What is a High Voltage Engineer? Who are They? Where are They?

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Dr. **Nancy Frost** has been active in the electrical insulation industry for over two decades. She now runs Frosty's Zap Lab, her materials R+D testing laboratory, while working for Gerome Technologies as Materials and Testing Manager. Nancy's education includes a B.S. in Chemistry and M.S. & Ph.D. in E.E. from Clarkson University, finishing her PH.D while working for GE Research. She has given more than 100 papers and short courses in the areas of dielectric materials, aging phenomena, and testing. Through her various roles, she has experienced the points of view of materials suppliers, customers, utilities and manufacturers.

WHAT IS A HIGH VOLTAGE ENGINEER? MAYBE THAT'S THE ISSUE. PERHAPS THE DEFINITION HAS GOTTEN LOST. TRADITIONALLY, HIGH VOLTAGE ENGINEERS ARE THE 'KEEPERS' OF THE HIGH VOLTAGE IN A POWER SYSTEM.

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In the last several months I've had a variety of conversations with people and organizations regarding high voltage and dielectrics engineers, and how there appears to be fewer of them than in the past.

How, in our standards working group meetings, there are the same bunch of people, all of us aging together, with fewer and fewer young folks staying around in the industry. We've been puzzling.

Why is this happening? Where are the young engineers being trained? Why are they not coming nto their classic roles in the industry?

Who is going to pick up the banner and carry forward the high voltage engineering for the next generation? I'm going to share some of my thoughts on this topic with you.

What is a high voltage engineer? Maybe that's the issue. Perhaps the definition has gotten lost. Traditionally, high voltage engineers are the "keepers" of the high voltage in a power system.

They are the ones that design and implement new transmission or distribution lines, so have to keep an eye on the clearances needed to keep the high voltage on the line and not arcing to some tree or tower.

They design substations, with the various equipment, transformers, three phase breakers, grounding schemes, dealing with VAR compensation and other aspects that keep the power flowing smoothly in the transmission or distribution network. They run the power stations, keeping the grid alive and well and functioning smoothly, for example, as lines need to be switched in and out due to changes in grid demand from, say, local outages. They also work on projects underground and undersea, developing cables for transmission and distribution.

But high voltage or dielectric engineers are also the people that make MRIs work. No one wants a false signal or white spot in their MRI! Dielectric engineers also work to design the internal workings of that bone saw that was needed for your loved ones' hip or knee replacement. They design the generator that powers your cruise ship. They help our military by powering our subs and battleships, keeping them functioning safely. And they work undersea, designing and building undersea cables for power transmission over long distances. Someone has to connect those new off-shore generators to the on-shore grids.

HAVING WORKED ON POWER GENERATORS, LARGE MOTORS, SMALL MOTORS, LOCOMOTIVES, TRANSFORMERS, LIGHTING BALLASTS (A SPECIALTY TRANSFORMER), BUSES, MRIS, BONE SAWS, DENTAL DRILLS, POWER CAPACITORS, CABLES OF ALL SIZES AND SHAPES, AUTOMOTIVE IGNITION COILS, TRANSPORTATION ELECTRIFICATION (A MODERN BUZZWORD - THAT ALSO COVERS MANY APPLICATIONS), OUTDOOR INSULATORS, CIRCUIT BREAKERS, ROTOR INSULATION, STATOR INSULATION, TRAINS, PLANES, AND AUTOMOBILES... AND THEY ALL HAVE THE COMMON NEED OF KEEPING THE 'POSITIVE' FROM TOUCHING THE 'NEGATIVE.'

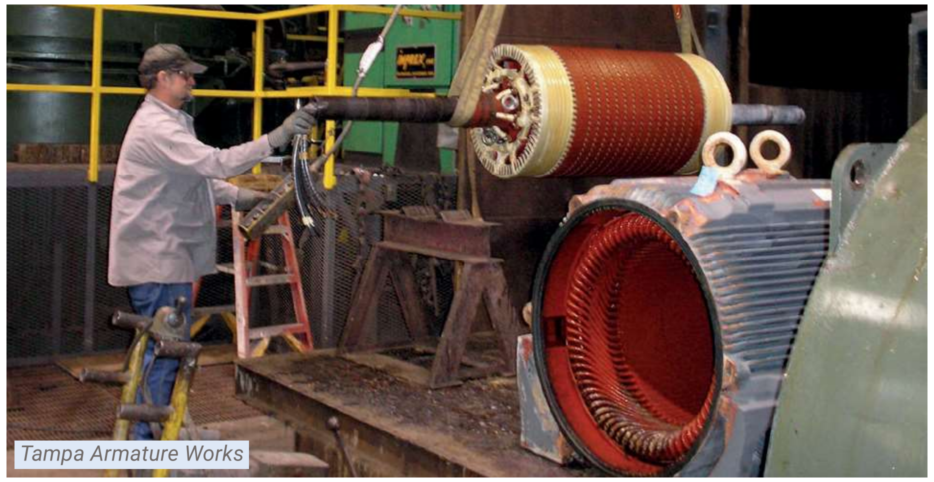
Having worked on power generators, large motors, small motors, locomotives, transformers, lighting ballasts (a specialty transformer), busbars, MRIs, bone saws, dental drills, power capacitors, cables of all sizes and shapes, automotive ignition coils, transportation electrification (modern buzz word - that also covers MANY applications), outdoor insulators, circuit breakers, rotor insulation, stator insulation, trains, planes and automobiles… and they all have the common need of keeping the "positive" from touching the "negative". In other words, having long lasting dielectric materials or insulation that can withstand the electric field, aka the applied voltage, despite the diversity of applications and operating/aging environments. And this diversity may be the key to finding the elusive high voltage engineer and tracking their career path.

