Lessons learned from running and auditing EU EMC Labs

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Abstract: Is EMC (CE) testing a business or just another regulatory requirement?
- Tricks of the trade in global EMC compliance for various sizes of enterprises with the focus on Germany will be demonstrated.
-Present EU EMC market requirements with strong competition will be discussed
-Latest accreditation issues and challenges (EN 45001 vs. ISO /EN 17025) will be highlighted, followed by practical and optimized solutions
-Requirements for good planning, investing, operating, marketing, managing, staffing, personnel training, including correct calibration of EM-fields and traceability, will be explained.
Non academic, real life, case studies of running and auditing EU test facilities, based on 10 years German lead auditor and 20 years test house management experience, will be given.
All this is embedded in a critical analysis and overview of latest political, market, service quality, business ethics as well as technological EMC issues. Practical advice is offered when ever applicable.

Introduction

Electromagnetic interference control (EMI) is often considered difficult, because most protection measures are not directly visible from outside of the equipment nor do they necessarily add any optical beauty. Rarely is the customer willing to pay an extra price for good EMC. Moreover, since 1996, the implementation of the legal European CE requirements, the manufacturer is obliged to declare conformity with the protective goal of the directive, namely a suitable degree of compatibility for emissions and immunity of the equipment. Knowing about these facts and considering the overall economy, which as always calls for prudent management concepts, implementing and controlling appropriate steps on all levels. In EMC, as we all know, international standards are governing the scene and their goal is harmonization of technical specifications for the sake of removing trade barriers. Enforcement is a must. This is not new and was also realized in the United States by the FCC-art. 15 subpart J- when they found fines to increase slowly, and after several years jumped (3. -4. year), because of more personnel and funds being allocated by politicians to booster the market screening process. Finally saturation or even a decline follows after 5 to 10 years.
Standards and regulations on the other hand are not necessarily the beloved child of all sectors of industry and unfortunately misconceptions about EMC Standards do exist.
Too expensive, we don't need it, we receive no complaints.
As a short introductive summary it seems legitimate to state, "EMC is a vicious circle".
Late implementation of protective EMC measures lead to cost explosions. Keeping the right balance between good legal and engineering decisions in a particular management and business environment is often a very big challenge, not totally appreciated by all parties concerned.

Offering EMC Lab Testing Services

EMC Market Analysis-the Business Case Germany: Is EMC a business or just another regulatory requirement? If the "EMC GURU" only performs some kind of band-aid and ad hoc actions without following sound technical concepts, negative scenarios will continue, this is no healthy business. Fundamental approaches in EMC are e.g. the zoning concept with systematic EMI Reduction in steps by filters and shields, prudently making use of given mechanical barriers.
The EMC business as such is more than 40 years old and was hardly ever a stand-alone item. EMC is simply a design criterion, like electrical safety or environmental tests. Changes in EMI protection, however, do exhibit far-reaching consequences by interaction with other design parameters. But the EMC experts apply the same system design principles over and over again. Most of the changes in EMC were introduced by major technological developments. After the second world war, sensitivity in radio reception and color TV demanded better signal to noise ratio. The car industry started taking care of EMI emission suppression from the spark plugs of the engine. Mass-produced household products and fluorescent lighting needed EMC fixes to avoid massive high frequency spectrum pollution. It was that time, when German EMC legislation became mandatory and the regulation authorities, including semi government institutions like VDE and TUV, became driving forces behind EMC. Major corporations and a few privately owned EMC labs set the scene. With the introduction of faster microprocessors and large-scale integrated circuits, electronics industry became more and more aware of EMC problems. Slowly but surely immunity issues started to become evident. Finally with the vast proliferation of mobile telephones operating below 1 GHz susceptibility issues increased dramatically and already led to product liability cases. With the introduction of the common market in Europe, national legislation had to be harmonized by Brussels to enable free circulation of goods and services throughout the European Union. The EMC directive was born in 1989,to be finally implemented in 1992. Quite a number of people in EMC industry started now seriously thinking of setting up their own EMC test labs. Outside Europe the technical emphasis was still on emission control. Product liability with EMC focus on immunity started increasingly, shifting the pressure from the military into the commercial world. At this time Germany had about 20 EMC labs and the prices for testing a desktop PC for emission and immunity sometimes exceeded 5 k$ US. This is a figure close to military EMC testing prices. The CE marking was at the horizon and hopes were flying high to do good EMC business in the years to come. There was a strong believe among EMC people that CE marking could finally trigger a breakthrough in EMI-control, based on strong and hopefully effective government enforcement. It was the United Kingdom, where management consultants, venture capitalists and banks generated an overwhelmingly enthusiastic report about the prosperous future of the EMC business. In the early '90s this ATKINS report led to a strong increase in EMC test houses throughout the United Kingdom. In Germany this process was delayed by several years, mainly due to major politi-

