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National Electrical Safety Code® (NESC) Standard

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Technical standards are formal documents that establish uniform engineering or technical criteria, methods, processes and practices developed through an accredited consensus process. The purpose of this publication is to help raise awareness of standards, show the importance of standards, present real-world applications of standards, and demonstrate the role you can play in the standards development process. Knowledge of standards and standards activities can help facilitate your professional engineering practice and improve technological developments to meet the needs and improve the lives of future generations.

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Letter from the Editor

Safety First

A Closer Look at National Electrical Safety Code® (NESC) Standard and Dealing With Disaster Recovery

We are back after a long break. No, we were not goofing off on a long summer break; to the contrary, we have been quite busy with the preparation for launching the Standards University. Hence the new look for Standards eZine, and the new home where you will find us in the company of some great resources. With all that is new, we also have a new member on our team, Ms. Tara Gallus. Tara has been immense help in bringing this issue together. I'm sure you will see the stamp of her personal touch in every article of this issue. For now, let me leave you at that because we have put together this issue with some really informative articles that everyone should read.

Did you know that National Electrical Safety Code (NESC) is more than 100 years old and is adopted not just in US but in more than 100 countries around the world? That it applies across the electrical industry from power generation to reaching the distribution point outside your home, office or factory? That it also applies to communication systems such as telephone, cable and even railroad signal systems and associated equipment? I did not know any of this information. I also learned (but not surprised) that IEEE has been the secretariat for NESC for 43 years, and the code is continuously revised to deal with all the advances in the technology as it relates to electrical power. Mike Hyland from NESC brings us quite an informative background on NESC in his article, and explains the importance of NESC in safety regulations and the roadmap for its future.

So why does it matter to you? In really simple terms, remember how dependent are you on having access to electricity? The laptop or tablet or whatever device you are reading this article on is feasible only because of electricity. No, not the 5V or 12V kind, but 110V or 220V kind; the kind that keeps your device's batteries charged. That power is generated, transmitted and distributed over thousands of miles on a grid, a network of poles and towers, thick cables and wires, transformers and circuit breakers, and much more that is often not visible to us as consumers. Creating and maintaining that infrastructure requires thousands of utility works, and their safety is paramount. That's the important role NESC plays in keeping all those people safe.

Now, what happens when a disaster strikes? One of the first impacts is loss of power, and the same electric utility workers mentioned above are out there trying to restore power as quickly as possible. NESC keeps them safe and helps us recover faster from the effects of a disaster. Jeff Handal has some first-hand experience in disaster recovery during hurricane Katrina. You bet he used several technical, communication and procedural standards in action during that time. He has nicely connected the emergency response and improving living conditions in a third-world country. You just never know how you can apply the knowledge gained from one experience to a completely separate, but very similar, situation. In this case it is standards used in the disaster recovery.

Oh, and what do Sun-spots, Geomagnetic Disturbances, transformer harmonics, patented technology and a standard have in common? Look no further than an expert engineer and a Fellow of the IEEE, Gary Hoffman, to explain to you in his article on protecting power grid from catastrophic geomagnetic events. That's how the regulations, patented technology, product development and standards interact in real life. It's up to you to engage in similar innovative work that crosses the boundaries between technology and business.

If you are a student or an educator, or someone looking at updating your knowledge in the field of NESC and related regulations, you should be looking at the MOOC (Massive Open On-line Course) to be offered by IEEE. Talk about 100 year old technology keeping pace with the latest internet based education. Shouldn't you keep up the same way? It will be a very comprehensive source of information, and yet, very easy to access because it is on-line. Of course, it's a MOOC. Duh!

Finally, if you are familiar with the safety code and are interested in contributing to NESC's revision tasks, contact Sue Vogel in IEEE-SA. Her article describes the process, but more importantly, invites you to join the working group and share your experience and expertise in updating the NESC documents. Collaborate with your peers and bring better safety to everyone.
Remember, Safety First!

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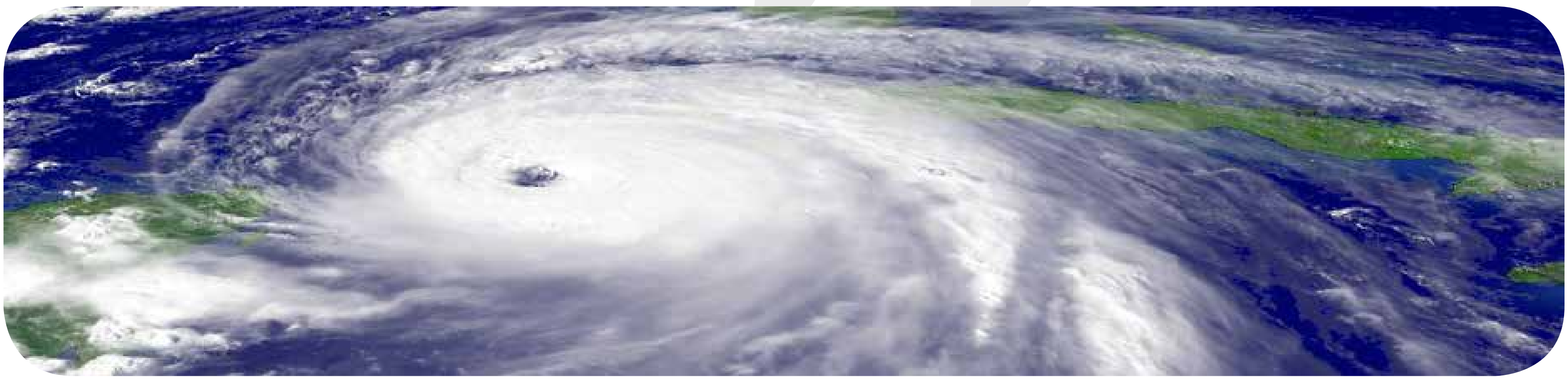
The Standard Response – Disaster Recovery

by Jeffrey J. Handal

What do VRRP[1], FEMA ICS-400[2], and IEEE 379-2014[3] have in common? They are all standards designed to mitigate some kind of emergency/failover situation. Technology plays a key role in our lives whether it means becoming more efficient at our jobs, allowing us to communicate with family members across the world, or simply using it for entertainment. Have you ever stopped to think of all that is involved in making this work? For instance, where does the electricity come from? How is it made? How does it make it to my device? Without this single element, all the great software in the world on your expensive device would not work. This really comes into perspective once you have been in a disaster situation.



Now, lets consider the emergency situation occurs, then what? Do standards have a role to play? Naturally, the answer is a resounding yes! In the last century, as we have learned to depend more on technology, standards have been introduced to help us sustain the life style we have become accustomed to. A classic story that shows the importance of standards during emergency responses is the great Baltimore Fire of 1904[4]. The level of response to put out the fire was great by the adjoining cities (i.e., sending their firefighters and firefighting equipment). Unfortunately, there was one problem: none of the out of town equipment would work with Baltimore hydrants. From this experience, the first early national standards started to appear to make sure all hydrants had the same type of standard connection for hose couplings.

