinars and we hope you found it worthwhile to attend. Hopefully, we'll be able to run them again in 2025 but we'll keep you updated on that and keep an eye on the InvestNI.com events webpage for details. Other than that, thanks everyone for attending and that's the end of today's webinar. Thanks, bye.

Simon: Thanks Colin, thanks everybody, thanks Barry. Bye.

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