cal events, like the reunification between East and West. Nevertheless exactly in this process, many young entrepreneurs looked at Germany as the future goldmine. Additionally a clear move of daring pioneers set off towards the eastern part of the country. By this time, however, serious changes took place in the German electro technical industry. Industry was right in the middle of a strong recession, unemployment was high and everybody in engineering in general was struggling for survival. Only a few sectors of this industry experienced a strong growth, which was mainly driven by the opening of the East German market. Textile and food industry, satellite dishes, VCRs, stereo equipment and automobiles started flying high. On the other hand due to the financial collapse of the government-owned GDR industry, unemployment figures in some areas exceeded 30 percent. Industrial compounds with thousands of employees had no more East block export markets, because the West German political leaders introduced the Deutsch Mark overnight. Public, financial subsidies at this time did exist, but their administration was sheer chaos. An unhealthy mix of letting go and harsh, bureaucratic controlling interaction was common.

Early ‘90s, the official government accreditation system started working. The regulation authorities BAPT/RegTP, however, were right in the middle of a deregulation process in which the ministry of post and telecommunication finally disappeared. The Ministry of economics took over. The newly acquired “field offices” in the east had to be integrated. EMC legislation and the final implementation of the directive started therefore delayed in 1996. For a period of almost one year the European labs had now some kind of monopoly position throughout the world. Picking up the phone and telling a client “sorry, we are fully booked” was the usual answer in this gold rush period. Hundredths of unfinished test reports started piling up in the labs. The level of lab instrument automation as well as report generating automation was relatively low. Prices were quite reasonable and the profit margin substantial. Competition was no major issue. Many international clients, from all over the world, were flying in at nighttime and working through a three shifts system, which got quickly installed in some labs to met the demand. Such labs operated close to 22 hours a day. Furthermore it was difficult to rapidly buy extra test equipment, because even the EMC equipment manufacturers underestimated the extra need in the market by a factor of 2 to 4. Before these days, not too much effort went into very detailed planning. Years of box testing experience were normally sufficient to successfully run and manage an EMC lab. Management in extraordinary times however requires new steps and visions. About 10% of the labs started expanding into EMC of larger machines and systems, which did no longer fit onto the turntable. Their background was mostly military EMC requirements. Here they learned EMC system planning as an art of systematic break down of large, complex systems ***and*** environments into blocks that can be tested in the lab. The testable interface threat conditions are calculated, estimated or simulated from total system analysis. This is economically cost effective and leads to meaningful, tailored test procedures, if one sets the priorities right. Conducted EMI is always to be treated before attacking the radiated part. Not too many test house managers knew this in the beginning. System business is slower in acquisition, but can be financially attractive in the long run. An interesting side effect, in the German EMC market in particular, was to see public institutions and universities jumping onto the EMC bandwagon. High-voltage engineering started lacking funds. Well-trained telecommunication engineers faced all of a sudden many discussions with engineers coming in from the power and high-voltage domain. At the same time the German government decided to dedicate research money for EMC. Soon after this, big programs, mostly well targeted and coordinated, came to light. The first graduate students enrolled in specific EMC Ph.D. work. Some consultants and test labs got into bitter fights over clients, because some universities used dumping prices. Students don't cost much, however, their assignment is only of limited nature and time to market was getting more important in Central Europe. So most of the labs could somehow survive.

After 1998 mergers and acquisitions dominated the German EMC test house market place. Many small and independent labs disappeared or had to be sold cheaply to bigger organizations. A critical shake out period started. On the other hand the number of newly accredited labs still continued to grow. The majority of these labs, however, represent major or medium corporations. Here EMC is taken more seriously, due to long term over all business strategies. Conflicts with regulations, liability cases are bad PR and ought to be avoided.

Again all it takes is long-term experience, financial resources, courage, a little bit of luck and certainly very detailed planning, before running of a lab becomes the issue.

<u>Lessons learned:</u>

EMC is not a stand-alone item; EMC requirements are permanently changing due to regulations and standards, which are both driven by the rapidly changing technology in modern electronics industry. The basic technical EMI protection concept is stepwise reduction by zoning. Changes in the German political scene, mainly the reunification with high unemployment rates in the former GDR, makes the choice of the business location and the size/type of EMC lab to be implemented decisive. After the boom year of 1996, the EMC market growth is now down to max. 5% per year. This lowers the chance to attract investors. EMC awareness in small enterprises is low and directly regulation enforcement driven. Some EMC labs moved into EMC system engineering after 1997, to break away from the main box testing competition. Setting up an EMC lab is very capital intensive and is therefore, nowadays, potentially going to be a high-risk business.