The Baltimore fire is just an example of how the needs for standards have been born. When we speak of natural disaster preparedness, we are really narrowing ourselves to only a small segment of emergency responses. By forcing ourselves to think in the broader terms of business continuity, it allows you to grasp situations you would normally not consider that are very elemental and disruptive (e.g., a substation equipment failure; a burst water pipe; an electromagnetic pulse (EMP)). These are all man-made situations that take us down the same road of emergency response. By forcing ourselves to think of these events and coming up with standards (technological or procedural) will allow us to mitigate these occurrences. In other arenas, engineers have tried to foresee and prevent similar situations. For example, in the event of radio system aircraft failure, the procedure to land safely and communicate between tower and the pilots of the aircraft is through color-coded flashing lights that have been standardized to mean something specific across the world.

Having lived through Katrina and experienced the emergency response to such a large-scale natural disaster, it really put standards into perspective as how vital their role is. In the aftermath of the storm, the Louisiana State University (LSU) Office of Telecommunications had little time to react and prepare for a response so quickly. Literally, overnight, because we produced our own electricity, had hardened communications systems (i.e., IP networks and old analog radio systems), and a "standard" for responding to blackouts, we became the center of operations for the entire response. Having a set of known standards as a basis ensured the timely, coordinated, and effortless response to properly setup functioning telecommunication systems for our operation and those required for the government response team. Communication systems were key to improving and savings lives.

It is uncanny to think of the similarities and parallels between living through an emergency situation and living in a third world country. For example, how do you provide disease diagnosis when no lab equipment is available? If you can develop a standard, portable lab that can aid in such a task, you just helped solve a very important riddle. For those researchers out there, instead of waiting for the disaster to happen, third world countries provide a perfect test bed. The added benefit is that you are improving human lives as well – a rarely thought of byproduct of creating and using standards.

Standards also bridge the gap between technology and different sectors of society. A great example of standards fostering a sense of community is the Santa Clara County emergency response system in California: Civil Air Patrol (CAP) with their eyes from the air, the local ham radios operators with their ears over the radios waves, and the county government agencies ensuring the safety of everyone. The underlying glue for this to happen are the standards that allow ham operators to talk to each other; the semiconductor business that allowed the creation of components in the airplane and radio systems;

and the "standard" steps in place between government agencies and society groups to respond to situations (e.g., earthquakes). Another example of technological standards helping others in time of need is NetHope5 –telecommunication professionals come together to put the standards (e.g., IEEE 802) they know and love to good use.

As we have briefly reviewed, standards show up in all shapes and sizes. Whether it is on the technology front in the way we make things, or the procedures we follow to communicate and coordinate tasks between humans, they play a key role to ensuring our survival in mitigating the gravity of a situation. Students, researchers, and hobbyists, next time you are working on a project, remember to include standards in your ventures. They will help make your project more robust and meaningful. If a standard is not available in your line of work, help drive and create one. Who knows, your standard may help save a life one day. And remember, standards are key in ensuring human survival.

References

1. Virtual Router Redundancy Protocol (VRRP)
2. FEMA Incident Command System (ICS) Classes
3. 379-2014 – IEEE Standard for Application of the Single-Failure Criterion to Nuclear Power Generating Station Safety Systems
4. Baltimore Fire of 1904
5. NetHope

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The National Electrical Safety Code ® (NESC®) in Disaster Covery

by Mike Hyland, © Baloo, Jantoo.com

Commonly shared, standardized rules defining how various utility workers of different disciplines and regions can work together safely are critical for a long list of good reasons. Their value in disaster recovery is near the very top.

Language, engineering controls and other aspects can vary substantially among the different types of utility workers who share joint structures. For example, while different power and communications workers presumably might work out issues of conflict as they arise on an ad-hoc, case-by-case basis, cooperating within the parameters of the National Electrical Safety Code® (NESC®) makes working together both safer and more efficient. This is especially true when working outside of their own home regions and ensuring that all workers adhere to the correct clothing requirements, minimum approach distances and fall protection. The value of being able to refer to shared safety guidelines is magnified in scenarios that inherently introduce unknown factors, such as disaster response in unfamiliar territory.

For utility workers in almost all of the United States and many other nations around the world, the NESC—in particular Part 4: Work Rules—provides an established, well-known and proven rallying point that successfully works within its scope to help protect not only those workers but also the general public during the installation, operation and maintenance of electric supply and communication lines and their associated equipment.

Contributing to Worker and Public Safety for More Than a Century

For both public and private utilities, the NESC specifies best safety practices for electric supply and communication systems such as telephone, cable and railroad signal systems (and their associated equipment). The more-than-100-year-old code is applicable from the generation of power or communications signals, all the way to the customer "service point," which is the point of transfer to a premises wiring system

The NESC is among the most widely adopted safety codes. Almost all of the U.S. states leverage the code in whole or part via legislative, regulatory or voluntary action, and approximately 100 countries around the world use the NESC in some way.

The IEEE Standards Association (IEEE-SA) offers a range of e-courses that pertain to NESC usage in the field, including: Introduction to Application of the NESC and the Grandfather Clause

- Introduction to Electric Supply Stations
- Introduction to Overhead Clearances Between Wires at Supports and Midspan
- Introduction to the NESC Overhead Clearances to Ground
- Introduction to the NESC Overhead Strengths and Loading

More information on the e-courses is available at http://standards.ieee.org/findstds/prod/tut/index.html#nesc.

There are many other training opportunities in support of the NESC in its entirety, but also specifically for only the changes in the NESC from edition to edition. Many of these are external to IEEE, provided by educational institutions, lineman colleges, consulting companies, in-house programs and individuals that specialize in teaching of the NESC, both publically and privately. Sometimes, it is members of the NESC that participate in the development of the code who independently perform the training, providing in-depth insight into how NESC rules evolve. There have been opportunities where NESC members have provided preliminary information on proposed changes to the NESC at IEEE workshops or panel sessions in conjunction with the IEEE Power & Energy Society meeting. With the NESC becoming effective six months after its publication date, there is adequate time for workers to become up to speed on the latest NESC changes.

Also, the NESC is often cited in apprentice programs, all-hands safety meetings, safety manuals, spot checks to ensure regulations are adhered to, "tailboard discussions" and other aspects of the holistic safety programs that utilities today employ. For utility workers of all types and in many different markets, the NESC is pervasive in their daily work and helps create a Culture of Safety required in out ever-changing industry.

Participating in the Code's Ongoing Refinement

Since 1972, IEEE has served as secretariat of the NESC, and, as the standards and collaborative solutions arm of IEEE, the IEEE-SA oversees the structured process that plays out over five years, during which the code is continually revised through open collaboration. Work on the 2017 edition is well underway. A proposed revision of the NESC, Accredited Standards Committee C2, is scheduled to be submitted to the NESC Committee by Jan. 15, 2016, for letter ballot, as well as to American National Standards Institute (ANSI) for concurrent public review, resulting in the 2017 edition of the NESC.

Continuing upon the code's first 100 years of success, the open, collaborative effort to ensure that the NESC remains a relevant, up-to-date resource never stops. In fact, today it is expanding. Not only are its shapers at work today on readying the next, 2017 edition, they also have broadened the conversation to look at how the NESC might need to evolve to address the needs of the coming decades.

