Introduction to the Crafted EMC Operational System

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Abstract

Many companies are looking to reduce their cost by using automated test software as their test process control. If your software controls the test then you open your labor pool. You are no longer restricted to technicians and engineers. There are lower cost resources available. This article was created to help electromagnetic compatibility (EMC) personnel understand EMC automated test software limitations and how to craft an EMC test system to maximize efficiency and minimize cost without sacrificing quality.

Keywords

EMC operational system; test software; measurement process; safety

Introduction

During the late nineteen eighties and early nineteen nineties there was aconcentrated industrial effort to provide an individual technical quality performance recognition standard (certification). It was administered by the National Association of Radio and Telecommunications Engineers (NARTE), now known as the International Association for Radio, Telecommunications and Electromagnetics(iNARTE). NARTE provided the means for EMC personnel to certify their technical competence using a third–party methodology. The thought was if you had proven experts designing, administering, and reviewing the EMC/EMI tests then you would ensure a high level of quality and degree of competency. One of the side benefits you would receive wasa quick test time since you are dealing with recognized professionals. Today,I see us drifting away from where the technicians are the masters of the test. The current trend is to migrate toward the automated process as the test control.

My present employer designs, manufactures and installs turnkey EMC/Wireless systems. My main job responsibility is developing, validating, and delivering these EMC test systems where the user answers the questions from the test controller. The test is magically performed and results can be formatted into a report. In fact, many of our request for quotes (RFQs)includes automated system software where the test process is to be a black box solution. My concern is the growing acceptance that a company can have by using a less skilled operatorperforming tests and relying on the process control from an automated system without sacrificing quality.

This alarms me, greatly. I work with system automation all day long. I do not trust computers. I believe there is a vital place for software automation within our field. Test software used correctly will reduce errors and standardize test processes. It is an important tool within our toolbox. We need to be aware it is not the only tool in our toolbox. There is an inherent danger in having one tool within your toolbox. If all you have is a hammer then all your problems look like nails. We need to re–familiarize ourselves with all our available tools and give each of them their proper place.

Traditional EMC Test System

Our traditional EMC test system consists of the following: instruments, transducers, cabling, technician, engineer, chamber, automated EMC test software etc.The automated test software is a relatively new comer to the EMC test system. It was introduced during the mid to late nineteen eighties. It must be understood the automated test software does not replace thought. Its use can enhance performance, minimize error, and standardize the test processes. It does not fix all. It does not make testing error free. For example, if the test setup is incorrect the test software is not going to tell you why. Yes, it can detect an error. It can alert the operator to a system fault. The easiest fault to detect is within an immunity/susceptibility test. The user would be prompted "failed to meet level" or receive a similar error message. The operator is encouraged to review the setup, equipment etc. to find the solution. Emission fault detection is a bit more complicated. The competent user should be able to look at the emission results and realize something is wrong. The automated test software is not as clever. It can detect instrument errors. It can be typically made to understand the emissions data is either below or above the limit butthe basic automated EMC test software rarely does more than that. The basic software's assumption is everything was set up and working correctly. The equipment under test (EUT) is within the correct operating mode and it is functioning as intended. The ambient test conditions are sufficient to support EUT testing. The test system, itself, is performing satisfactory. Everything is as it should be. Although as I think about it a little more, I stand corrected. You could design the automated EMC testsystem to control the EUT, know its operation and monitor its performance. The automated EMC test system would no long be basic. It would be customized to your EUT. Therefore, if you took the time and effort you could designa EUT specific automated test software. You should consider typical room ambient conditions, likely EUT active conditions, EUT standby and EUT Support Equipment influences. You could generate emission masks and create algorithms to compare expected versus unexpected results then query the operator should the test results fall outside the expected parameters. It would be an interesting project. Rarely could you afford the luxury of such a EUT customized software program unless you were testing the same product over and over. I will stop this tangent now.

