EMC management in the railway industry: Concept to completion

Modern networks require up-to-date EMC management.

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Given the stringent need for safety and reliability within the railway industry, the electromagnetic compatibility of railway networks and systems is an essential requirement of all products developed for railway applications worldwide. Although EMC is a complex issue regarding systems and installations, by applying proven control methods, it can be managed both effectively and efficiently.

In Europe, legal obligations have been established for demonstrating conformity with essential requirements for EMC. When the EMC Directive 89/336/EEC was published in 1996, it was widely known and accepted that electrical/electronic equipment must show compliance with the directive. However, the fact that complex installations must also comply has only slowly been recognized. Even though the EMC Directive's jurisdiction is limited to Europe, its principles are being applied worldwide and are valuable guidelines for EMC control. Indeed, authorities in Asia have stipulated in recent tenders that EMC compliance should be in accordance with European EMC standards, citing the EMC Directive.

In reference to the railway industry operating a network, the essential aim of the European Directive is acceptable operation within the working environment. However, the major concern of suppliers and operators is that where EMC is at issue, no safety hazard is caused.

This concern has had a direct and far-reaching effect on the perceptions of manufacturers and operators in considering how EMC compliance is achieved and its relationship to proper equipment operation within the network. For manufacturers, compliance of equipment is usually achieved by satisfying a set of minimum requirements for emission and immunity. The situation is different where installations are considered, especially those that are physically large (for example railway and telecommunication networks), complex, and have evolved over a period of time.

In the case of the railway industry, many of the systems currently in use were installed a number of years ago. Though compliant with the regulations that were in place at the time, such systems now face tougher EMC requirements due to changes in both legislation and the operating environment. Many systems have evolved and the environment has changed due to the introduction of more electronic and electrical systems and processes on both a micro and macro level. An example at the platform level is automatic door sensors, and at network levels is the use of train identification systems (Figure 1). Further, mobile sources of interference have added a new threat to existing systems and has the potential to alter the environment. A simple example is the common and wide

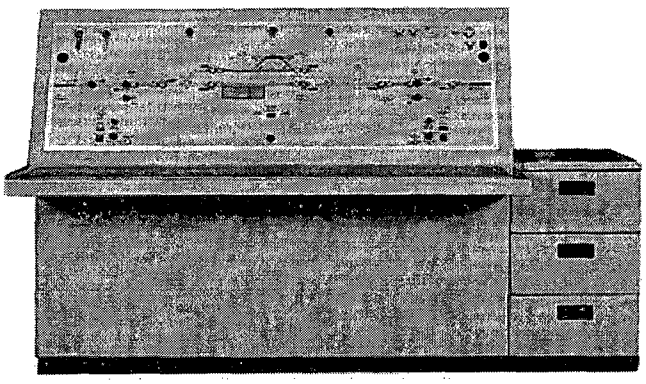

Figure 1. Evolution to a centralized control system environment.

use of mobile phones; while the mobile phone alters the train-borne environment, the base station alters the external railway operating environment.

Many systems supplied to the railway industry have a defined immunity level to published standards. However, the use of published standards is a compliance procedure that does not indicate the true susceptibility of the equipment and systems as the installation evolves over time. Suppliers should not fall into the trap of assuming that it is sufficient to demonstrate compliance for a single unit at a single point in time. In fact, continuing EMC compliance is rarely a matter of simply carrying out a set of compliance tests in the last phases of the development cycle.

The reality of EMC compliance requires the involvement of a more total EMC approach to entire business and operating processes, where compliance is an integral part of the product and operational life-cycle. Consequently, continuing compliance involves a variety of business disciplines not normally considered part of the EMC process. The business framework requires that EMC codes of practice and quality assurance systems are fundamental at all stages of equipment design, development, approval, procurement and production, installation operation, upgrade and replacement. Procedures should be in place which address ongoing compliance up to the withdrawal of the product from operation. Where installations are concerned, an integrated set of procedures should be in place which is recognized and used by equipment manufacturers, systems integrators and installation operators. The approach to be taken is described here.