A summit in April 2015, for example, brought the NESC's shapers together to imagine the code's next 100 years? What emerging issues in resiliency, safety, reliability, installation, operation and maintenance might impact its evolution? How might the NESC change over the next three, four or five editions? What needs to be addressed that is not currently supported? How can the code support agile, timely responsiveness to rapid changes in the industry and field? These were the types of far-reaching questions the summit addressed.

For example, among the topics discussed was the various disasters that can present significant safety threats, as well as losses in the tens of billions of dollars, and how the NESC relates to the issue of disaster preparedness and response. Prioritizing safety, reliability and resiliency, including the effectiveness and efficiency of current best approaches to disaster response and the customer and regulatory benefit of codes and standards for supporting resiliency efforts, were discussed.

Conclusion

The NESC has been in continuous use since August 1914, and, more than a century later, there is an intense, never-ending effort to ensure it remains a vital and relevant resource protecting utility worker and public safety.
To learn more about the code's history and how you can contribute to its future, please visit http://standards.ieee.org/about/nesc/.

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International Software Engineering Standards

by Claude Y. Laporte

International Software Engineering Standards Applied in Undergraduate and Graduate Software Quality Assurance Courses

Abstract

At the École de technologie supérieure (ÉTS), an 8000-student engineering school, software quality assurance (SQA) is taught in the undergraduate and graduate software engineering curricula. The course includes a 10-week project in which teams of students apply the SQA practices taught in class in a software development project. A new international software standard, ISO/IEC 29110, has been used in the team-projects. This standard as well as a set of management and engineering guides have been developed specifically for very small projects and organizations. Throughout the 10-week project, student-teams collect measures, such as the number of defects and the rework effort, and the performance of each team is analyzed. This analysis allows discussion to take place on the impacts of SQA practices as a way to support the development of quality software on time and within budget.

Introduction

Systems and software are growing larger and more complex every year. For example, mainstream cars have about 20-30 million lines of code and, top-of-the-line cars contain up to 100 million lines of code (Fleming 2014). According to Humphrey, it has been found that developers typically inject about 100 defects into every 1,000 lines of the code they write (Humphrey 2005). Defects are not injected just in code, defects are unfortunately also injected, amongst others, in the requirements document, the architecture. There is a tremendous challenge to detect and correct the defects, especially defects of software critical components such as the braking system, before consumers use the cars. Therefore, a signification portion of the software development budget is allocated to the detection and correction of these defects. As reported by Charette, software specialists spend about 40 to 50 percent of their time on avoidable rework (Charette 2005). Software quality assurance (SQA) provides many software engineering practices needed to produce quality at the level of world class organizations having a defect escape rate of about 1 defect per 1,000 lines of code (Nolan et al 2015).

The École de technologie supérieure (ÉTS), an 8000-student engineering school of Montréal, began offering its graduate software engineering program in 1997 and its undergraduate software engineering program in 2001. The professor who designed the SQA

courses has a combined industrial experience of more than 20 years, mainly in the defense, and transportation sectors. The aim of the SQA courses, which are mandatory in the ÉTS undergraduate and graduate software engineering curricula, is to ensure that software engineering students are aware of the importance of SQA, and that they understand and are able to apply SQA practices in a wide range of organizations (e.g. size and business domain). This also includes hands-on knowledge of the key ISO and IEEE standards, as well as how to use SQA tools. The courses allow students to apply a wide range of SQA practices throughout a software development cycle in a software development project simulating a mature industrial environment.

Software development companies of the Montréal area, where the ÉTS is located, were surveyed. As illustrated in Table 1, and it was found that close to 80% of software development companies have fewer than 25 employees. The survey also showed that over 50% of companies have fewer than 10 employees.

Table 1: Size of Software Development Companies in the Montreal Area (Translated from Gauthier 2004)

Size (Employees)	Number of Software Enterprises	Percent of Software Enterprises	Number of Jobs	Percent of Jobs
1-25	540	78%	5,105	29%
26 to 100	127	18%	6,221	36%
over 100	26	4%	6,056	35%
TOTAL	**693**	**100%**	**17,382**	**100%**

The large percentage of small organizations is not unique to the Montréal area. In Europe for instance, over 92% of enterprises, called micro-enterprises, have up to 9 employees and another 6.5% have between 10 and 49 employees. Micro enterprises account for 70% to 90% of enterprises in the Organisation for Economic Co-operation and Development countries and about 57% in USA (OECD 2005). The SQA courses of ÉTS have been designed having in mind that a high number of our graduates will work in micro, small and medium enterprises or in small and medium scale projects of large organizations.

Software Quality Assurance Courses
The SQA undergraduate and graduate courses are composed of thirteen 3-hour lectures as illustrated in table 2[1]. The graduate and undergraduate courses are quite similar since they are targeted at students that have not taken an SQA course before. Each lecture topic is illustrated with industrial examples, international or professional standards, and weekly reading assignments (in French (April 2011) and (Laporte 2011), in English (Laporte 2016)). To ensure that students grasp the importance of SQA activities, the concept of business model (e.g. the risks associated to a business domain) and the cost of quality (e.g. prevention, evaluation, rework effort) are stressed throughout the course.

The topics are described in more details in (Laporte 2013b)

Table 2: List of SQA Courses Topics

Lecture	Course Title
1	Introduction (Business models)
2	Quality culture (Cost of Quality, IEEE Code of ethics for software engineer)
3	Quality requirements
4	Standards and models
5	Software reviews
6	Software audit
7	Verification and validation
8	Configuration management
9	Policies, processes, and procedures
10	Measurement
11	Risk management
12	Management of suppliers and contracts
13	Software quality assurance plan

Many standards are presented in the SQA course. As an example, the IEEE-1028 (IEEE 2008) is used to cover the reviews and audit topics, the IEEE-1012 (IEEE 2012) is used to cover the verification and validation topic, and the IEEE standard for software quality processes, IEEE-730 (IEEE 2014), is used to cover many topics of the SQA courses.

The quality requirements topic of the SQA courses is composed of 3 subjects: models of software quality, definition of software quality requirements and traceability of requirements in the software life cycle. The ISO/IEC 25010 (ISO 2011a) standard defines two quality models: quality in use and product quality. As defined in ISO 25010, quality in use is the degree to which a product or system can be used by specific users to meet their needs to achieve specific goals with effectiveness, efficiency, freedom from risk and satisfaction in specific contexts of use. In ISO 25010, the product quality model categorizes product quality properties into eight characteristics (functional suitability, reliability, performance efficiency, usability, security, compatibility, maintainability, portability). Each characteristic is composed of a set of related subcharacteristics. As an example, the reliability characteristic, which is defined as the degree to which a system, product or component performs specified functions under specified conditions for a specified period of time, is composed of the following four subcharacteristics: maturity, availability, fault tolerance and recoverability.
Students that do not use a software development framework, such as ISO/IEC 29110 presented in the next section, are often amazed that their own project data may reveal a percentage of rework of 50%, and sometimes even up to 70%. Students of the SQA courses are required to continuously measure the cost of rework in their team projects. They are also required to analyze their data and draw conclusions about the cost/benefit of SQA practices.