Getting back to this article's objective, my test setup error example shows a small portion of the relationship between operator and system. The automated EMC test system can be designed to guide the user through the test process. It can control the test equipment, EUT, perform calculations and even create a report. It cannot do everything. It needs the user to complete itself. The system is inoperative without the user. The reverse is not true. The user (a competent operator is assumed) can perform the test, operate the EUT and create the report. The user would be less efficient and error risk would be higher than the automated system but the user could perform all tasks.

Crafted EMC Test System

The question is how to craft the EMC test system to minimize cost/time and maximize efficiency while maintaining a high level of quality. What you need to achieve the maximize efficiency, minimize cost/time and maintain quality objectives takes a communitive effort (team). I want to provide a few definitions and constraints before I continue. From this point forward within this article auser/operator is defined as an individual who has not had informal and/or formal EMC/electrical education, experience and/or training. The technician is defined as an individual who has EMC/electrical experience and/or education. You can insert iNARTE's definition for the certified EMC technician if you would like. The same is true for the EMC engineer. You can use iNARTE's definition for the certified EMC Engineer. The crafted EMC test system is nearly the same as the traditional EMC test system. If you add the operator/user you have the crafted EMC test system. The engineer responsibilities are typically defining the test process, supervision, analysis, reviews and etc. The technician within the traditional EMC test process is the master of the test. He/She performs the tests and provides the results to the engineer. The technician may also author reports. It depends on the company's policies. The engineer role will not significantly change within the crafted EMC test system. What role should the technician and operator play?

I was involved in creating an operator test organization. We designed the system based on our company's business need. My company had an issue where we could not retain our entry level technicians. After a relatively short time the junior technicians would leave for greener pastures (meaning more money) and greater challenges. It left a weakness within our company. Customer delivery commitments meant senior technicians were required to perform entry level tasks while continuing to work on their primary responsibilities (regular job). It stretched an already lean workforce and generated a tremendous amount of stress. I once saw a senior design engineer building a test cable harness in order to start a highly-accelerated life test (HALT) on time. He needed the HALT results to determine if the design would meet customer requirements. No one else was available to build the cable. The saddest part was the senior level engineer built the cable incorrectly. It induced EUT failures and it had to be completely reassembled. The EUT had to be retested and we nearly missed our product launch opportunity. We had to throw a lot more resources at it when we found out our EUT failures weredue to the incorrect cable harness assembly. Throwing the resources at this project's test caused missed deliveries for another project. The problems multiplied and drama ensued. This cable build was just one of the many episodes that revealed two business needs. The first is never send an engineer to do a technician's work. The error probability was too high.And the second was we could not afford to keep repeating the same expensive mistakes. We needed a better solution.

We had an hourly workforce available within ourdesign/production facility. The operators already performed automated testing within the production line. We believed with the right training and guidance we could give our hourly folks another career opportunity. The position would be at one of their senior levels. It would attenuate our junior technicians run off to greener pastures while providing us a stable resource. Some of these hourly workforce individuals were incredible. What they lacked in formal education was offset by their common sense and work ethic. We could not and did not expect them to perform at the same level as a technician.

We knew we needed to invest in their training, provide guidance and a support resource. Still, we realized we could give them a more challenging opportunity while benefiting from them as well.

We acknowledged testing is a process. It is based on the scientific method like science fair projects we learned during our elementary school days. We needed to identify the test methods and break it into itsdiscrete components.

So, our first step to bring the hourly workforce into the laboratory test world was to formalize the test process into flowcharts. We determined where the responsibilities for the hourly operator would be placed and when the test technician would support the operator.

We also included how the operator would be able to receive additional support from the technician as they needed it. The remainder of this article will explain how we integrated thehourly operators into the test process using an emission test as an example.

There are typically three phases of the emissions test process: system checks, ambient measurements and EUT active measurements. The full system's check process is performed at the beginning of the test or at some regularly schedule period based on the laboratory's quality management system (QMS) or as dictated by the test standard. The full system's check process as we defined it is shown in Figure 1.