EMC MANAGEMENT CONTROL PLAN

The starting point for achieving whole-life EMC management is the preparation of an EMC management control plan. The creation of such a plan has a three-fold objective:

- To ensure that new equipment, a new installation or a modification to an existing installation meets the objectives of the EMC Directive, i.e., operates as intended, and is both safe and reliable.
- To ensure that over the lifetime of the new equipment or installation, compliance will continue until the equipment is withdrawn or the installation environment has been modified.
- To ensure that this is achieved at the lowest possible cost.

The EMC control plan should be part of the existing business procedures (QA, QC) and not stand outside them. Some of the contents of a typical management control plan are listed here:

- Electromagnetic environment assessments and risk analysis
- Product and installation definition in terms of their relationship for conformance to the Directive
- Definition of legal requirements, compliance routes and decision flow charts
- Applicable standards and their use for equipment design and installation conformity
- Purchasing rules and supplier audits
- Conformity in production, or installation operation
- Installation, assembly and operation techniques

Each of the above aspects should be considered in chronological order, in terms of where in an apparatus' development or installation life-cycle the necessary strategies or procedures should be inserted. It is easier to address these issues when a new equipment or installation is planned, e.g., a new type of motor unit or a new line to a new housing or business area. For an existing installation or equipment development, the same approach is invaluable for demonstrating compliance and due diligence in satisfying EMC legislation and for ensuring safe and reliable operation.

Certain EU Member States' regulations recognize that documents are evidence that manufacturers and installation operators have attempted to do the best they can to comply with Directive requirements within recognized constraints. This is termed "due diligence." An EMC control plan is an essential first step in showing due diligence.

MANAGEMENT OF DESIGN, MANUFACTURE AND INSTALLATION

The level of EMC expertise and facilities a manufacturer and system operator should possess is dependent on the size of the company, the nature of its business and the size, age and complexity of the installation. A trade-off exists between the cost of such resources and the cost of ensuring compliance that is forecast, although proportional investment inevitably produces proportional success.

DESIGN

It is well-known that EMC design measures implemented at an early stage in the development cycle lead to less problems at the testing and commissioning stage. The

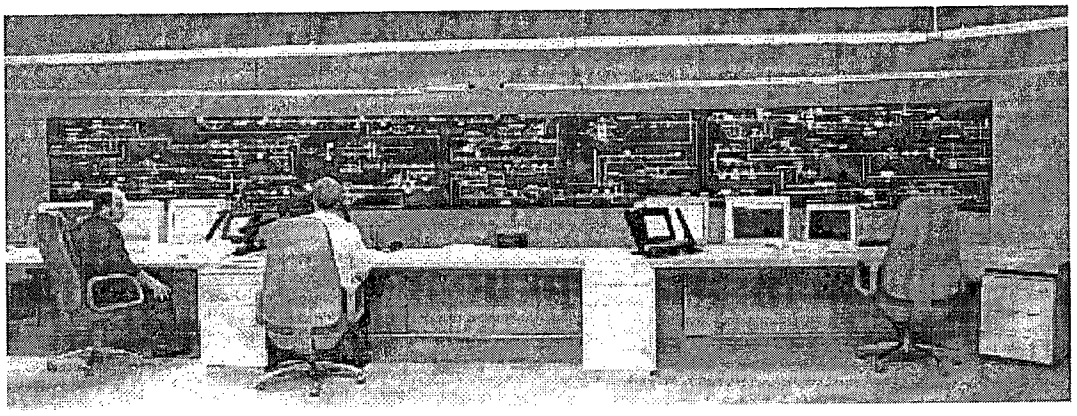

Figure 2. A centralized traffic center.

benefits of good EMC management at the design stage should be recognized and should not be considered a burden. These benefits can only be obtained when EMC is borne in mind from the commencement of a project and when various corrective loops are activated during the project development.