Overview of ISO/IEC 29110
ISO/IEC 29110 has been originally developed for a vast majority of very small entities (VSEs) that do not develop critical systems or critical software (Laporte et al 2008). A VSE is defined, in ISO/IEC 29110, as an enterprise, an organization, a department or a project having up to 25 people.
ISO/IEC 29110 provides VSEs with a four-step road map or also called 'Profiles'; the four profiles of ISO/IEC 29110 are: Entry, Basic, Intermediate and Advanced (ISO 2011b). VSEs targeted by the Entry profile are VSEs working on small projects (e.g. at most six person-months effort) and for start-up VSEs. The Basic profile describes development practices of a single application by a single project team of a VSE. The Intermediate profile is targeted at VSEs developing more than one project with more than one team. The Advanced profile is target to VSEs that want to sustain and grow as an independent competitive business.

At the request of the ISO working group mandated to develop ISO/IEC 29110, technical reports and guides are available at no cost from ISO. The Management and Engineering Guides, the most valuable documents for VSEs, have been translated in French, in Portuguese, Czech and in Spanish. Japan has translated and adopted ISO/IEC 29110 as a Japanese national standard and a German version should be part of the catalogue of the German standard organization DIN[1]. The reader who would like to read more about the standards and guides is invited to consult the articles publicly available on the public web site of the ISO/IEC 29110[2].

[1] Deutsches Institut für Normung

[2] http://profs.etsmtl.ca/claporte/English/VSE/index.html

Figure 1 illustrates the two processes of the Basic profile of ISO/IEC 29110, as described in the Management and Engineering guide (ISO 2011c), for VSEs developing software: the Project Management (PM) process and the Software Implementation (SI) process. Each process is composed of a set of activities and each activity is composed of a set of tasks.

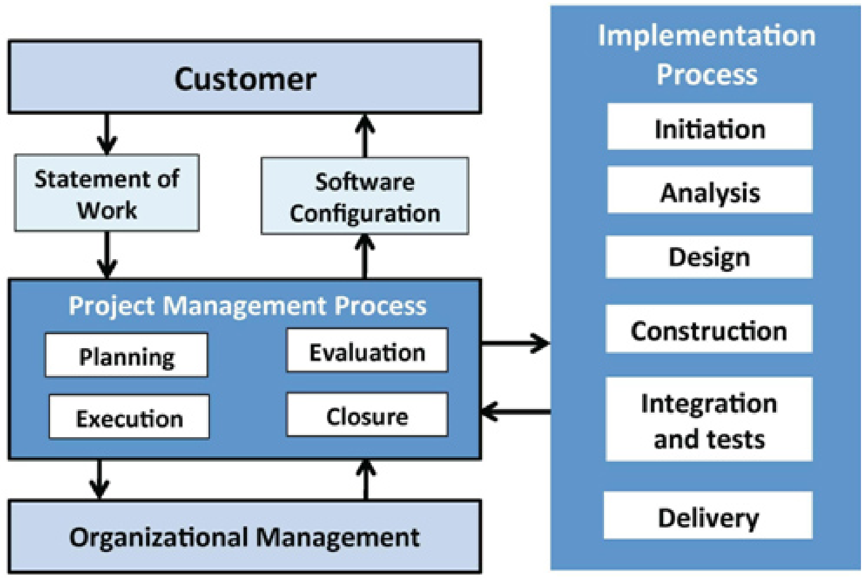

Figure 1. Project Management and Software Engineering Processes of ISO/IEC 29110 (Laporte et al 2013)

The ISO working group mandated to develop ISO/IEC 29110 decided to include a project management process since it is a weakness of many VSEs and their financial success depends on successful project completion within schedule and on budget, as well as on making a profit. The other process of ISO/IEC 29110 is the process, titled software implementation process, dedicated to the development of a software product and its documentation.

For illustration purposes, one task of the ISO/IEC 29110 Project Planning activity is listed in Table 3. On the left side of the table are listed the roles involved in a task. The Project Manager (PM) and the Customer (CUS) are involved in this task. On the right side on the table, we listed the product required as an input to perform a task as well as the products produced by a task. All tasks are described using this format in the management and engineering guides.

Table 3. Example of 1 Task of the Project Planning Activity (ISO 2011b)

Role	Task List	Input Products	Output Products
PM CUS	PM.1.2 Define with the *Customer* the *Delivery Instructions* of each one of the *Deliverables* specified in the *Statement of Work*.	Statement of Work *[reviewed]*	Project Plan Delivery Instructions

Deployment Packages to Facilitate the Implementation of ISO/IEC 29110

A novel approach taken to assist VSEs with the deployment of ISO/IEC 29110 and to provide guidance on the actual implementation of the Management and Engineering Guides in VSEs, a series of Deployment Packages (DPs) have been developed to define guidelines and explain in more detail the processes defined in the ISO/IEC 29110 profiles. The elements of a typical DP are: description of processes, activities, tasks, steps, roles, products, templates, checklists, examples, references and mapping to standards and models, and a list of tools. The mapping shows that a deployment package has explicit links to standards, such as ISO/IEC/IEEE 12207 (ISO 2015), or models, such as the CMMI® for Development (SEI 2010). By implementing a DP, a VSE can see its concrete step to achieve or demonstrate coverage to ISO/IEC 29110.

DPs were designed such that a VSE can implement its content, without having to implement the complete framework, i.e. of the management and engineering guide, at the same time. For the Basic profile, as illustrated in figure 2, a set of nine DPs has been developed and are freely available[1].

[1]http://profs.logti.etsmtl.ca/claporte/English/VSE/index.html

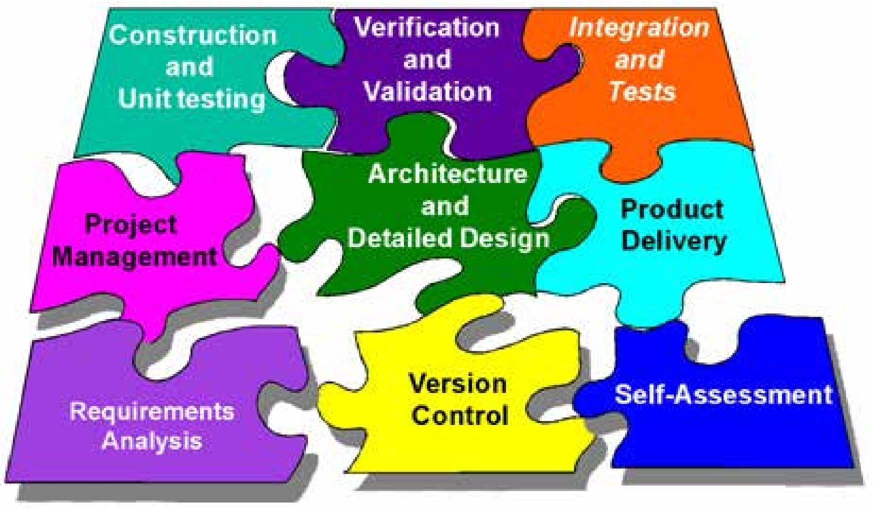

Figure 2. Deployment Packages to support the Software Basic Profile (Laporte 2008)

In the next sections, we describe how ISO/IEC 29110 standard was used by undergraduate and graduate students in implementing software engineering practices in a team-project.