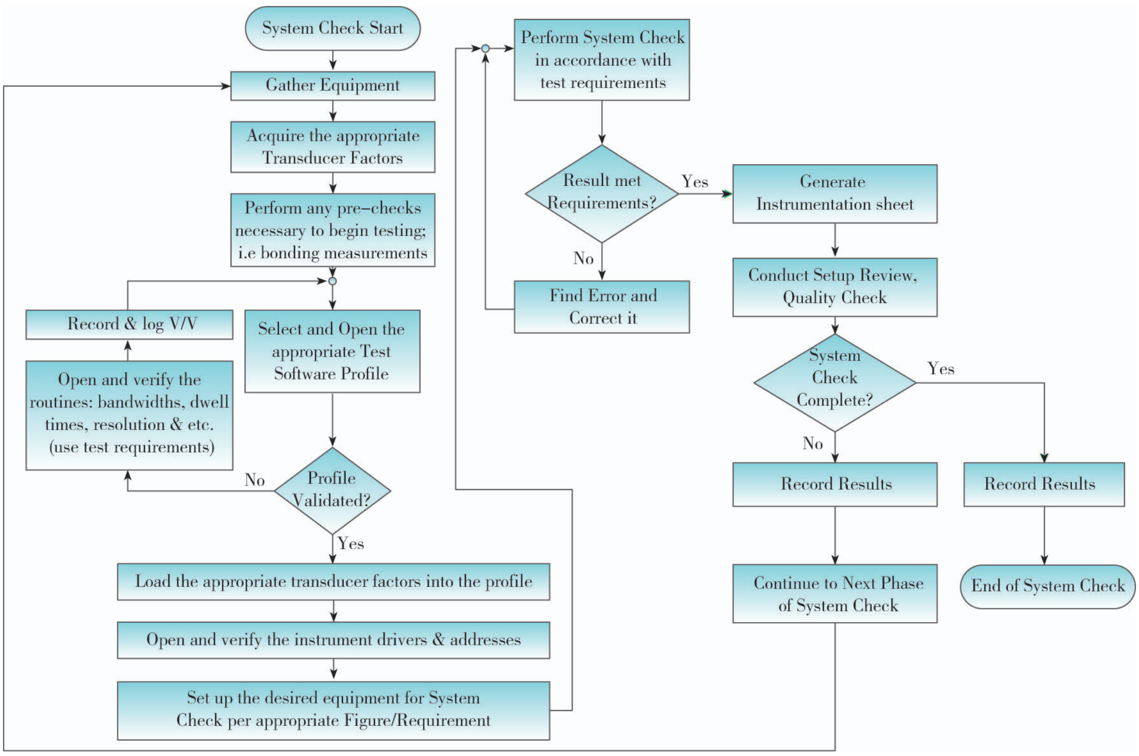

Figure 1 Emissions process flowchart full system check

We decided the full system check should be conducted by the technician to ensure everything was in good working order before we turned testing over to our operator. We adhered to the principle "good in equals good out". The operator would take over after the full system was verified to be in good working order which left the operator with the daily system check, ambient and EUT active measurements. With the operator's assistance, the technician was available for other tasks. If the testing was in compliance, its duration was dependent on the test plan/procedure. Unless the compliance testing went into mitigation. I am not going to go into mitigation details in this article. If the nature of the test is research and development (R&D) then the operator could be occupied for days, weeks, months...

The daily system check, ambient and EUT active measurements each had their very own process flowchart. The operator followed these flowcharts knowing that at any time deemed necessary, he/she could ask the technician and/or engineer for guidance. Our process followed the carpenter's philosophy "measure twice cut once". The testing and the results would be reviewed as well as the ambient/test conditions after the measurement was completed for accuracy and correctness. The daily system check's process as we defined it is shown in Figure 2.