Planning to start an EMC Lab: After having established the strategy and found the financial resources as well as location to start the company, the question arises of how quickly can one get the necessary test equipment and further office equipment delivered from the various suppliers. Using public financial support by the government for this is very tricky, because a lot of unnecessary bureaucracy is introduced into the process. Value added tax problems must be considered and the project may not be started before the government approves the support. This can become a very serious issue, because time to market is extremely critical in the real world, but not for government people. On the other hand receiving millions of Deutschmark in support has most definitely to be considered. But governments may change over time and former mainstream political activities may change very quickly after elections. Banks are normally not supporting High Tech EMC startup projects, mostly because they have no clue, and no figures about such business.

Many compromises have to be accepted by the young startup company and its CEO, including key people. Time to delivery of most EMC equipment in the '90s was approximately three to six months. At least 6 to 12 months must be planned, where no external revenues for the company can be expected.

Moving into the new German territories and being grown up in the western part of the world is another potential problem. Separated from the family for considerable time, living off very small budgets for several years and only following the burning desire to start the own company is not an easy job.

Independent of all emotional and financial factors the young entrepreneur has to face reality and install his delivered equipment technically correct and economically wise. It also becomes extremely important to think about cost-effective alternative test facilities and their applications as well as inherent restrictions [1]. GTEM cells and fully Anechoic Chambers (d=3m) need to be evaluated.

Let's assume for the time being everything has been installed. Next is, naturally recruiting the first test engineers and training these people of how to use this type of brand new equipment. It goes without saying, the recruiting process is essential for the future success of the company. This is not necessarily EMC specific, but many times finding good people and only having small budgets for recruiting and advertising is also not an easy job. Moreover the recruitment situation strongly changes over time. During a recession or close to that, unemployment may be high and consequently one can find EMC experts more easily. In the past decade this market has undergone extreme changes, from many to almost no available EMC engineers. Furthermore, there are however additional, interesting things happening in certain geographical market segments. For example some people in the East German workforce, with 40 years of continuous influence under the communist regime, have mentalities and attitudes that are not necessarily identical with western people. It does not become immediately evident for somebody from the western world of how to read resumes issued in the former German Democratic Republic. What you see is not necessarily what you get. This is by no means to generally say that people from this area are not qualified to become top-notch people in EMC. A young entrepreneur and CEO is in such case well advised to possibly recruit a sound mixture between eastern and western people. Personal initiative, making decisions in due time and not waiting for the boss to decide is in some cases very difficult for people grown up behind the former iron curtain. All this should be part of the business plan, because it adds cost. But for almost everybody in the EMC business in Germany e.g. it was a very big shock to see the start of the EMC act and its enforcement, which was originally scheduled for 1992 to be moved to 1996. One can easily imagine how this shift in government policy triggered an outcry in the test house industry and turned the market place upside down overnight. All the planning with the firm belief, the government will do the enforcement in due time and effectively, all of a sudden became obsolete. Business plans are certainly very important, but what is even more important is an escape strategy. Any good merchant knows these potentially negative scenarios.

Fact is, starting a lab will range, depending on size, in between 500.000 dollars and a multimillion-dollar investment. Such activity falls definitely under high-risk business. Why is this so? It is simply due to the nature of expensive EMC instrumentation. Covering a wide range of EMC areas in a lab, like household, telecommunications, ISM, ITE, automotive or even military testing, requires extensive instrumentation that is not necessarily used all the time. Consequently there is equipment, which from an economical point of view, is not effectively used. On the other hand, in order to meet the market needs, one has to have a wide range of tests in the scope to be offered. As start-up strategy, coming in at 50 percent of the usual market price, can be a very serious issue for existing EMC labs. On the other hand if somebody undercuts market prices for a long time, consequently using unfair business practices, one can easily suspect this company to be either subsidized from major financial resources or even fostered by questionable government support. The price is certainly very important and an attractive point in establishing professional services, but it is not the only criterion for long-term success. Quality and reliability is hopefully going to prevail in the long run. May be it is also not necessarily evident to everybody, not directly familiar with some business practices in the eastern part of Germany, but cases of deliberate, well targeted, official support, to kill well positioned competitors did exist in some cases! The East German scenario does exhibit peculiarities, which are difficult to understand in the first place. Most of them are based on old party relationships and military related camaraderie and old boys networks like NVA or STASI. This is extremely hard to fight and in some cases even hopeless.