Student Team-Project

Students embark on a project in teams of four students for a period of ten weeks where they must apply the SQA practices presented in the course, using the Basic profile of ISO/IEC 29110 as the framework for their software development project. Professors of the SQA courses randomly select the members of each team, to simulate an industrial context where an employee doesn't usually choose his teammates. At the start of the project, the teams receive a copy of the Statement of Work (SOW), which they use to develop the project plan. The professor plays the role of the president of the Acme manufacturing company and the student teams play the role of the software developers of Acme. At the beginning of the project, the president gives to the teams a SOW describing the functionalities to be developed. To reflect the reality of any organization, a few 'defects' have been intentionally inserted in the SOW. As an example, a SOW listed the functionalities of a new model of a washing machine that the president of Acme wants to produce. As an example, four washing cycles were described (e.g. soaking time, washing time, water temperature). In the description of one washing cycle, the water temperature was given in Fahrenheit (F) instead of Celsius (C). During that project, once the architecture was finalized, the president came to the developers with a change request impacting a few documents of the project already delivered by the teams (e.g. project plan, specification, architecture). At another stage of the project, teams were given the high-level schematic (black-box) of the hardware of the new washing machine (e.g. microcontroller, display, sensors, actuators). Students were required to write code components that would turn on/off actuators and read data from digital sensors. To simulate a real development environment where mistakes are made, one hardware component had been 'omitted' in the schematic. This 'omission' required the students to initiate a second change request. From one semester to another, only the SOW has to be changed. As an example, a SOW for the development of software for a rice cooker and a crockpot (i.e. a slow cooker) were provided to student teams.

The course website lists the objectives and deliverables for each of the ten-week project. The site also contains all the templates required to produce the deliverables. The templates list the content of the documents required by ISO/IEC 29110, such as the project plan and the specifications of the software. The site also includes descriptions of the various types of reviews they have to perform (e.g. desk check, walkthrough) and the forms for registering defects, they detected during reviews.

During the planning phase of the project, the students in a team must share the following roles, as defined in ISO/IEC 29110: analyst, designer, programmer, technical lead, and project manager. At the beginning of the project, the four-team members must also complete and sign a 'contract' that specifies the roles of each participant, the deliverables of each team member, the expectations of each participant, and the operating rules which they agree to respect.

Teams must estimate the effort that will be needed by each member to carry out the activities and deliverables required by ISO/IEC 29110. These estimates are recorded on a spreadsheet, and every week members of the team must record the hours they have worked on defined project activities. Also, students must record their rework effort.

During the first week of the project, students are also required to select and install the tools they will use during the project. For example, they must choose and install a document repository tool, a version control tool, and an issue tracking tool.

Table 4 describes the 6 parts of the SQA student team-project that map to the management and engineering guide of ISO/IEC 29110. The 6 parts of the project are synchronized with the weekly lectures and reading assignments.

Table 4: The SQA Team-Project (Adapted from Laporte and April 2013b). Please click on each part to expand that section.

Part 1 - Project Planning and Installation of the Work Environment

Objectives
- Perform the "Project planning" activity according to the Basic profile of ISO/IEC 29110, perform a desk check (review) of the project plan;
- Select tools and set up the working environment (e.g. a version control tool and an issue tracking tool);
- Customize the measurement spreadsheet for the measurement of effort and the cost of quality for the project.

Deliverables
1. Project plan: • Profile of freedoms/constraints • Identification of the criticality of the project • Roles and responsibilities of team members • Version control strategy • Delivery instructions
2. Work environment [*installed and tested*]
3. Contracts among team members
4. Defect registration form (desk check of the project plan)
5. Measurement spreadsheet tailored to this project. [*updated with current data*]

Part 2 - Analysis and Documentation of Requirements

Objectives
- Perform the "Software requirements analysis" activity of ISO 29110;
- Perform a walkthrough (review) to verify the specifications before they are submitted to the customer for approval.

Deliverables
1. Functional and nonfunctional requirement specifications [*verified and baselined*]
2. Audit results (audit performed by teaching assistant)
3. Anomaly registration form
4. Validation results
5. Software user documentation [*preliminary*]
6. Measurement spreadsheet [*verified, baselined*]

Part 3 - Software Architecture and Detailed Design

Objectives
- Perform the "Create the architecture and the detailed design" activity of ISO 29110;
- Perform a walkthrough to verify the architecture.

Deliverables
1. Software design [*verified, baselined*]
2. Verification results of the architecture document
3. Anomaly registration form
4. Traceability record [*verified, baselined*]
5. Test Procedures and test cases [*verified*]
6. Measurement spreadsheet [*verified, baselined*]

Part 4 - Software Construction

Objectives
- Perform the '"Construction, implementation, and evaluation" activities of ISO 29110;
- Perform a walkthrough to verify the components developed.

Deliverables
1. Software components [*corrected, baselined*]
2. Correction register (if necessary)
3. Anomaly registration form
4. Analysis of measures collected and recommendations
5. Traceability record [*updated, baselined*]
6. Change request form [*ready to be signed by the customer*]
7. Measurement spreadsheet [*verified, baselined*]
8. Progress status record [*evaluated*]
9. Analysis of measurements collected and recommendations
10. Analysis of the cost of the quality measures collected

Part 5 - Software Integration and Tests

Objective
- Perform the "Integration and testing, execution, and evaluation" activities of ISO 29110.

Deliverables
1. Test procedures and test cases (updated if necessary) [*baselined*]
2. Software (i.e. components developed in the previous activity have been integrated) [*tested, baselined*]
3. Traceability record [*updated, baselined*]
4. Test report [*baselined*]

5. Product operation guide [*verified, baselined*]
6. User documentation [*verified, baselined*]
7. Measurement spreadsheet [*verified, baselined*]
8. Progress status record [*evaluated*]
9. Correction register (if necessary)

Part 6 - Product Deliver and Project Completion

Objectives

- Perform the "Product delivery" activity;
- Conduct a lessons learned review of the project.

Deliverables

1. Maintenance documentation [*verified, baselined*]
2. Software configuration [*delivered*]
3. Correction register (if required)
4. Acceptance form [*signed by the customer*]
5. Software configuration [*accepted*]
6. Measurement spreadsheet [*verified, baselined*]
7. Information repository [*updated*]
8. Report on lessons learned

As described in ISO/IEC 29110, a traceability matrix is developed to connect the requirements, to the architecture, to the software components and to the tests. One advantage of a traceability matrix is the rapid identification of the software components impacted when requirements are modified, added, or deleted during a project. A fragment of a traceability matrix is presented in Table 5.