The ambient measurement process as we defined it is shown in Figure 3.

The EUT active measurement process as we defined it is shown in Figure 4.

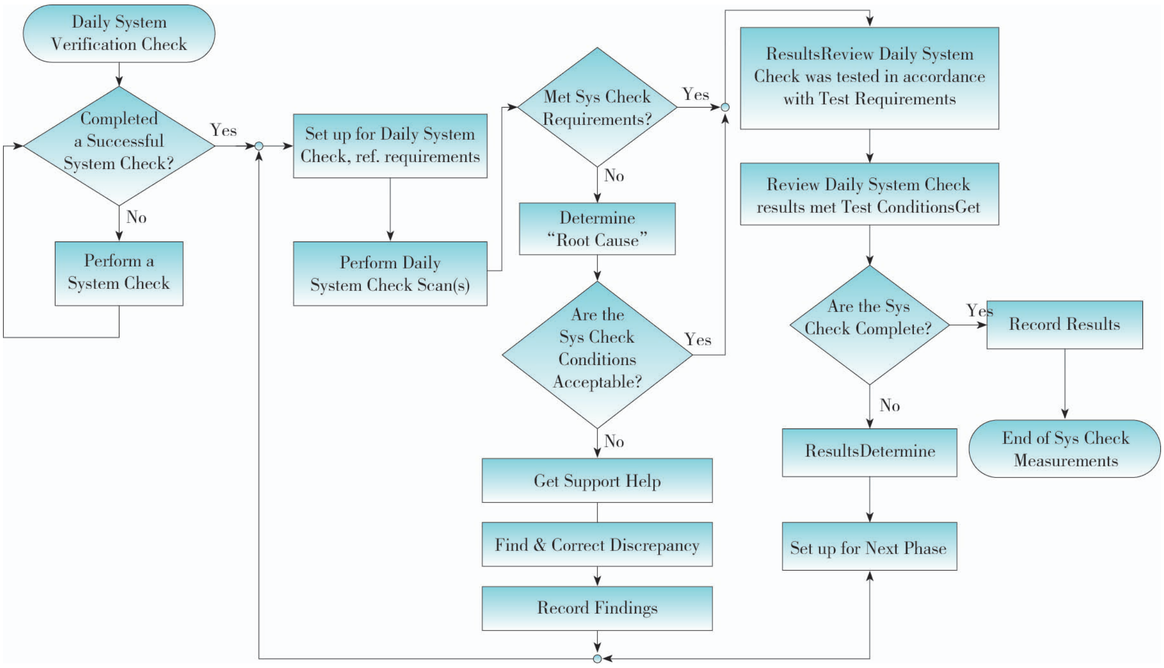

Figure 2 Daily system check process

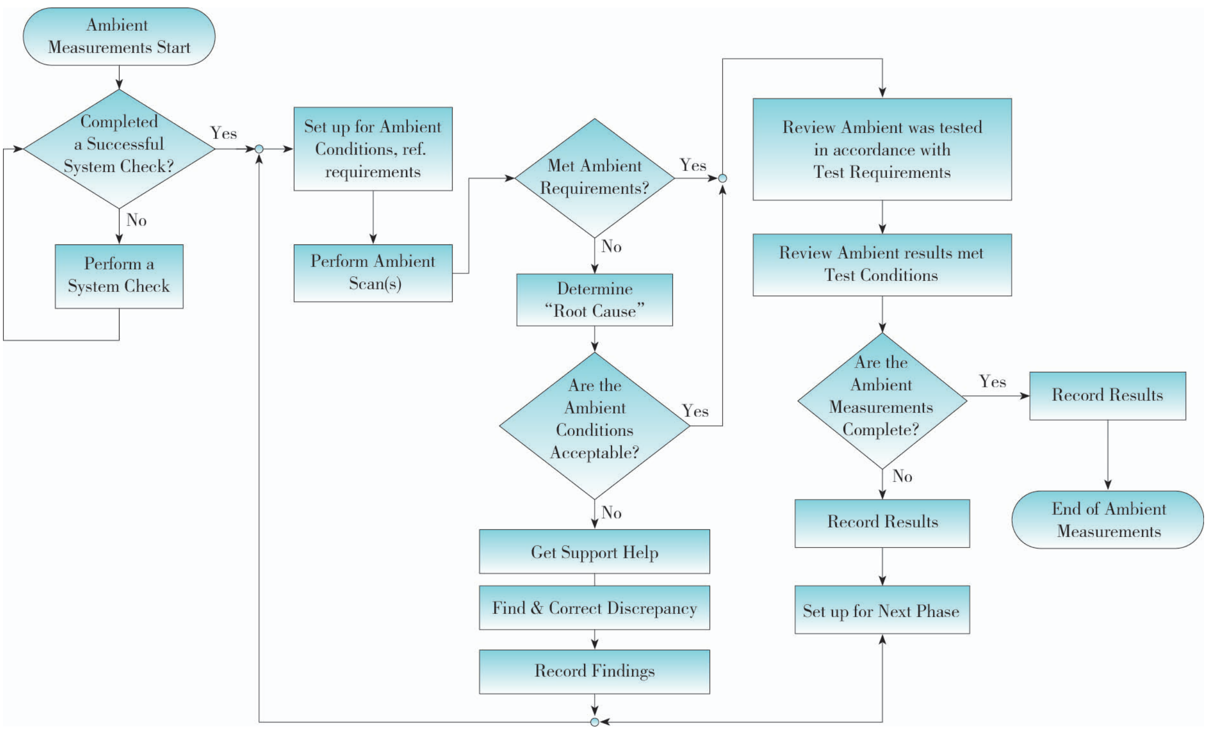

Figure 3 Ambient measurement process

The process flows we created defined how we wanted our laboratory to run. I am not stating these processes are the one and only true method to perform EMC emissions testing. There are many avenues to reach your goal. We deemed these to be our method to achieve best in class. It allowed the technician to support multiple operators and tasks while having the test performed in a cost effective and timely manner. We discovered the technician could effectively support four to six operators without an undue amount of stress. There are other variables you need to accountfor which could lower or raise the technician's support level versus the number of laboratory operators. The EMC engineer could effectively supervise approximately three to four technicians. Your

