Rainer Frotscher

Senior Expert for Insulating Liquids, Gases and Tap Changers at Maschinenfabrik Reinhausen

Interview with **Rainer Frotscher**

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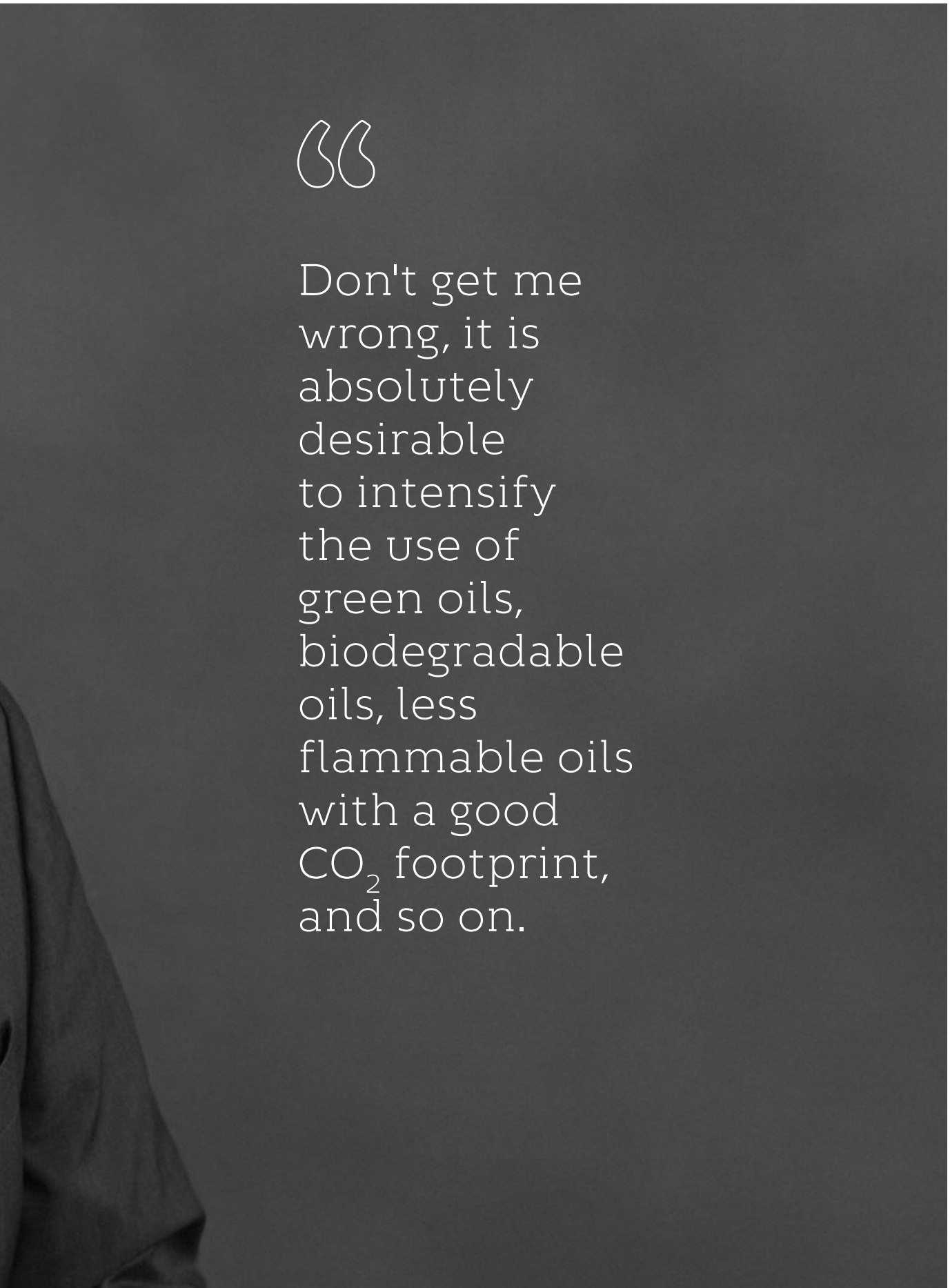

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Green Oils - The Power behind the Power

Alan Ross: I am delighted to have as a guest today, Rainer Frotscher, who is the Senior Expert for Insulating Liquids, Gases, and Tap Changers at Maschinenfabrik Reinhausen (MR). It is so good to have you.