Table 5: Traceability Matrix

Traceability Matrix

Date (yy-mm-dd): ___________

Title of project: ___________________

	Name (Print)	Signature	Date (yy-mm-dd)
Verified by:	________	________	________
Approved by:	________	________	________

Identification Number	Text of the need	Text of the requirement	Verification method	Title or ID of Use Case	Title or ID of Code Module	Title or ID of test Procedure	Verification Date	Person who performed the verification	Result of verification

In addition to the documents required by ISO/IEC 29110, students have to produce a lessons learned report and an analysis of the metrics collected. This report captures, from their point of view, what went well, what could have been done better and what surprised them during the 10-week project.

Conclusion

Many changes have been made to the SQA courses since they were initially set up over 10 years ago. One main objective was to get undergraduate and graduate students not only to learn from our textbooks but to apply SQA practices in a team-project, simulating a mature industrial environment, using an appropriate framework such as the management and engineering guide of ISO/IEC 29110.
The SQA lectures and laboratory sessions provide a solid foundation for software engineers and software developers, even though SQA is still perceived as a low priority by many software development organizations. The software engineering practices of the SQA courses of ÉTS help organizations of all sizes in achieving very low defect escape rates of world class organizations, such as Rolls-Royce, which has achieved an overall defect removal effectiveness of 90% and a defect escape rate of 0.03 defects per 1000 lines of code (Nolan et al. 2015).

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The NESC® and the New Fontier of Education Technology: The MOOC

by Ernesto Vega Janicac

As technology evolves, so does education and training. Adapting to new venues and communication tools is a constant challenge for all stakeholders, especially for professional organizations that foster technological innovation and excellence, such as IEEE and other standards development organizations (SDO).

In anticipation of the publication of C2, National Electric Safety Code® (NESC®), 2017 edition, education experts and standards professionals are working together to leverage technology, research, and recommendations to integrate MOOCs (massive open online courses) and other training materials into our technical community. What is and what is not a MOOC has been the topic of multiple papers and discussions and will not be reiterated in detail here.

A global consensus presented in a unified tone

Imagine a massive public educational program teaching safety and regulatory standards, in this case, the NESC. This is a remarkable milestone for the global technical community and for the professionals contributing to all of our standards. As pioneers on safety, the NESC technical committees have provided valuable contributions for over 100 years and now, with the sponsorship of IEEE, they will be pioneers in the world of massive open online courses, or MOOCs.

A primary goal of the NESC MOOC will be to provide a unified message in a timely and comprehensive fashion to all participants, which in the case of a MOOC, may vary from a couple of hundred to several thousand participants. Thus, the MOOC will be a preferred instrument for transmitting the standard's content (that is, technical global consensus) in a direct unified format.

How can it be achieved?

There are many ways of providing online courses. One of the most cost-effective is using existing IT platforms as a backbone and making necessary arrangements to handle the requirements of massive open courses.

Proper planning and collaboration with technical experts, as well as with MOOC providers, will be needed in order to get it done right. Failure to provide timely and comprehensive sessions by poorly designed courses, or during any particular session, could mislead participants or open the door for misuse and misinterpretation of the standard's content. Therefore, planning will be rigorous and the IEEE Standards Association and IEEE Educational Activities will jointly oversee the production of all course material. The main development milestones are summarized in Figure 1.

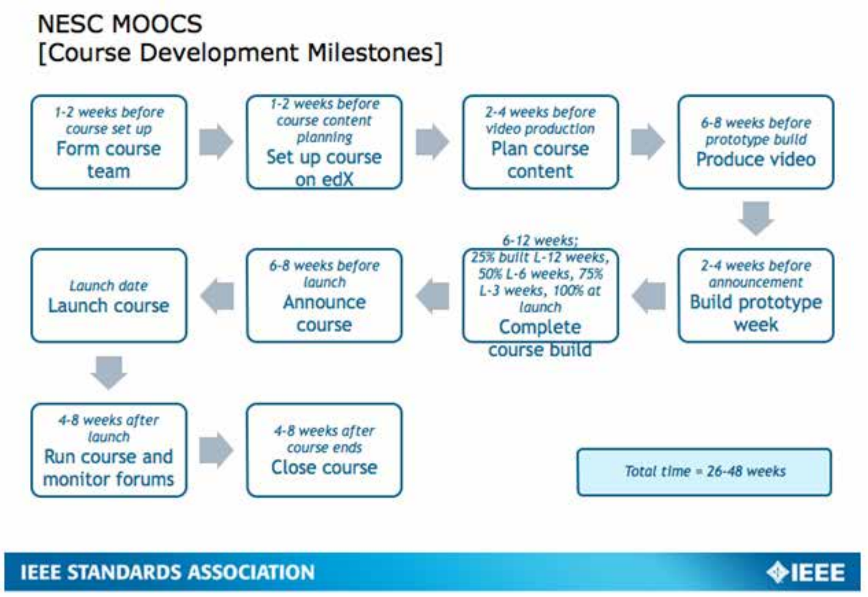

Figure 1. Course Development Milestones.

What is a MOOC?

Briefly, a MOOC comprises four qualities:

M-Massive: With more than 7,000 registrants in one of our earliest MOOCs[1], the capabilities of IT resources have been put to the test, and passed with flying colors.

O-Open: There are no pre-requisites for participants other than access to a computer or mobile device and connection to the Internet. Students and professionals, even those not in the electrical engineering field, will be able to access the courses. Also, the participation of code enforcers, researchers, standards development representatives, and other interested parties is expected. Everyone is invited. Access to our initial MOOC was free. For future MOOCs, administrative fees may be required for processing certificate and/or CEU credits.

O-Online: Courses can be transmitted partially or entirely via the Internet. The more video content, the more broadband will be required from the participant's Internet connection.

C-Courses: One of the characteristics that differentiate MOOCs from most other open educational resources is that they are organized into a complete course over a series of sessions on a specific topic, in this case the NESC.

Topics, Metrics, and the Road Map for Improvement

The relevance of the topic is a key element for a successful

MOOC. Fortunately, the NESC is a magnificent source of technical and safety material for presentation via MOOC. An overview of the tentative NESC MOOC is summarized in Figure 2 and Figure 3.

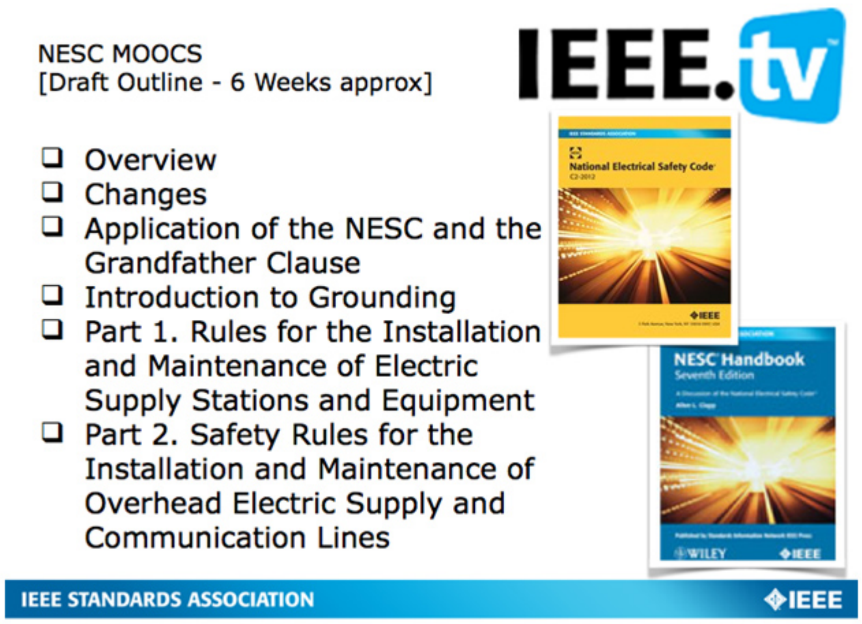

Figure 2. An Overview of the NESC MOOC.