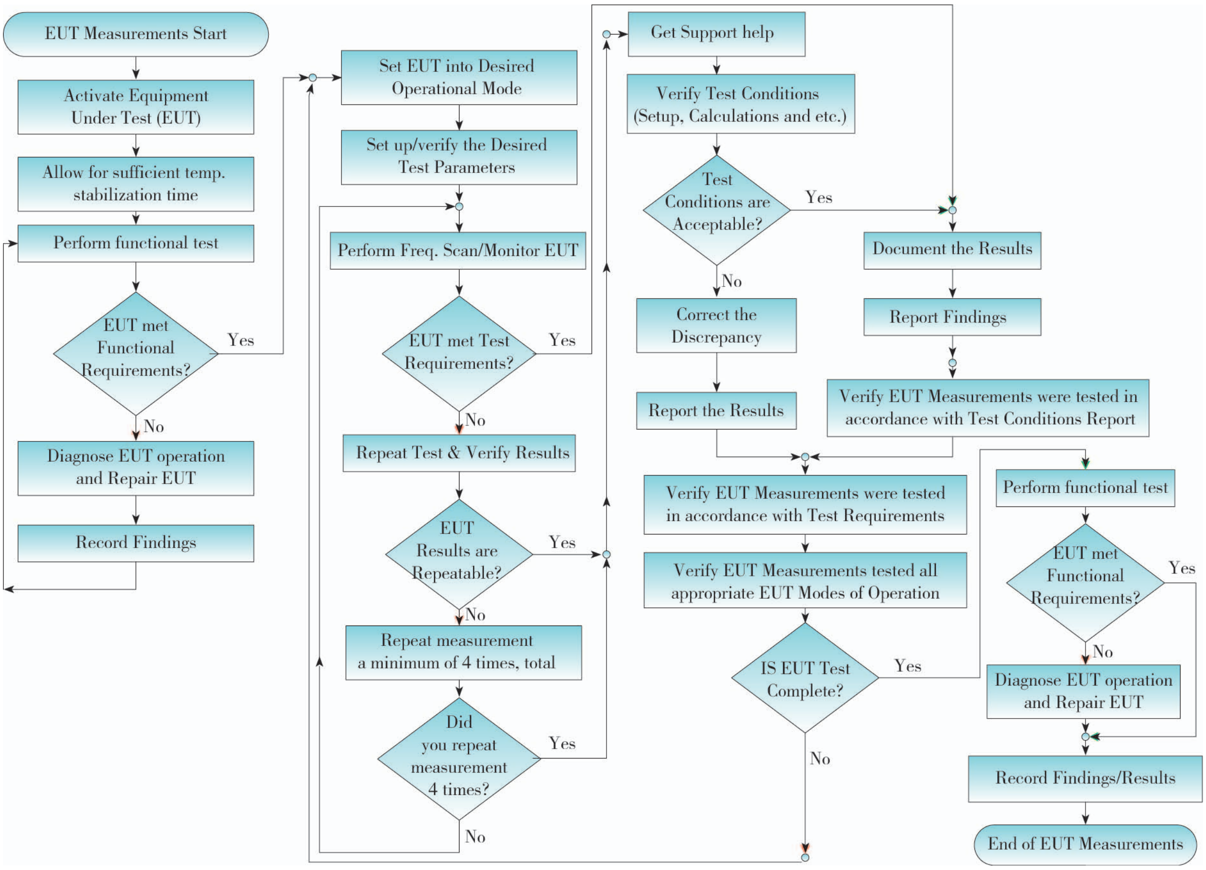

Figure 4 EUT active measurements process

system using one engineer and four technicians with corresponding sixteen operators and would have ideally sixteen individual test stations occupied at approximately eighty five to ninety percent capacity. You need to include maintenance and training within your system so you should not target one hundred percent productivity. If you use one man month of one hundred and twenty hours as one hundred percent capacity then ninety percent productivity is one hundred and eight hours. It gives you twelve hours per month for training and maintenance.

Operator Training

I cannot over emphasize the need for operator training. It needs to be formalized and recorded. Our operator training was an evolutionary process. We developed multiple levels of operator: operator in training, operator under supervision, certified operator, and operator/trainer as shown in Figure 5.

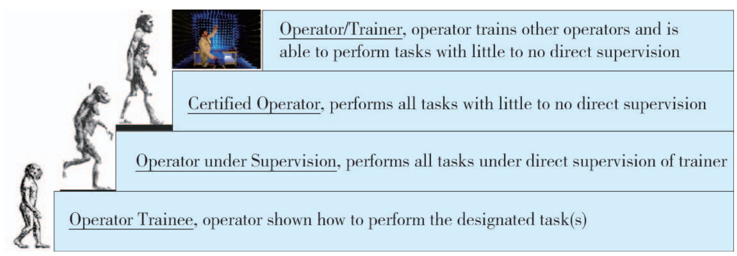

Figure 5 Operator levels

Each operator level from trainee, operator under supervision, certified operator and up to operator/trainer had a bump in pay and responsibilities. The pay/responsibility levels were less than what you would pay a technician, but they were sufficient incentive for our hourly personnel to want the position.

Most of the operators' training was "on the job" although we did hold lectures. We used a brown bag lunch where the company paid for lunch as the employee incentive and the lecture was held off normal business hours. During the on the job training (OJT) the operators were shown the practical side of testing. Our OJT included test control operation, how to test, EUT operation and what to expectduring testing including safety aspects of the test. Theory was also covered during our brown bag lectures.