Back to planning, what is the correct test sequence for a particular piece of equipment? To please the customer and to get the most information out of the equipment under test, this calls for nondestructive tests in the beginning and critical once like ESD, surge, electromagnetic field illumination or radio frequency current ejection, at the end.

It is an illusion to believe external renting services are in the position to supply such parts of equipment timely and cost effectively. Furthermore insurance may well cover damaged equipment and a certain degree of lost time in testing, but never covers future business and having lost a key customer, because the power amplifier was down.

When determining the size of the equipment to be tested, experience teaches that most of the time, this type of equipment will fit onto a turntable with 1.2 m in diameter. Such equipment is hardly ever to exceed 2 m in height and may well fit into smaller anechoic chambers. On the other hand, if somebody shoots for big system tests, like testing complete vehicles, a full-blown 10 m anechoic chamber, or bigger, is definitely needed.

Let it be a small or large EMC lab with whatever annual revenues. How much profit is left over in Germany? With 50 % taxation, profit after tax becomes quite small!

Raising test prices? There are different strategies in different labs. But in general it is justified to say the desktop computer tested according to the genetic standard will be in the range of 1300 $ US. A test report, from an accredited lab could range anywhere from 200 to the 400 dollars U.S. The complete day in a large test facility like 10 m anechoic chamber, including the test engineers, could be typically around 2000 to 4000 US$.

From these figures it becomes immediately evident that testing has to be planned very carefully. The throughput is very similar to what happens on the production line in a factory and there are today about 130 accredited EMC test labs throughout Germany! Munich, Stuttgart, Frankfurt and Dusseldorf are the major locations. The northern part of Germany and particular the eastern part of Germany are anything else but showing strong industrial growth in electronics industry.

<u>Lessons learned:</u>

Good planning starts with a solid business plan, outlining the strategy. Good planning, however, can quickly become obsolete, because of rapid market changes and the lack of speedy implementation of European legislation into international law. This happened in 1992, where the implementation of the German EMC acts was delayed and shifted to 1996. As a general concept, the size of the company small, medium or large, has to be determined. The corresponding, substantial investment ranges from 0.5 to multimillion-dollar U.S. This is a critical figure, because the individual price for EMC tests has become relatively low. Consequently everything is based on throughput and optimized operations. Be aware of considerable, ongoing instrumentation investment, to meet newly developed standards. The choice of the location for the company is the prime factor in strongly competitive markets. A healthy industrial infrastructure in the chosen area is extremely important. As a startup company, financial reserves for at least twelve months without external revenues must be planned for, to survive the setup phase of the lab. Investing into full-blown EMC facilities or using smart, alternative test sites need to be evaluated very carefully. Even with substantial financial government support, in particular in the new territories in Germany, the former German Democratic Republic, this location and some employee's work ethics are not easy to deal with. The EMC test facilities must be fully automated. The work/accreditation scope must be carefully selected, based on local industry needs and economical constrains. Test prices are very competitive. Recruiting good EMC staff is quite difficult today, because of shortage of engineers in general. Marketing may include direct mailings or more successfully finding pilots clients from the region. The typical radius of the 130(!) German test labs, to attract clients, is about 50 miles. Most of the labs are concentrated in the southern part of Germany. This is exactly where most of the German electronics industry is situated and the test house density is the highest in the Republic.

Running an EMC Lab: Following the outlined considerations in planning a lab, running an EMC lab is again quite a challenge. Let's assume for the time being, the location is situated in the optimal area, the test stands are all in place, people are well-trained, management established and marketing has just started to bring in the first customers. Very soon the test house manager will realize how important good planning and precise performing of the EMC tests is. Scheduling the tests is often not an easy job to do, because some customers tend to make appointments, but this will not necessarily mean that they will show up at the schedule test time. Quite often the customers are delayed for various reasons or bring in their equipment with almost no preparation for the actual test. In this case the assigned test engineer must demonstrate his talent for improvisation. Connectors will have to be quickly soldered; some cables have to be cut to fit them to the filters of shielded rooms. In addition to this, the test engineer is quickly trying to get familiar with the fundamental design of the circuit to be tested. He's basically condemned to grasp all the design ideas and layout considerations in an extremely short period of time compared to the development process. The accompanying development engineer is sometimes very helpful because he knows his equipment inside out. In other cases this is not so, because the boss told somebody in the research and development department, at the very end of the design phase, to finally get the boxes tested at the EMC lab, assuming that everything will go fine the first place. If EMC is not considered in the early stage of the project the chances of wasting time and money are quite high. Consequently if anything fails in such a project, this might easily lead to a disaster, a revision of the circuit boards, extra money and possibly jeopardize the whole project, due to time delay. It is natural in this case for the design person to fear negative consequences and he or she is therefore not immediately willing to accept a negative result from the test house. It takes quite a bit of psychological expertise for the test engineer to present negative test results to the client. Nobody likes to receive and pay for a negative test report. Very often the test house manager has to decide to put the project on hold, not issuing a report and an invoice, because the project is not completed yet. That's a dangerous process in terms of cash flow. But since the customer is always right, many test houses act accordingly.