Rainer Frotscher: It's my pleasure, thank you for inviting me.

AR How long have you been with MR?

RF Oh, about 36 years.

AR That is a long time to be a technical expert. Tell me a little bit about your background. Did you have a degree in chemistry or chemical engineering?

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RF No, I'm an electrical engineer, and I studied high-voltage engineering in Munich. After my studies, I came here to Reinhausen and I found a very good environment to develop tap changers and to do calculations and really did deep dives into numerical field calculations, project studies, and on how tap changers interact with insulating liquids. And then over the years, this developed into my favorite subject, and I just sort of picked up the chemical knowledge on the go, as it were.

AR There's a gentleman named Dan Martin whom you worked with and he said to me *Rainer knows absolutely everything to know about tap changers*. So, you're going to be our tap changer expert. I'm going to add even more to your title. I would like to hear your insights on the changes happening in the industry with the addition of a lot of synthetic esters, natural esters, and even changes in mineral oils and the fact that tap changers need to be looked at specifically when it comes to fluids. Could you please talk about what the current situation is as it relates to oils and fluids and these new products?

RF Yes, that is true. The current situation is that many new liquids are entering the markets. There are new synthetic esters and a bunch of new natural esters, plus the further developed so-called mineral oils which are GTL oils and oils made from renewable hydrocarbons. They are all entering the market simultaneously, and all are a little bit different, and they are also very local. Every country is trying to develop its own liquids for reasons I don't know. But it creates a challenge for us because we have to approve them all. Don't get me wrong, it is absolutely desirable to intensify the use of green oils, biodegradable oils, less flammable oils with a good CO_2 footprint, and so on. But all transformer, bushing, and accessories manufacturers have to invest a lot of time and effort to qualify all these new liquids. And this leads to the situation that each equipment manufacturer designs its own test procedure because the current standards do not provide them. These standards do not cover all liquid properties which determine the performance of the equipment. They only determine some properties of the liquid itself, but not how it interacts with the equipment.

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AR I remember reading something you said about this. I believe you said that part of the problem is the standards for the alternative liquids were created based on transformer mineral oil standards. So, it's not like they were specifically created. The standards were created for something that's been used in transformers for years. What then is the difference when you're using alternative fluids and you're developing new standards for them?

RF As I said, there is much research going on, both in the industry and in academia. And these researches have revealed that alternative liquids, particularly esters, show significantly different properties. For example, when it comes to the dielectric properties, like the streamer breakdown properties. They are significantly different. And in combination with the complex insulating arrangements which you find in a transformer or a tap changer, this leads to a different dielectric strength. Other very important factors for tap changers are the viscosity range, lubrication, oxidation stability, and so on which are all different. We must take all that into account. Another example is the sealing of transformers. Unlike in the rest of the world, in the US, most of the transformers are sealed but when you want to use natural esters, then you must rethink how to seal the tap changer as well.

AR I would like to go back to lubrication for a moment. Because we don't think of that in transformers. I don't think it needs lubrication, but it's an important part of what the

liquid does. It has to have lubrication qualities. Could you elaborate a little bit on the lubrication requirements for these alternatives?

RF All types of tap changers were originally designed for mineral oil. This is what all mechanisms have been optimized to. But now we have these biobased hydrocarbons or GTL oils which can be very low-viscosity liquids. And viscosity is connected to the lubricating behavior. Not directly, but it has a certain influence. And when the viscosity is too low, then the lubricating properties can be insufficient which leads to functional problems, as it affects the switching sequence of the tap changer.