During some specific training point within the operator's training, the technician or operator/trainer would move from instructor to observer as the operator performed the test under their trainer's direct supervision. As the operator's competency grew, he/she moved from trainee to certified operator. The certified operator couldperform the test with little to no direct supervision. The technician involvement was reduced until the operator could perform the operator's tasks unassisted. The certified trainer/operator/personnel removes the technician from the training responsibilities and takes on the operator training role. Our operators would recertify on an annual basis to provide evidence they were capable to perform the tasks they were assigned. Their recertification criteria had a high emphasis on the operator's safety. They needed to know the potential hazards and their safety protocol. Again, it was an evolutionary process. It took time but the benefits outweighed its costs. Each time you are audited and showed your auditor your processes, training, recertification and training matrix, you were thankedfor the attention to detail and your auditor was pleased with the results.

Operator Safety

We anticipated and designed safety features within the test process to ensure no operators are left in jeopardy. Each EUT was analyzed regarding operator safety. There was a risk assessment performed for each EUT and the testing would not start without our Environmental/Safety's Engineer's approval. The operator's safety was hard wired into the system as well as soft wired into the automated test software and work instructions.

Automated Test Software

This article would not be complete if I did not mention how important it is to create an effective automated test software program development program (PDP) that is aligned with our process and guides your operators down your chosen path. I have written another article (In Compliance magazine, October 2013) which describes how to create an automated test program to meet your requirements as well as international standards. I show the process I use to create a test program in Figure 6.

