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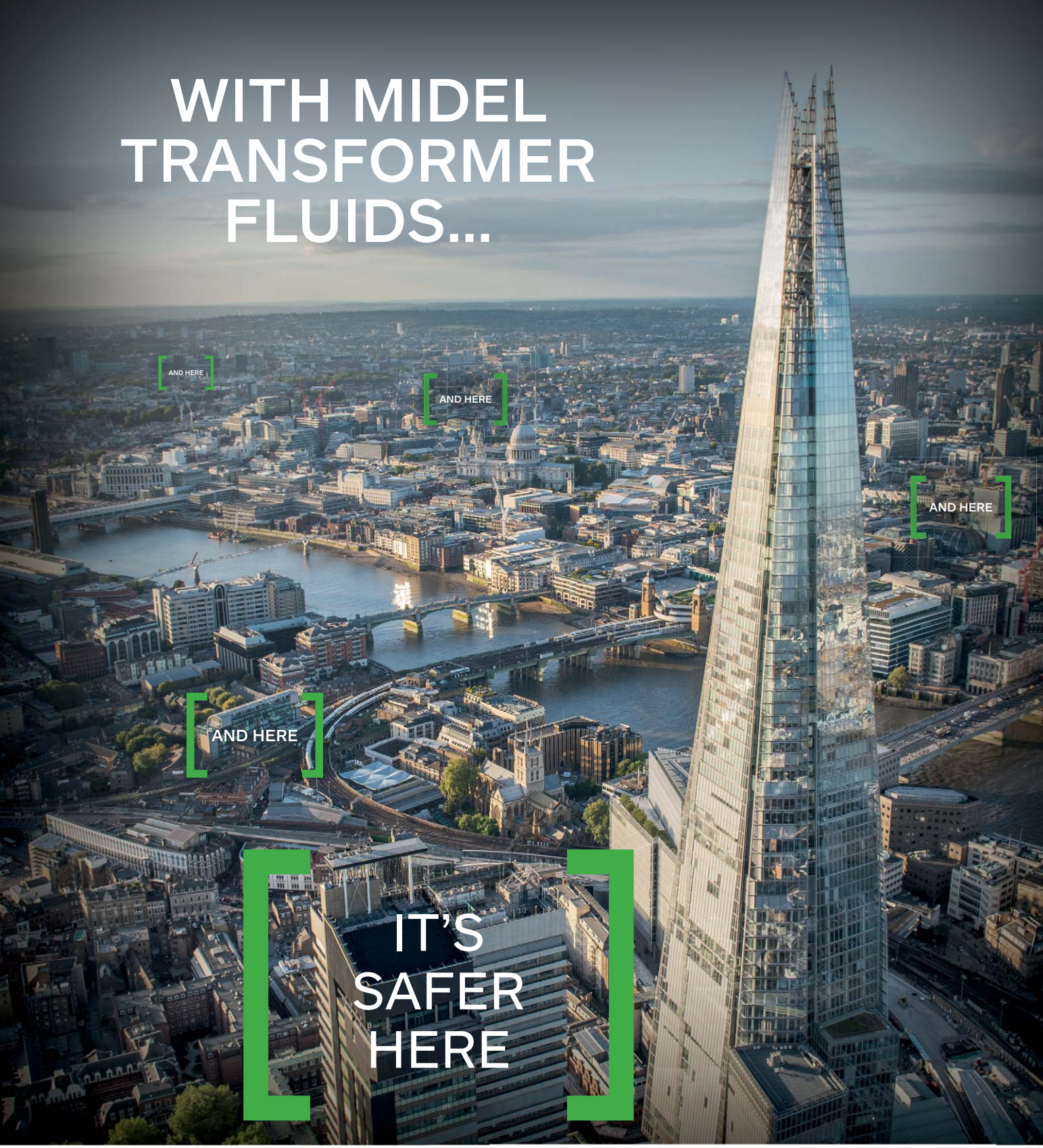
Transformer risk management roundtable



When it comes to protecting what matters, there can be no compromises. MIDEL ester transformer fluids offer superior risk mitigation for power transmission and distribution assets; in addition, the fluids can be used to retrofill older fleets. Fire safe and biodegradable, MIDEL reduces liability, the threat of losses and costly business interruptions. It's time to go beyond mineral oil for a safer, more efficient future. MIDEL is transforming asset performance, reducing risk and delivering cost savings every day across the world. Let's make it safer together.