Even worse, the client does not appreciate the quality work being done and decides to go to the competitor, hoping to get away with nothing. In this case it is legitimate to say the client goes shopping for the best and most pleasing results. How can this happen, when labs are accredited? More to this in the second part of auditing labs. Legally speaking, the lab can hardly do anything, because it is the manufacture to declare compliance with the EMC directive and other applying regulations. Exactly this procedure will become more and more accepted by certain cycles in industry, if market enforcement by the authorities is not appropriately conducted. The effective chances of getting caught are fractions of a per mill. But on the other hand, if, the authorities start picking on you all the time! Now big trouble is ahead.

Without exaggeration, running an EMC test house does certainly not stop here. Since we already feel how important automation is, it's time to speak about software. They're all different kind of software programs out in the marketplace, including those that are homebrew. Asking the leading EMC test equipment manufacturer of EMI-receivers and spectrum analyzers, they will definitely recommend their own-easy to use-EMC software. How does this work out in reality? In many cases labs have spent 50.000 or more dollars until the test house management realizes that the software has been written more than 10 years ago with a databank system that is simply no longer appropriate for use under windows 9x, NT or similar. The database is programmed in such a strange way that this will automatically lead to major problems in handling the software. The program is enormously big, can do almost anything, but practical default solutions are mostly missing (e.g. R&S ES K-1).

Harsh requirements were lately set by new accreditation guidelines (ISO/EN 17025) in Europe. Now software needs to be validated!

Solutions of technical difficulties in running an EMC lab is only one side of the coin. Administration problems are the other one. The nature of EMC testing is mainly defined by many small jobs. It is therefore extremely important to have a system in place which allows speedy documentation of the process, well engineered integration of test data output into preformatted, standardized test reports. The test report is the actual product sold by EMC test labs. All these beautifully arranged activities, however, be worth nothing, if management is not in the position to organize accounting. To the author's knowledge, no suitable, commercially available software system exists to integrate all these jobs. It is up to the lab to subcontract with an external software house or start building its own EMC management software system. The efficiency of the lab strongly depends on this function.

Lessons learned:

Scheduling test time in EMC labs is a difficult job, loaded with uncertainties.

Customers and the very testing process of products itself introduce unforeseen delays. The customer should do preparation of EMC tests upfront, very carefully. Otherwise time and money is lost unnecessarily. Strictly subdividing the tests in compliance and development testing is sometimes unrealistic. The reason lies in the unpredictability and failures of the equipment under test. Experience, however, teaches things go often wrong the first time in testing and take one round of fixing. About 50 percent of the client's have a psychological problem in accepting bad news as an outcome of EMC testing. It is a big challenge for the test house manager and the test engineers to cope with that. Being in the service business, even the demanding customer is always right; but there are of course some technical and legal limits. A prudent choice of test sequence, starting with nondestructive tests, will certainly help the process. Aside from good fixing capabilities, high-quality EMC testing and meaningful test reports, EMC labs have to invest now heavily into new micro-wave measurement instrumentation, calibration, reporting and general EMC management software. To keep everything updated and current, continuous efforts and financial resources are needed.

Auditing of EMC Labs

Background and History of the German Accreditation System for EMC: The German EMC accreditation started in the early '90s. Prior to this accreditation for EMC was only an issue in the military world and in some parts of the automotive/ aeronautical industry. In Germany, at this time, there were three different accreditation organizations operating, namely the PTT government body BAPT, later RegTP in Mainz, a private body DATech in Frankfurt/M and Dekitz for Telecom Software Protocols, now integrated into DATech. The roof organization is the German accreditation council (DAR). A UK equivalent is NAMAS or presently UKAS. A US equivalent could be NIST/NAVLAB or A2L. From the beginning the RegTP focused on legally mandatory accreditation like competent bodies (CB), notified bodies (NB) and nowadays conformity assessment bodies (CAB) under the mutual recognition agreements between the EU with North America, Australia and New Zealand. The authorities mostly performed laboratory accreditations in those cases, where the client requested the accreditation of his certification body as CB under the German EMC act. This activity started 1992/93.