AR But there are also other complex situations that you've got to think about, the sludge and soot and arc quenching and all of the other things. Talk a little bit about the different application requirements of the alternative fluids. How do we prevent the buildup of sludge at the bottom of the tap changers?

RF It actually gets even worse if you run these old arc-breaking tap changers with ester liquids. The viscosity is somewhat higher, which means that the arc is not cooled as directly and efficiently as it is in mineral oil. So, the arcing time is somewhat longer, which produces more sludge and also may produce some unwanted gasses. If you do

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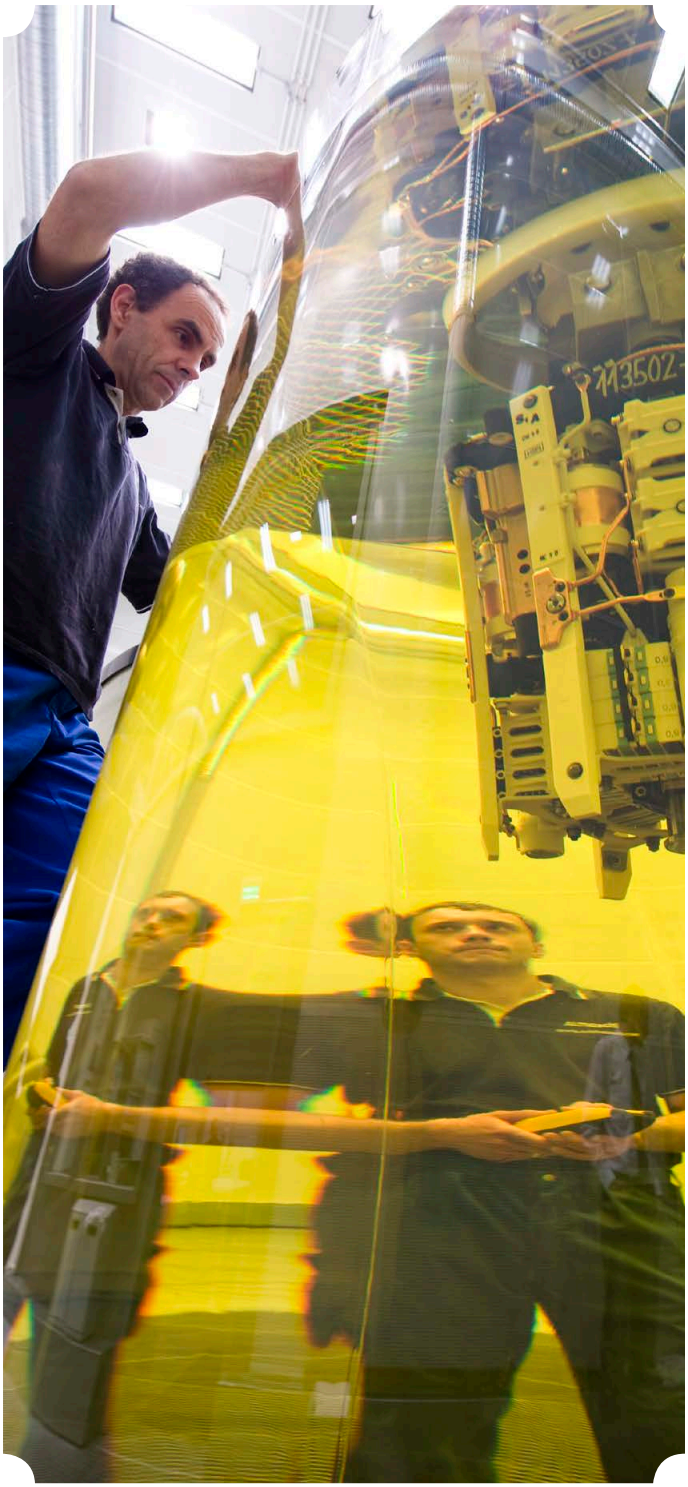

some maintenance on these tap changers, you should provide a good ventilation system so that some possibly toxic gases can come out. So, this is what happens when you have a pyrolytic degradation of ester liquids and this is the reason why Reinhausen doesn't approve ester liquids in combination with arc-breaking tap changers, only with vacuum-type tap changers. There, esters work just fine, without sludge or toxic gas byproducts.