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Roundtable

Transformer risk management

Transformer failure is one of the main causes of power outages globally. CIR hosted a roundtable to discuss the ways in which the risk of failure can be minimised

Energy demand globally is forecast to grow by another 30 per cent by 2040. As a result, not only does the infrastructure need to grow to deliver that consumption but it also needs to replace ageing infrastructure that is reaching the end of its life.

The cost of new power transformers globally is forecast at US$30bn. The current demand for transformer fluid is approximately 1.5 million tonnes, of which 95 per cent is mineral oil. Although mineral oil is a very good dielectric fluid and is effective at removing heat from the transformer, it has some major shortfalls: it is toxic, it does not biodegrade and it's highly flammable.

An alternative to mineral oil

BM: Over a five year period to 2013, an FM Global review found that the third highest cost as a result of equipment failure was related to electrical transformers, at US$339m. The ferocity of a transformer fire and extent of damage it can cause is significant. Recently, The Royal Bank of Canada offices in downtown Toronto had to be closed for an estimated six months due to a transformer fire. In the US, two nuclear power plants were shut down in 2016 and 2015 as a result of transformer fires and in the UK, a National Grid substation fire near Hull in 2013 containing 100 tonnes of mineral oil burnt out for an entire day. In Turkey, the Soma mine disaster in which 301 miners died was reported by news agencies to be due to a transformer fire. In Bangladesh in 2014 39,000 transformers exploded, mainly as a result of overloading and poor maintenance. By eliminating the risk of fire, esters represent a solution to this problem and adoption is beginning to grow globally. This is not a new technology, esters have been used in transformers for almost 40 years. The current market share of esters (natural and synthetic) is about 3 per cent. In the US, it is about 10 per cent – predominantly in small, pole-mounted transformers. Elsewhere, take up of esters varies. Jordan has undertaken an extensive retrofill and new transformer programme over 20 years, so far taking over 5,000 tonnes of MIDEL. The Kuwaiti utility, MEW, started using MIDEL esters two years ago; now 20 per cent of their new distribution transformers use it, with plans to increase this percentage. Obviously in hot climates, transformers operate at extremely high temperatures, which increases this risk of fires.

Due to the fire safe properties of ester fluids, transformer design standards allow transformers to operate at 30ºC higher fluid temperature than if using mineral oil. Increasing the operating temperature of a transformer will decrease the life of the insulation paper. Due to the ester moisture adsorption properties, however, transformers can operate at 15ºC hotter than with mineral oil with no effect on the paper life.

CW: Is that 15ºC of the average oil temperature or the hotspot temperature?

BM: The guidance refers to the hotspot temperature, which is the temperature of the copper coils. The coil temperature does correlate to the average temperature. If you were to replace mineral oil with an ester then the guidance predicts life of the paper if operating at the same temperature would increase by fivefold.

CW: Is that still the case if you replace the oil during a transformer's lifetime?

BM: Yes, though ideally to get the full benefit you would have a new transformer. You can retrofill the transformer by removing the mineral oil and replacing it with MIDEL. This is a common practice. If a transformer is coming towards the end of its life ester fluid won't repair degraded paper but you will delay the replacement of the transformer.

AL: Does any remnant mineral oil in

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Attendees:

Barry Menzies, Head of Dielectric Fluids, MIDEL

Edward Sankey, Risk Consultant, Larocourt Risk

John Warton, Senior Risk Consultant, Allianz Risk Consulting (Engineering – Oil, Gas, Chemical and PharmaChem)

Andy Lund, Risk Engineer, Power, Zurich Risk Engineering UK

Steven Phillips, Head of Power Energy, Onshore Property, Zurich Global Corporate UK

Carlos Wilkinson, UK Power & Utilities Practice Leader, Natural Resources, Willis Towers Watson

Jamie Abbott, Senior Specialist Underwriter in Construction, Engineering and Renewable Energy, RSA

Graham Coles, Senior Loss Prevention Consultant, XL Catlin GAPS

Calum Wood, Senior Engineer, Travelers

a retrofill compromise the fire safety benefits of MIDEL?