Since 2001 the picture has changed in the way that only one organization in Frankfurt – DATech e.V. - is now handling all lab accreditations. The organization is not only accrediting EMC labs but rather deals with all areas of electro technical activities. The regulation authorities (RegTP) concentrate now entirely on their legal mandate. With a change of legislation, in particular in telecommunications, the emphasis is now on certification bodies (CB/NB) according to the EN 45011 March 1998**.** It is not a lab standard and describes the managerial as well as specific technical requirements and evaluation procedures, including quality management issues.

Confidentiality, documentation records, qualification criteria of the personnel and their independence from third parties are just a few important highlights. At the end of the day this accreditation leads to legal assessment of compliance with the national EMC act. As one can well imagine, product liability is certainly an issue. The decision-making process must be clear, justified and repeatable. It is very important in this respect to consider complaints by clients and formalize all steps in that procedure. For the auditor or assessor this requires very detailed technical experience, assessment training, and knowledge in quality assurance systems combined with the latest information about the corresponding EMC legislation both in Germany as well and on as on European level. Speaking about EMC labs and their accreditation, EN45001 " General requirements for the competence of testing and calibration laboratories" was the rule in the beginning. The standard spelled out requirements regarding the quality management system and put some emphasis on technical details related to competence and technical procedures of performing

EMC tests. Traceability of test results to national and international standards and norms, as well as test report requirements are outlined. In practice, however, one has to admit EN 45001 is more of a formal than a detailed technical requirement.
This scenario has changed dramatically with the mandatory introduction of ISO/EN 17025 finally at August 1. 2001 by DATech. Now, there is a good balance between formal quality management and detailed technical requirements.
Management requirements include: organization in quality system document control review of requests, tenders and contracts, subcontracting of tests and calibrations, purchasing services and supplies, service to the client, complaints, control of nonconforming testing and/or calibration work, corrective action, preventive action, internal audits, management reviews.
Technical requirements include: general, personnel, accommodation and environmental conditions, test and calibration methods and method validation, equipment measurement traceability, sampling, handling of tests and calibration items, assuring the quality of test and calibration results.
In this respect it is important to exactly understand technical procedures to estimate and control expanded measurement uncertainty. Technical training of all people involved in EMC testing therefore gains increasing importance. Generally speaking one can state the standard making bodies did now recognize the complexity as well as the dominating technical issues to the full extent. Disappointing consistency and accuracy in laboratory tests made this step imperative. In particular in EMC test business, it is not uncommon to see test result variations, from one lab to another, under almost the same conditions, to exceed one order of magnitude! Round Robin tests between the labs are one solution. Performing sophisticated EMC tests in the presence of the auditor, during the lab assessment, is another solution.
The accreditation organizations RegTP and DATech have a pool of about 20 auditors, which is subdivided into two parts, the lead auditors (QM) and EMC auditors (technical expert). The Author is both, QM as well as Technical Expert and lectures at the annual assessor and technical expert trainings. In case of an annual (or now 18 month assessment interval) surveillance audit, the assessor will spend one day on-site for the lab or certification body evaluation, going through quality management and technical issues, based on a questionnaire. Half a day is spent on preparation and half a day is spent on writing the assessment report. This report is then submitted to the accreditation organization, which also issues the certificate for the client.
Only in cases that involve reaccreditations after five years or disputes, it is the job of the sectorial committee, with a special little working group, to finally decide on granting accreditation. If no agreement can be reached, the case is taken up to the German accreditation council (DAR) for decision. The final step after DAR is appellation of German courts.
The schedule for any actual assessment on-site is always very tight and there is no way of doing a 100 percent examination. A positive attitude, experience, psychology and some guts feeling combined with outstanding technical expertise may lead the way to fair, successful audits. In spite of having studied the Q. M. manual intensively in advance, there will always be surprises.
Even very experienced assessors, with several decades of professional hands-on experience, both in practical and theoretical issues, will certainly, and once in a while be deluded in an assessment. It is part of the human nature to pass an audit, if possible, with the minimum amount of work and effort needed. Hardly anybody would lead the auditors to the weak spots.
Therefore it is very important for the auditor to establish good, friendly and trustful relationship to the people and lab to be assessed. The auditor’s training will certainly include a lot of psychology. If the lab and its management are convinced about the advantages of accreditation, the job becomes a lot easier. Normally one can already tell from the way the quality assurance manual is written, what kind of attitude can be expected from the candidate lab. A good quality management system is tailored in such a way to optimally meet the client’s individual workflow and quality/performance criteria. There are naturally big differences between small labs with three to five people, all working in one place, and big international test organizations, which are global players. Their Q. M. system can easily be measured in meters by lining up the many written files and folders. It is quite obvious that this kind of the system cannot be sent to the auditor in advance. There's a lot of confidential, company internal, data in those files, which should for security reasons not be distributed outside the organization.
How good are the descriptions of the various QM work procedures? Is it written in a practical way, with due consideration of the appropriate standards to be applied?
The list of test equipment and calibration dates and intervals normally reveals quite a bit. Is it new equipment that is being used or old stuff? Is it fully automated? Is the software validated, and if so, how? How does the lab perform the calibration jobs? Will it entirely rely on external calibration services? Is it in the position to judge the quality of these services? In many big organizations there's a clear trend to outsourcing of any service not being part of the core business. The core business, however, is testing. This means it is very difficult to predict the type of products to be presented to the test lab tomorrow, if the test lab has a large accreditation scope.
In general, traceable calibration could follow relatively simple rules. The calibration tree of traceability to national, international standard, basically calls for just a handful of truly traceable test equipment. If amplitude, frequency, time and RF-impedance traceability is established, then it is not too difficult to refer the other jobs to this. The test lab itself can now measure these deduced quantities. This procedure is quite time-consuming and certainly does require a deep inside into the functioning of the test instruments. It is the author’s experience from running medium-sized labs that this calibration cycle will cost about two to four man months. By no means at all does calibration stop at box level. Calibration according to EN 17025 has to consider the whole chain of test instrumentation within a test stand. It is exactly this point, where most of the labs presently have their biggest problems. Following the EMC standards word by word does not present a solution, because some of the standards are not clearly and explicitly written. Their interpretation is sometimes quite difficult.