What is meant by the applied voltage? For some applications that means 30kV (30,000 volts), and sometimes that means 30V. All depends on the application. It is the electric field that matters. And that's the voltage across a distance (volts per mil, or kV/mm). So, if you have a power line with tens or hundreds of kVs between the line and the ground, that FEELS like it should be different than a wire in a cable that carries a few hundred volts on a submarine. But depending on the distances between the positive and the negative, the basic dielectric properties are very similar. The theory driving the dielectric strength of the materials are similar, despite the diverse extremes in voltage levels.

Where are the next generation dielectrics and high voltage engineers? It seems that they are moving into even newer areas far exceeding the fundamental insulation needs. They are developing the power systems for next generation space applications and travel. They are investigating the influence of nanoparticles and how the laws of physics and chemistry are seemingly different when we get down to that scale; exploring how those materials operate; and if there are really different fundamental laws driving their performance. Of course, they are also diving deeper into the science of the present-day systems and making necessary advances to provide cleaner, greener energy and devices.

What makes a high voltage engineer? High voltage engineering covers a broad swath of skill sets in order to advance the science. They are chemists, and physicists, electrical engineers, and mechanical engineers. They are designers, researchers, development engineers, and yes, those that apply a wrench and get the job done.

Designing a generator is very cool, lots of drafting and computer modeling, considering all aspects of the magnetic as well as electrical field effects of the stator and rotor combination. Power controls, power feeds, plus connections to and from the generator. Never mind the dielectric insulation system and mechanical bracing aspects. Remember, those stator bars will want to fly apart when you turn that rotor. Not to mention the momentum of the rotor itself. Without bracing and electrical insulation, the machine won't work.



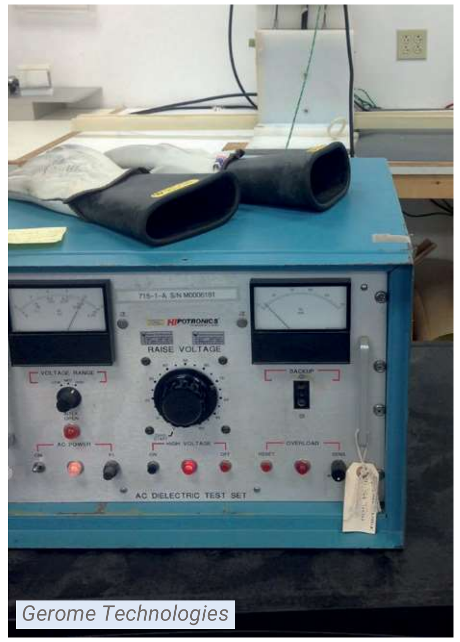
Tampa Armature Works

But generator design isn't all sit in the office and click on your computer to design stator bar sizes and quantities and then hit a button and the generator is made, although some of our young engineers only want to do that when asked, just push computer keys and not touch the real world. The real fun, in my mind, is when one gets to the actual build of the generator; making all the parts fit together, and more, making sure the unit lasts in the field.

Clearances can be designed, but in reality there are measurement errors, and material substitutions may have to be made. Many minute changes that can broadly affect the function and life of the entire generator. That is where the specialist, the dielectrics engineer, comes to play. They understand the materials that are utilized in a generator and how they function individually, as well as together as a system; plus, more critically, how the dielectric materials age and change over time the system is in the operational environment.

That submarine I mentioned - well, the busbars on that system are a critical component to the operation of the sub. Of course, safety is of the utmost concern, both for the personnel as well as for the asset, the sub. But continuous operation is also key! No one wants to be on a sub without power for ANY length of time. So that power system HAS to work, 24/7/365.