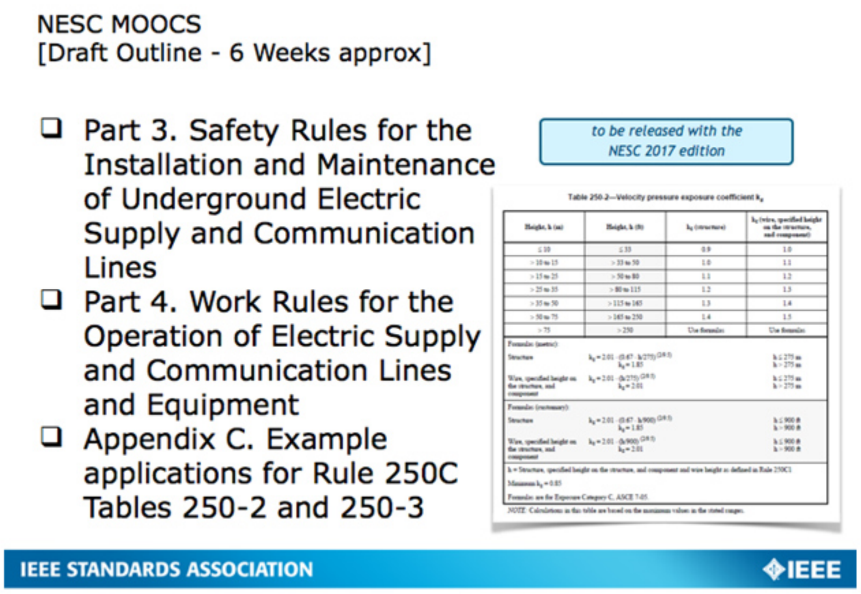

Figure 3. An Overview of the NESC MOOC. Cont.

Success will be measured with new IT analytics and metrics, such as history logs, data transmission indexes, internet connection/crash reports, etc. IEEE IT infrastructure allows collection of all that data. This will help identify hot topics as well as those topics or sessions where participants struggle. This knowledge will then add significant value to the standards development process, as well as refining and improving the participant experience.
The road map for improvement and refinement will be inclusive and open. In some cases, sessions will need special assistance due to geographic location where participants are situated; others will need special features and supportive documentation based on education level (high school diploma, college, advanced degree, etc.) or based on the age of the participants, or other criteria. Translation to other languages will be evaluated after the first couple of sessions are released in English.

User Interface, Feedback, and Networking
Currently being designed, the user interface will be interactive and will allow for constant communication and feedback between participants, as shown in Figure 4.

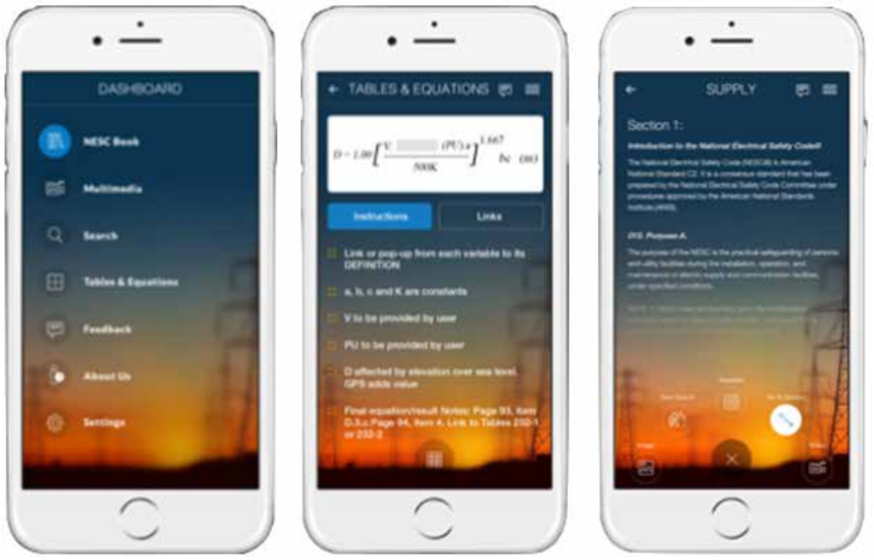

Figure 4. Draft sample of the NESC Mobile App and MOOC interface.

Formal Code interpretations and even historical reports could be shared and discussed among participants, which will expand networking opportunities and collaboration.

To conclude, it is essential to recognize the multiple challenges involved in developing a successful MOOC. Through intelligent topic selection and advanced technological features, IEEE is committed to providing an unprecedented experience to those interested in the NESC areas of expertise.

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Protecting the World's Power Grid from a Catastrphic GMD Event

by Gary Hoffman, © Baloo, Jantoo.com

It all began on April 1, 2009 at the Doble Clients Conference in Boston, Massachusetts, with a curious visit by George Wood of Dominion Virginia Power Company (DVP). The company where I am President and CEO, Advanced Power Technologies, manufactures transformer monitoring equipment sold to electric utilities. I was discussing a new product we had under development that would do some interesting things including measurement of AC current harmonics on power transformers. At the time I was aware of an issue with more reliably start cooling on a certain type of older but very important power transformers. This resonated with George who at the time was the manager of Electric Transmission Substation Operation for DVP. As we talked, George brought to my attention another problem DVP and other utilities were facing: detection of the effect of Geomagnetically Induced Currents (GIC) on their fleet of important power transformers. He indicated that GIC may cause an abundance of harmonics which a device like ours could detect and thought that had value.

We continued to talk and in the ensuing months met in Richmond, Virginia to discuss the issue with some of their engineers tasked to look at the vulnerability of the DVP transmission system when GIC is present due to a significant Geomagnetic Disturbance (GMD) from our Sun. A GMD occurs from sun spot activity. Sun spots are darker and hence cooler areas of the Sun. Sun spots occur when the sun's magnetic field becomes non-uniform. This allows solar flares to occur that throw out Hydrogen and Helium ions into Space. This phenomenon is known as a Coronal Mass Ejection or CME. It was clear from our discussion that there was no consensus of how to detect if an event may cause a problem. In the past, CME's have caused problems in the Power Grids of North America (1989) and Europe (2003). These events caused blackouts and great concern about the Grid's vulnerability. Further the most significant GMD event known as the Carrington Event after a British astronomer studying sun spots, occurred in 1869 when people saw the Aurora Borealis in the Caribbean and Hawaii and telegraph systems operated without their batteries. The conclusion of our discussion was that detection was important and certain harmonics may be important to detection but what were they?