Bizarre Cases of EMC Lab Assessment: This chapter is meant to be illustrative, but not negative. In a period of 10 years assessment experience one can well imagine to come across some wild cases. On the other hand this does by no means at all say these cases are representative for the average German accredited EMC Lab. It is important to stress the fact of the following cases to be true and non-academic. Confidentiality and secrecy agreements however do not permit to reveal traceable facts that would involve names, organizations or locations!
Case 1: In one of the first audits as a technical expert, the author had to assess a large anechoic chamber of a commercial and military EMC test facility. The quality management audits went very well and it was only the practical evaluation of the test facility left over. By looking at some of the measurements data, it became quickly evident there was some sort of sensitivity problem below 100 MHz, measuring radiated emissions from the 10 m site, inside the anechoic chamber. Technical discussions could not answer questions asked, so the decision was made to have a life demonstration of the emission of a small test radiator. The outcome of the test was very surprising, because it did not match reality. Emissions where far too low at low frequencies from 30 to 100 MHz. A detailed technical analysis revealed the actual problem. The inner pin of the N connector in the coaxial feed through (RG 214) between the measurement room and the control room was broken. Consequently there was only weak capacitive coupling in that frequency range. This had not been detected for at least 10 years. The calibration procedure, however, included software offset for this effect in the low frequency range!
The second surprising effect in the same facility was demonstrated using a small battery driven broadcast receive. In spite of the totally shielded facility, radio reception was possible in the short wave and FM radio bands. A detailed technical investigation followed and revealed the problem area was the filter ar-