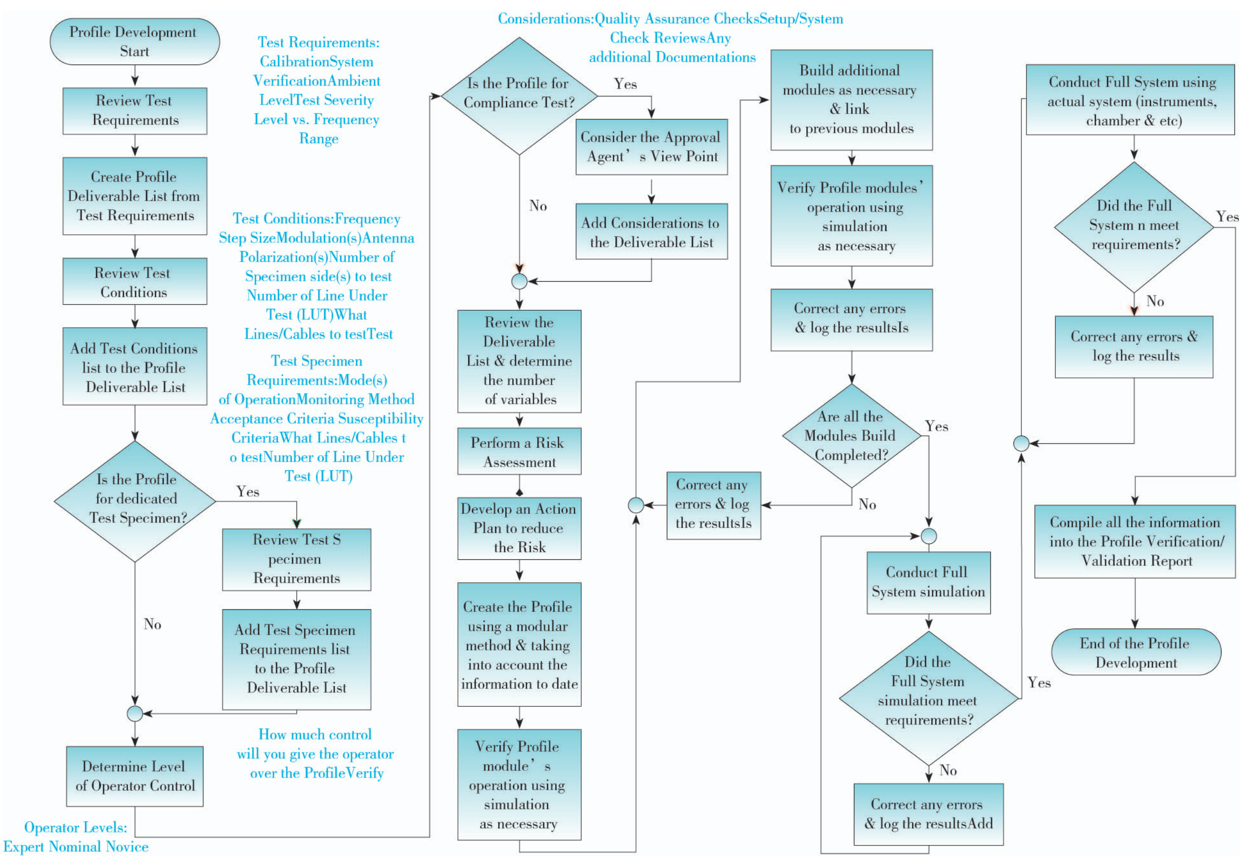

Figure 6   Test Program Development Process (PDP)

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History of Electric Shock Protection

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Abstract

A short history of electric shock protection is given to provide the reader a background for the present level of understanding in this area. Some key pioneers are identified along with the impact of their work. The broad ranges of measures providing protection are summarized. Discuss how the changes in the use of electricity leads to the need to update the understanding, evaluation of protection measures and limits are provided. The development of requirements in IEC standards is clearly presented. Modern techniques in evaluating body response as well as measurement techniques are covered.

Keywords

Electric Shock; evaluation of protection measures and limits; standards; measurement techniques

History of Electric Shock Issues

The electric universe

Historically electricity was a curiosity shown to amaze those nearby (fur and amber generation of a discharge) or feared (lightning) whenever someone was severely injured or killed during an electric storm.

Early workers such as Galvani (~1790) measuring 'animal electricity' of frog legs; Volta's battery which enabled controlled experiments and Faraday's (~1831) discovery that interrupted electricity could control muscles led the technical advancement in this area. Young American students are amazed at the description of Benjamin Franklin (a founding Father of the United States) as he flew kites during a thunderstorm to collect the electric charge in a Leyden Jar (capacitor).

Others, obviously, were involved in similar activities about the same time. One might wonder how many other budding scientists were killed because they became the discharge path to ground rather than the intended path and their name never became known in history.

Manmade electricity

The pioneering work in the mid–19th century (e.g. Edison and Westinghouse in the USA – and their infamous DC vs. AC battles) led to the development of the national power grid in the 20th century and industrialization in many countries.

The generation of electricity has moved fromthermal (coal, oil and gas) and hydro generated to nuclear, wind, fuel cell and direct photovoltaic generation as we enter the 21st century.Large, centralized power stations providing power to large loads will continue to be challenged by smaller systems installed near the load which are networked to the large system and can both give and take power from the grid; wind powered generators and solar cell arrays have been aggressively developed and implemented as distributed power sources. Co–generation from processes that generate excess heat is being used to reduce supplied power costs in many businesses.

The large power stations have let to national and international transmission at High Voltage for long distance transmission of power (75 kV up to 1 MV in the US).

More locally, distribution at Medium Voltage for short distance,

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Conclusion

A company's success depends on how well you provide your customers quality service at a reasonable price. The company's future requires them to look for ways to minimize costs. This article shows you can create and implement a crafted EMC test system to maximize your productivity and minimize cost while maintaining a high degree of quality. It will not just happen. It will not fall into place or occur because of an accident. It takes planning and effective communication as well as clearly defined roles and responsibilities. It can be achieved. It has been achieved.

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