AR I would like to talk about different segments because I honestly don't believe most of the market understands the issues. You said you're not quite sure why each country is producing its own, different fluids. It's called politics, okay? Each country has its own thing. Somebody tells the politicians, who then tell the regulators, who tell the manufacturers, that's how it goes. But what can liquid manufacturers, the people that make these alternative fluids, do?

Viscosity is connected to the lubricating behavior, and when the viscosity is too low, then the lubricating properties can be insufficient which leads to functional problems, as it affects the switching sequence of the tap changer.

RF They should take into account the elaborated requirements. It is not only about electrical insulation and cooling. There are also additional properties of the tap changers like an adequate viscosity range and compatibility with all existing materials and designs.

AR An alternative fluid manufacturer who was out trying to sell his product to, either the specifiers at the utility or whoever is buying the transformer needs to ask questions about applications. How is this going to be used? What kind of tap changers are going to be used? And then that way they can become consultants if you will. That way they could learn how to make the fluid that fits the customer's needs best. But they're not going to do that. What they're going to do is make a problem.

RF Yes, they simply don't seem to be aware of all these issues in detail.

AR Exactly. And that's why we're doing this, to make them aware. Reinhausen makes load tap changers, and you are the global leader of load tap changers in the marketplace and have been for a long time. So, you're the equipment manufacturer. Could you talk a little bit about what the equipment manufacturers ought to do to address this problem?

RF From our meetings with transformer manufacturers, we have learned that they all have their own test setups for their insulating arrangements like paper-wrapped windings, for example. They have established test setups and they test with AC or with a lightning impulse which is quite similar to that what we do. So it would be a good idea to bring us all together to come up with simple and practical setups and methods and to develop model arrangements that are applicable in practice and that represent real insulating arrangements. The standards we have now for dielectric strength, and for breakdown voltage, are not sufficient because they only allow

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AR At the end of the day, the end user, the customer, says, *Hey, we need a transformer or a series of transformers and we have to specify them.* What do you say to the end users in their specification projects? There is an electrical engineer sitting in a room with no windows and he's told to develop the specs and he's disconnected from things going on on-site. What can you tell him or her about what they need to do?

RF It's not so easy but perhaps he could encourage the liquid manufacturer to develop environmentally friendly liquids with properties that are not too far away from what we know from classic mineral oils.

AR And that will force the liquid manufacturers to really look into what changes in viscosity they need to make. Because I think, as you have stated, they can do that, but they just have to have a standard to go by. And without well-developed industry standards, they're going to have to go by the specification

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standard that the end user uses. Talk about what you are talking to the industry now. Your fellows in the IEEE transformer committee and your fellows at CIGRE and IEC talk about what they can do in order to address this problem. Because it's going to create greater problems down the road sooner rather than later and people are going to go *It's because of the fluid.*

RF The industry should do, what I'm currently doing. I'm working on the IEEE C57.166 which is the combined liquid guide that combines all the previous liquid guides for mineral oil, for synthetic and natural esters, and for high molecular weight hydrocarbons. I had an annex inserted into this guide which puts the finger on these special issues, special requirements, that tap changes have. I think that CIGRE could also set up a working group, for example, where manufacturers, be it for transformers or other equipment, come together to propose and agree on test methods that allow an estimate of the performance of liquids.

AR Well, this has been a delight. Rainer, thank you for joining us, this has been very informative. We will do some follow-up interviews on this because I'd like to find out more, and I'd like to use this to help the industry come together. Thank you for sharing with us the problem and the solution for equipment manufacturers, liquid manufacturers, for end users, and for the industry.

RF Thank you, Alan, for the opportunity.