We introduced our new product called ECLIPSE, coincidently not named for the Sun, with harmonic detection and we sold a few systems for the purpose of detecting GMD events. While visiting one of our customers who decided to try it, I observed the presence of the very harmonics being touted as indicative of a GMD event. However, that day the readings from the various magnetometers that the National Oceanic and Atmospheric Administration (NOAA), who was responsible for reporting space weather, were very low. As it turned out the power transformer was feeding a server farm used by one of the larger Internet retailers. These server farms have large UPS battery backup systems that are notorious for generating copious amounts of harmonics. That was a seminal moment as the method chosen would never be reliable and there had to be a better way.

It was now the winter of 2012 and I gathered my Engineers for another brainstorming session on the topic of GIC detection. As we reviewed what we knew, we started to examine some IEEE Transaction Papers, of which there were many on the subject. We decided to look only at those that reported results from actual physical events. There it was hiding in plain sight! The transformer core could be seen to saturate when the GIC was high enough and the harmonics associated with every one of these events had a specific pattern: The even harmonics were greater than the odd harmonics! We next formulated a detection algorithm and built a prototype to test our idea. Commensurate with that activity we began to work on a provisional patent filing in April 2012 to protect our idea. Satisfied from our tests that our idea would work, we proceeded to work with our Patent Counsel to file a U.S. Patent Office (USPTO). On January 8, 2013 we filed our patent with the USPTO and on April 28, 2015 the US Patent Office granted Patent 9,018,962. This was good timing because the United States Federal Energy Regulatory Commission or FERC, issued Ruling 779 calling for Electric Utilities interconnected in North America had to develop operating procedures, a vulnerability assessment and mitigation strategy in event of a significant GMD.

The IEEE has many Societies and Technical Committees that are involved in Standards development through the IEEE Standards Association. Many Standards are created by these Societies and Technical Committees that impact what we Engineers do on a daily basis. As a Member of the IEEE Power and Energy Society's Transformer Committee, we took the initiative to answer the need for a comprehensive guide to answer the call to satisfy Grid operators across the World. In March 2014, a Project Authorization Request (PAR) was approved by the IEEE Standards Association for a new guide PC57.163 titled: Guide for Establishing Power Transformer Capability while under Geomagnetic Disturbances. In the Guide, the Working Group participants felt it important to cover the monitoring of GIC as well as harmonics. In an effort to share our technology, my Company filed an accepted Letter of Assurance (LOA) in May 2014 for the use of our technology for a reasonable and non-discriminatory (RAND) license. This enabled implementers of the Guide to have a reliable method to alert Grid operators when a vulnerable power transformer may have an issue.

I am pleased to report that in September 2015, IEEE Std™ C57.163 was approved by the IEEE Standards Association for publication making this unique technology available to improve the Grid's reliability should a significant GMD event occur.

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Gary Hoffman is Founder, President and CEO of Advanced Power Technologies where he has been for the last 15 years. Previous to starting APT, Gary was General Manager of ALSTOM T&D Protection and Control Division in the United States where he spent three years. Prior to ALSTOM, he was with RFL Electronics where he held various executive positions including Senior Vice President of Sales and Marketing, Vice President of Operations, and Vice President of Engineering over an 8-year period. Mr. Hoffman holds 10 U.S. and Foreign Patents and is a Fellow Grade Member of IEEE, Member of the IEEE Transformers Committee, and Chair of Working Groups C57.12.10 and C57.116 as well as Vice Chair of PC57.163. He is also a member of the IEEE SA Standards Board, member AudCom and ICCom past member of RevCom ProCom, and PatCom. He is the author of Chapter 24 titled On-Line Monitoring of Liquid-Immersed Power Transformers. This book is edited by James H. Harlow. Mr. Hoffman's chapter deals with economic justification for on-line monitoring and covers the various techniques used to perform on-line monitoring major power transformer components including Power Transformer Core, Coil, and insulation systems; Power Transformer bushings; Load Tap Changers; Instrument Transformers. He is also a contributor to EPRI's The Copper Book, Chapter 9–Monitoring and Diagnostics. He holds a B.S. Engineering and M.S. Electrical Engineering from the State University of New York at Stony Brook.

Keeping the NESC® Current

by Sue Vogel

The IEEE has long been a custodian of electrical safety standardization, but none more so than when it became Secretariat to the National Electrical Safety Code (NESC) committee in 1972. Work began on the NESC at the National Bureau of Standards (NBS) in 1913, and the early efforts of the NESC were published as NBS Handbooks that evolved in many parts on different topics as this work progressed. One of the IEEE's first actions when it became Secretariat was to publish all of the current parts in a single NESC volume, resulting in the 1973 edition. Since that time, the NESC has been revised as a whole on a tightly-scheduled revision cycle, which now occurs every 5 years. Ten comprehensive revisions have taken place since that first compilation occurred, with an 11th edition to be published in 2017, spanning 45 years.

The role that the NESC plays in the industry and regulatory landscape is that of a voluntary standard. However, some editions and some parts of the code have been adopted, with and without changes, by some state and local jurisdictional authorities. This process varies, depending on the state; each edition of the NESC can be adopted either automatically when a new code is issued, or it can follow a rulemaking proceeding at a specified time following a new code's release. Some states adopt a particular edition that may be in place for a period of time, until a later edition is specifically adopted.

Today, nearly all of the U.S. states use the NESC in whole or part, and about 100 countries around the world leverage the code in some way. The NESC is among the most widely adopted safety codes.

Keeping the code relevant and up to date in the face of innovation in power and communications technologies and services is a never-ending task—and never a more crucial one with regard to the safety of utility field technicians and contractors, as well as the public.

A five-year process of refinement exists for the NESC that commences with publication of each new edition of the code:

- Change proposals can be prepared and submitted electronically by any substantially interested person, organization, NESC subcommittee or member of the NESC Committee or its subcommittees.
- Each change proposal is considered by an NESC subcommittee, which can then endorse the proposal, propose revisions or additions, refer the proposal to a technical working groups for more detailed evaluation, seek coordination with other subcommittees and/or recommend that the change proposal be rejected.
- A preprint of the proposed changes is prepared and made publicly available for the purpose of soliciting public comment from all stakeholders and interested parties.

- After a period of open commentary by the public, the proposed revisions to the code and comments are processed for NESC subcommittees' consideration.

A draft of the revised NESC is prepared in light of the subcommittee reports and goes before the NESC Committee and the American National Standards Institute (ANSI) Board of Standards Review for concurrent reviews and final approval.

The current edition of the NESC is available at http://www.techstreet.com/ieee/products/1786726

Also, please visit http://standards.ieee.org/about/nesc/ to learn more about how you can contribute to the code's future.

For more than 100 years, the NESC has contributed to the safety of the public and more and more types of utility workers. Inputs, expertise and lessons learned from across the real-world field of implementation are needed to ensure that the NESC remains a vital and relevant industry safety code, even with new technologies and developments affecting the lines to which the code applies. Industry, utility, government and other stakeholders of every discipline have a uniquely necessary perspective on not only the next, 2017 edition of the NESC but its long-term evolution over the coming decades.

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Funny Pages

Lukewarm

by Rick Jamison

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