rangements of the chamber. The very expensive filters for power/signal lines had no more ground contact to the metal and chassis of the anechoic chamber. Corrosion had settled in and the contact was virtually gone. This additionally represents a major safety hazard problem!
The zoning concept was entirely violated in this area. The cables just penetrated the protecting shield.
It almost sounds unbelievable, that the client's test engineers took two more weeks to confirm the findings. It took another three months to finally fix the problem. Therefore accreditation was awarded after four months. (Note, today the outcome would probably be different.)
Case 2: One Lab in the southern part of Germany had successfully passed the re-audit with some minor deviations. The assessors left and were accompanied to their cars and off they went. Then all of a sudden, one assessor realized he had left one part in the lab, including the test instrumentation list with the newly delivered test equipment. When he arrived at the test house a big truck just finished collecting and up loading the brand-new test equipment, recently delivered to the lab. It goes without saying, this trick of teasing the auditors by only showing temporarily available test equipment, was not a good idea and based on the sheer coincidence, the incidence triggered major problems in granting re-accreditation.
Case 3: An EMC test lab in a major corporation was reevaluated after five years. Previous audits revealed the very high level of professionalism and good engineering practice. All lab personnel were highly qualified, motivated and technically very competent. The big event in the organization, however, was reorganization throughout the German company group. In essence it was only one person left over from the old crew who was fully competent. All others were brand-new test engineers with not even six months of professional experience. Needless to say, this spelled trouble. The young, innocent test engineers had no clue how to run the tests in detail, nor did they know anything about calibration. Even worse everybody relied on external calibration services and was unable to re-evaluate the equipment before using it. There was no written plan how to qualify the new engineers by sending them to EMC symposia, lecturers or seminars. Corporate top management had decided from the ivory tower cost of running the EMC lab had to be cut back dramatically. Old equipment could not be repaired and new equipment, to meet latest expanded standard requirements, could not be bought. The single, old professional crewmember was not the position to train the engineers, because his new responsibility included marketing and sales. A detailed analysis of the external calibration service and its traceability by the technical expert resulted in complete disaster. This service was a DKD calibration lab, which was only, calibrate (traceable) up to 100kHz. The lab, however, did perform receiver and subcontracted antenna calibrations up to 1 GHz. The DKD calibration certificates were falsified, except for multi-meters, and the external service firm pretended to be traceable. Almost 20 k$ US had been spent on a useless contract, worth nothing. The lab had fully trusted the statements of the sales people in calibration. Even worse, since the lab had not done any plausibility tests in between calibration intervals, they had to recall all products tested during the last year. Reaccreditation was not possible at that time.
Case 4: An EMC lab in Asia requested official German EMC laboratories accreditation and recognition. The parent company in Germany had successfully been accredited for many years. The quality management manual looked fine and the procedures seemed to be in place. After a long business trip to ASIA, the assessment was performed on-site. Technical competence was given. The equipment was installed and operated in a professional manner. It was time to check traceability of the test results. This turned out to be not an easy job. The lab mainly used secondhand EMC test equipment, which is fine, in principle. The difficulty resulted in all different kinds of test certificates and calibration certificates for the key test equipment, being presented in Chinese language! Nothing was traceable to European or North American national metrology labs. The lab fully relied on some old equipment manufacturer's calibration data. This included U.S. companies from which we knew they had major traceability problems. The field probe was finally re-calibrate by the parent company in Germany and was traceable to the German PTB or NPL London, respectively. All other test equipment was only traceable to Chinese speaking sources. That presented an enormous problem to the auditors not being able to speak or understand anything in that language.
In a very tedious effort, consuming almost two extra days on site, it was finally possible to trace back the calibration through the official Chinese sources, all the way to the U.S. NIST in Boulder CO. The biggest problem resulted in establishing the measurement uncertainty in the chain of all parameters needed. Chinese mentality and the fear of "losing their faces" was a major obstacle. Finally the case resulted in a lot of enthusiastic hand waving and joy on the customer side and made the assessor happy to be able to help effectively.
<u>Lessons learned:</u>
German EMC accreditation started around 1992. RegTP is focusing on CB/NB/CABs (EN 45011), while DATech covers EMC labs (EN45001, now ISO/EN17025). There is a pool of about 20 auditors, subdivided in lead QM and technical EMC experts. The roof accreditation organization forms DAR. In cases of dispute, the last decision is made by German court appellation. A typical audit takes 1 day on-site and 1 day for preparation /report. Audits are always done under time constrains; therefore no 100% check is possible. Calibration and expanded measurement uncertainty for the complete test stands and not only the individual equipment is presently giving the labs the most headache. The lab itself, using just a view traceable and very accurately calibrated key instruments can principally do calibration. All other boxes and quantities can be deduced hereof. This procedure is a good training but requires a deep knowledge of EMC.

Bizarre cases are illustrative but not always representative for the average EMC lab. Case 1 boils down to radiated emission instrumentation -cable calibration problems. A broken connector pin determines the low frequency measurement sensitivity. The corrosion under the filters in the shielded room makes the penetrating cables violate the shielding integrity and the zoning concept. Case 2 shows how bad the tricks can be. The auditors almost got fooled by the lab about the real status of their test equipment installed. Case 3 demonstrates corporate decision-making impact on lab quality and how serious a problem in calibration can be without save fallback positions by establishing sanity checks in between calibration intervals. In any case must the lab be technically competent enough to check external calibration service quality. Case 4 is a calibration, traceability problem in ASIA dramatized by Chinese language problems for the auditor.

References:

[1] D. Hansen et al., 2000, http://www.euro-emc-service.de GTEM, OATS, FAR-Chamber, complete, technical articles in English for free download available or contact the author in Switzerland by phone/fax +41 566 337381.