BM: Not if the mineral oil is properly emptied out by hosing down the sump of remnant mineral oil. You'd end up with about three per cent mineral oil.

AL: So you're targeting around three per cent.

BM: You can go to about three and a half per cent before the fire point will drop below 300ºC, which is the definition of K-class fluid.

JA: Are there any mechanical modifications required or do you simply retrofill with the oil?

BM: For distribution transformers up to 66kV, no design changes are necessary. Above that you do need to take into account some differences in the dielectric properties of the esters at higher voltages. MIDEL is now being used at 400kV. Three transformers were installed last year in Highbury, North London – 400kV, 240 MVA and with 100 tonnes of MIDEL in each. Operated by National Grid and designed and manufactured and installed by Siemens – both extremely conservative organisations.

Elsewhere, we have worked with Vattenfall in Sweden, on a 400kV underground hydropower station. Spain's transmission operator REE is testing a 400kV station with another transformer manufacturer, and a similar application is underway in Germany. Con Edison of New York has just taken delivery of some huge mobile transformers from Siemens operating at 345kV, which all use MIDEL. Closer to home, a number of locations visible from the building we are currently in, the Gherkin in the City of London, are using MIDEL, including St Thomas' and Great Ormond Street hospitals, Harrods, the Health & Safety Executive, Imperial College, UBS, The Gielgud Theatre and the London School of Economics. Transport for London are also users of MIDEL.

CW: Are the three installed by National Grid a trial, or part of a wider rollout?

BM: That particular project came about following a decade long study into high voltage testing at Manchester University's electrical engineering department. National Grid trialled at 400kV at GE (formerly Alstom), Stafford. Siemens in Austria were awarded the contract to manufacture and supply the transformers.

GC: What sort of testing did they do?

BM: In addition to high voltage impulse testing, and numerous tests on the transformer, they conduct lightening impulse tests, which are the most severe. The Highbury substation won the National Grid Chairman's award, and we understand they will be using MIDEL in future projects.

GC: Are you seeing acceleration in use of MIDEL or is this just a normal sales profile?

BM: Yes, it's an acceleration. I've personally been with M&I for six years. Three or four years ago, the majority of people were learning about MIDEL for the first time. Because the fundamentals are so obvious when you know them, the normal reaction is: why aren't we using it? Then it's a case of justifying the additional cost, as it's roughly three times more expensive than mineral oil. But it makes the transformer only about 10-15 per cent more expensive.

Initially, the fluid was used in

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traction transformers, because the ability to run a MIDEL transformer at a higher temperature means the transformer can be smaller and lighter than a mineral oil transformer – Up to 30 per cent smaller. Then wind turbine transformers were the next niche market, though renewables are much more mainstream now. The majority of European wind turbine manufacturers use ester transformers including Siemens Wind, Enercon, GE and Vestas. The advantages of MIDEL transformers increase in the larger wind turbines and those located offshore.

AL: It sounds like you're getting good penetration into the OEMs now but that they're not offering it yet as their standard fluid of choice.

BM: The standard offering will still be mineral oil transformers, but there is certainly growth potential for MIDEL in transformers that are in areas of relatively high risk, where the value proposition is much stronger.

Testing scenarios

JW: So if users can't be persuaded on risk improvement alone, are there any tangible cost savings that they can make through, say, a reduction in maintenance or asset longevity?

BM: There are. For example, FM Global has specified how you can reduce the area around the transformer. You can also reduce the need for fire suppression and containment walls. So there are significant savings to be made – especially in urban locations where land is more valuable. In the Highbury location I mentioned earlier, they've built affordable housing on the land that they've saved by having a smaller space around the transformer.