For the safety of our military, who risk their lives for us on a daily basis. If an adverse situation should arise, the sub personnel need to be able to access the power bus bar easily and readily tap into it if they need to perform an emergency repair at sea. But yet, they also have to have the busbar safely covered to avoid



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inadvertent contact. The insulation material on that busbar has multiple requirements, to be robust, yet easy to tap into, and have withstand capability of salt sea air, which has a corrosive effect on metals, to name a few. This involves totally different electrical needs from the power generator, yet similar high voltage and dielectric engineering concepts, that need to be known, understood and properly applied.

So, who is training these high voltage and dielectric engineers? Where do they come from? In addition to the diverse training background of the (way cool) high voltage engineers with which I've worked, those chemists, physicists, and engineers, they have unique and wide-ranging personal backgrounds. Men, women, tall, short, black, white, brown, from all walks of life and all corners of the globe. That is one of the most interesting aspects of this industry in my opinion: the diversity of the high voltage engineer. I believe it comes from our perseverance to solve the problems to make a device function, and function well, and function for a long time. Not only are we a diverse bunch, coming from anywhere in the world, but we also come with a wide variety of educational backgrounds.

People with Doctorates, Masters, Bachelors, Associate degrees, and even high school diplomas. I've worked with them all and learned from them all. Many of the traditional educational institutions that pumped out high voltage engineers for classic positions have moved their programs to other areas, many computer based. There are fewer academic programs to directly training high voltage engineers, at least in the USA, leading to a lower number of classically trained high voltage engineers. Although lately I see that there are several solid programs in a few universities, with several young professors starting new programs, I'm pleased to see.

WHAT IS MEANT BY THE APPLIED VOLTAGE? FOR SOME APPLICATIONS THAT MEANS 30KV (30,000 VOLTS), AND SOMETIMES THAT MEANS 30V. ALL DEPENDS ON THE APPLICATION. IT IS THE ELECTRIC FIELD THAT MATTERS. AND THAT'S THE VOLTAGE ACROSS A DISTANCE (VOLTS PER MIL, OR KV/MM).

Where do high voltage engineers work these days? I was talking with a colleague recently about candidates for a volunteer opportunity, and we were wondering where the talented young engineers were going for employment. Sadly, many large corporations have closed down their dielectrics groups in the last decade or two. It seems that there have recently come a new group of opportunities for the budding high voltage engineer/ scientist. This includes national labs, space programs, military, universities, and colleges.

There is a resurgence of interest beginning in the dielectric engineer for industry, manufacturing companies, and of course utilities once again. Industry is realizing that they need that specialize engineer on their design team for new devices. This wide variety of job types for a small number of young engineers means there are a plethora of opportunities for moving to new jobs that appeal to the mind as well as the pocketbook.

Where can the high voltage engineer gain mentoring? I have been sitting in two days of standards meetings for the IEEE PES EMC Materials Subcommittee, where I have been active for over 25 years. I cannot say how much volunteering on these standards have affected my career. I get to rub elbows with a diverse group of engineers that are responsible for the various aspects of motor and generator insulating materials. These people are from around the world and have a wide variety of backgrounds and areas of expertise. I have learned so much from these shared experiences and the generosity of these people, and have both been mentored and have mentored others. Both are rewarding experiences. For any new young engineers, and those that have a few years or decades under your belt, volunteer. Join your local professional society chapter. Join standards committees. Share, learn, and exchange ideas and experiences.

We all benefit from this. And this is how technical details are transferred from the knowledge base. Sitting over a beer or a cup of coffee, sharing experiences, discussing deep technical concepts and even definitions.

As a final word, I was at a conference last month, listening to keynote lectures on dielectric innovations. Wow, what a wonderful, exciting time to be interested in being a high voltage or dielectrics engineer, as they are reaching into and creating wonderful new areas. Space travel. Nanocomposites and multiple applications. Way cool future there! But to me, the most amazing, and utterly surprising, was that someone was making an artificial muscle! The polymer reacts to a field and shrinks, essentially serving as a muscle. It is a "long" way to real life application but compared to the time of the "war of the currents" of Tesla and Edison, I'm sure the medical application is just around the corner. The future belongs to the young, bright, creative minds of the high voltage engineers that think differently than the standard engineer, and they that will pave the way to new modern marvels.

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FROM THE MANAGING EDITOR

Just a word about this author and this article. I admit I am heavily biased, given I think the author Dr. Nancy Frost is a genuine hero of the cause. From the times we lobbied Congress and the White House together on behalf of the Society of Maintenance and Reliability Professionals (SMRP) to the many times we met at conferences and laughed, learned, and shared; every time was memorable. Doc Frosty and her lab Frosty's Zap Lab, LLC (and yes, this is an endorsement, which I rarely do) are the real deal. This is such a great read.

I hope you enjoy it as much as I did. Alan.