CW: Do you have any data on any MIDEL product failures, service failures or repair work?

BM: In terms of analysing the faults if they were to happen, it's the same DGA (dissolved gas analysis) as with mineral oil. It's the same gases you're looking for but because the transformer with MIDEL is more 'healthy', it's more resilient to faults should they happen. If there are spikes in electricity and the paper is in better shape it's less brittle, less degraded then it's better able to withstand that shock.

JA: Would it be resilient to an extreme fire scenario of, say, 3,000 degrees?

BM: Several transformer manufacturers, insurance companies and end users have concluded that under the possible conditions that could be experienced in a transformer, MIDEL will not burn. For example, in a fault condition the transformer fluid could be exposed to a high release of energy, but for a short period of time. With a mineral oil transformer, once ignited, the fire will be self-sustaining and continue to burn. But with an ester, despite that initial huge amount of energy, a fire is not sustained. This is because an ester generates much lower energy when it burns (approximately 30 per cent less than mineral oil), and the combination of this low energy release and the very high fire point means, unlike a mineral oil, the fire will not be sustained.

The transformer could rupture, but the fluid still would not burn. This has been trialled under test conditions with commercial transformers. We've also commissioned a practical evaluation with a testing company in Germany where MIDEL was sprayed towards a heated plate and then allowed to drain into a catchment pool. We had a proprane flame going into the spray at about 2,000 degrees to replicate the intense heat of an electrical fault. The result was that as soon as you take the propane flame out, the vapour simply stops burning with nothing carried over on to the heated plate or to the pool fire. In the mineral oil test, the fire got completely out of hand.

GC: You seem to have penetration in the small transformer market. I'm familiar with MIDEL. In the last few weeks I had a client who had a small transformer fire and they replaced it with a MIDEL filled unit – no issues. At the same time, I am working on a large infrastructure project with big independent power demands, and they are not considering MIDEL.

SP: We have to consider our exposures from business interruption. A large power transformer would probably take a year or so to replace. So in the event of a complete disruption of that transformer, you might have a year or so of business interruption. I would be interested in the amount of time taken to repair a transformer that had a fault when it's been fitted with MIDEL over and above the time it would take to replace a full transformer. Have you any experience of that?

BM: I haven't any experience of that.

GC: What's the worst damage you've seen on a MIDEL transformer? You must have had ruptures.

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BM: We are not aware of any ruptures.

JW: Have you tried to simulate any faults?

BM: We had the trial I mentioned earlier, which was designed to rupture the transformer and there was no fire and that's the absolute extreme.

JW: Was that an external impulse as opposed to an internal arcing? Because that would be quite interesting.

BM: Yes and there's no difference compared to a fault that you would get with the mineral oil, in that respect at all.

ES: Where procurement of transformers is concerned, to what degree do engineers consider risk from the beginning? Including the risks of one sort of transformer fluid compared to another? Especially if you're saying that ester based MIDEL is a lower risk in the longer term. Do people think beyond the construction, assembly and installation cost? Do they look at lifetime costs? Do they look at the things that would be uncertainties around those assessments of lifetime costs? What's the practice amongst engineers in the power sector when it comes to starting with a clean sheet of paper but a requirement for a new set of transformers?

CW: I think it depends on who the client is. If it's an independent power producer which is generally being driven by a group of developers, then a 10 to 15 per cent change in the cost is pretty key. Generally it will be the EPC contractor. Unless you actually specify that you want MIDEL in your transformer, you'll get what you're given. You'll get a 100 megawatt transformer but you would absolutely have to specify if you wanted that to actually be part of the scope of the project.

It's somewhat different when you look at large transmission utilities. They tend to be a lot closer to their equipment, and tend to be more specific about what they want.

GC: So you're specifying more the performance of the unit.

CW: Of course**.** Any proposals involving significant amounts of additional cost do have to come with a very strong business case attached to them. Every element is looked into in detail including redundancy, insurability and maintenance and so on. So there is that lifetime cost understanding built into it because the client is going to have to live with it. You've got to be able to identify the payback, otherwise it's unlikely to happen.

JW: If you use MIDEL, what sort of impact can that potentially have on the lifespan of the transformer?

BM: The life of the insulation paper is one of the main contributors to the life of a transformer. Using MIDEL effectively takes the paper out of the equation.

GC: I think the problem also with mineral oil units is if they're well maintained, you've got a 15 to 25 year or more lifespan anyway. The high frequency of losses you mentioned earlier are all down to lack of maintenance by the sound of it. So if you go to a site and say what you should really do is change to MIDEL, they're going to look at the cost and any potential lifespan increase, which is probably negligible, and at best they're probably going to say 'well, we'll think about that in 15 years when we're going to replace the unit'.

Applications

BM: There are a number of different benefits that using MIDEL brings about. These include location in terms of the environment and in terms of the fire. There can also be cost savings initially and obviously for a new build if you can save on space and the fire suppression and the containment. That saving outstrips the additional cost of the fluid. For example, a rail operator decided to install MIDEL in trackside transformers because the reduced need for civil work decreased the installation time and disruption to rail services.

AL: Is it physically possible to make the transformer smaller by using MIDEL?

BM: Yes, I mentioned earlier about why MIDEL transformers can be 30 per cent smaller and tighter than mineral oil transformers.

This advantage is not limited to traction and wind turbines. Large power mobile transformers have been designed using the same concept, then saving 30 per cent of the weight can be very significant. Also, smaller offshore substation power transformers require smaller cranes to stall on the platforms which saves costs and speed of installation due to the availability of the large offshore canes. So the benefits of MIDEL are quite diverse.

JA: So they're doing it for actual

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offshore wind turbines and the offshore substation as well?

BM: Yes, and also for mobile transformers. The Siemens Resilience transformers recently deployed in New York, weighing 300 tonnes are 30 per cent smaller than if they had used mineral oil. Some transformers need to be lighter just to physically get them to a particular location due to weight limitation on bridges and so on. Of course, these transformers also enjoy the benefits of fire safety and avoidance of environmental damage in the event of a fluid spillage, which must be more likely for a mobile transformer.

AL: In terms of the cost benefit analysis, how does the lifetime of the fluids compare? Are they comparable in terms of how long will they last?

BM: MIDEL lasts longer. As the paper degrades in mineral oil a sludge is formed and that can potentially cause problems in the transformer. As you've mentioned, in this country transformers last for 40 years. It's more of an issue in warmer climates, especially where transformers are run at higher loadings.

AL: I was thinking more about degradation of the fluid – oxidation of the oil.

BM: There's a reprocessing industry in place for mineral oil, for drying and filtering the mineral oil as that degrades. If necessary, MIDEL can be dried using the same equipment.

AL: So it doesn't become acidic as it ages?

BM: There is some small amount of acidity but the acid species are different from those created in mineral oil.

SP: If we were to recommend MIDEL, would we be considering about an extra 10 per cent cost for a retrofit?

BM: Yes.

AL: And in the event of wanting to replace mineral oil with MIDEL, what kind of support is there for making that change?

BM: They can come to us for advice and transformer oil service companies will be capable of doing the retrofill.

JW: And it's easy to just flush the mineral oil and refill?

BM: Yes.

CW: One of the frustrations I have is that a client can be doing everything right; they've got mineral oil in their transformer, they're doing online DGA and they're monitoring it, they've got great blast protection… then out of the blue they get a transformer failure, probably because of corrosive sulphur. Would I be right in assuming that there will be no sulphur in MIDEL?

BM: Yes, completely.

It's worth pointing out that some customers approach us to buy MIDEL because their insurers have specified it. This tends to happen more with industrial applications, but it happens quite frequently.

ES: In critical installations, reliability is everything, isn't it? Even the chance of a fire is too much to risk.

CW: When you're talking about the transmission network it's a bad network if anybody loses any power because of a transformer failing. But it's very rare. But from a power or manufacturer perspective it's much more key and it does interrupt their businesses. Equally, not every transformer failure results in a fire. In fact the minority do. Many more trip on an earth fault.

AL: It does give you protection against the nature of your bushing failure though, doesn't it?

BM: Yes, insofar as a bushing failure will not bleed to a transformer fire. Dry bushings are recommended for use with MIDEL transformers.

ES: I think it might help the power engineers if they thought not about the average failure rate or the average leakage rate or the average fire rate. But more ask what's the P90 in all this? What's an extreme event? How frequently could they happen, and could the network or firm withstand a major event? What would those consequences be to themselves or others? Start to look at the extremes rather than what the expected scenarios actually are because I think – especially when you're dealing with injury or death – the averages aren't the issue, it's the extremes that matter. This is where risk managers come in. We don't want 'average injuries'. We want no injuries.

SP: From the point of view of the underwriters we're probably looking in more general terms at, say, the average

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age of a fleet and past performance in terms of claims, or how clients deal with flooding – rather than individual transformer issues. It's very different when you're talking about a specific location or a number of specific locations. The risks from an entire distribution or a transmission network are completely different.

CW: One thing that never fails to surprise me is the huge variation in terms of risk appetite and risk aversion, which is an indicator of how a client operates, and that's driven by the board. At the same time, highly regulated companies with regulated income have only got so much to spend, and it's not just a one-time commitment. It's one that lasts for years, or even permanently, and is a very difficult thing to get them to agree to.

Insuring the risk

BM: How do you identify companies that are more risk averse?

CW: By sitting down at the table and talking to them. It's so difficult. I've got two clients in exactly the same part of the world and their approach could not be any more different.

They're completely the same and yet they could not be more different – something that renders benchmarking less useful. One thing they do all have as absolutely their primary consideration is health and safety. That is their number one priority – making sure their employees get home safe and that they don't harm the public. It's reputational, it's just at the heart of doing what they do. I think you see that across all of the regulated businesses in the UK. Then it's cost and operational efficiency and customer satisfaction.

BM: Where do you get the data to insure these risks?

GC: Data seems to be very bespoke to our own companies as well. We evaluate based on conversations with clients or prospects.

SP: We also rely on the expertise of underwriters and engineers. This is a very specialised area of insurance.

BM: Does that mean if the data's not there that its based more on an emotive decision?

SP: It's not emotive. It's something the engineering specialists have drilled into for years and information they glean from site visits. But time and time again, I see people like yourselves go on and make recommendations that they have never thought of. You might visit 10, 20 different power plants a year. Whereas these guys are not doing that. They're very focused on their own plant. So you're seeing best practice for all sorts of areas. I think it's that kind of experience that really helps.

GC: Sometimes the larger companies with a multinational presence might be more cautious about making a decision because it then becomes a corporate guideline – and is not just rolled out across one site but across 300…

CW: Ultimately when we're on site for a survey the people that the clients listen to are the insurance engineers, and you ignore them at your own peril effectively. Of course, clients don't have to do everything that they say but they do respect them and they listen to them.

AL: If a transformer is sprinklered and it's covered by blast walls to the NFPA standards and they're maintaining it to the standards we expect, then there's less of an issue. If the transformer's in an underground application where a fire is detrimental to the whole plant, there's no fire protection, maintenance is laissez-faire at best, then you need to start looking at what might reduce that risk.

CW: It is always easier to introduce the solution to new power plants and the like. And particularly to projects with more debt that equity. Simply because I think lenders demand good discipline.

JA: I think there's more that can be done to educate the insurance industry in this area.

CW: I think it is portrayed that risk engineers make their recommendations and plants actually go and follow them. But that is not always the case.

JA: From an underwriting standpoint it isn't too common to receive risk information relating to the type of transformer oil used, be it conventional mineral oil or synthetic dielectric. If we are aware that MIDEL is in use then it would be viewed favourably as transformers are invariably the pinch point in power generation risk. So if we can determine that the risk of fire spread is reduced or even removed following a transformer failure then will impact the severity of loss scenarios that have to be considered when writing power generation business.