Design and project engineers should work closely with the pre-compliance EMC team within the organization so that a fluid exchange of ideas on design, installation development, project compliance requirements, test methodologies and test results can be obtained. Where special measures have been implemented to improve EMC rather than functionality, these decisions should be documented and controlled throughout the lifetime of the equipment or installation. This will help to ensure ongoing conformity.

MANUFACTURING

It is a common mistake that EMC compliance is treated solely as the responsibility of the design team. The manufacturing process can breach the compliance of the equipment by changes to cabling routes or by the substitution of non-approved components. The size of the manufacturer will dictate the range of procedures and facilities that should be applied, from having a dedicated EMC department within existing test facilities, to appointing an EMC coordinator, to the use of regular vendor audits. Whatever the size of the company, it is essential that a range of EMC tests are considered throughout the product's life in order to ensure that the last-supplied product still complies.

INSTALLATION

Railway networks may be comprised of new developments or evolutions of an existing network (Figure 2). New, improved and/or upgraded equipment is supplied and installed to the network. Prior to installation of equipment, it is essential that the working environment should be defined and recorded. This may not be such an onerous task as it first appears, as there will be existing documentation and experience useful for this task. This activity should:

- Review existing documentation.
- Review the installed equipment base.
- Review equipment suppliers' data sheets.
- Review existing procurement requirements.
- Determine the differences between the environmental requirements identified above and those identified in harmonized international or company standards.

On completion of the definition of the working environment, comparisons can be made between what the existing environment is (or was) and how the environment will evolve as new, replacement or upgraded equipment is added to the network. Thus it will be possible to demonstrate that the installation environment is being managed so that safe and reliable operation is being maintained.

MANAGEMENT OF BUSINESS PROCEDURES

Having set the initial management process in place, a second level of detail is required. The second level of detail is related to actual business procedures; these procedures are equally applicable to equipment suppliers or to network operators.

Company procedures are required to ensure conformity with EMC requirements throughout equipment supply, installation procurement and integration, and throughout the life of the installation. They are applicable for engineering changes and improvements to functionality. Company procedures should employ EMC management techniques throughout to ensure safe and reliable operation.

The following sections describe some of the procedures which should be employed in dealing with these requirements.

EMC QUALITY ASSURANCE

Equipment and installations normally have a spread of functional variations that, in good designs, do not affect the correct functioning of the equipment or installation. Quality assurance related to EMC has a different status, especially when there are legal implications for non-compliance. There are three cases to consider:

1. Ensuring that equipment of a particular production procurement that is of the same type remains in conformity.
2. Ensuring that equipment with specific but apparently 'minor,' design changes remains in conformity.

3. Ensuring that the network environment description is updated as new or modified equipment and systems are added.

For EMC quality assurance purposes, the following strategy can be used to fulfill these requirements:

- Analyze and control at the pre-production stage any modifications in terms of EMC due to engineering changes, purchasing changes and manufacturing/assembly changes.
- Carry out routine re-verifications of the product at defined intervals based upon the pass margin and the number of units manufactured.
- Analyze the expected EMC-related performance of the procured equipment against the installation environment as described above. This analysis has two objectives:

  To ensure that the equipment will perform as expected in the working environment.

  To determine how the environment has evolved as the new equipment becomes operational.

Addressing the issues raised above will demonstrate that control of functional variations which affect EMC has been achieved.

CONTROL OF MODIFICATIONS

Engineering, purchasing and production modifications should be assessed in terms of their impact on the overall EMC performance in light of the safety margin in passing the standards. The purchasing and manufacturing staff should be following guidelines as to which equipment and installation techniques are critical from an EMC point of view.

CHECKLISTS

Checklists are an important element used to highlight specific points which should be addressed when developing strategies and policies for EMC management from concept to completion. Detailed checklists should be available for all of the topics presented below, though this list is not exhaustive:

- EMC control plan details
- Conformity procedures
- Project review and milestones plan
- EMC design reviews
- Test plans
- Installation guidelines
- Maintenance procedures

ONGOING COMPLIANCE

To ensure ongoing compliance of systems and installations, there are two elements that have to be addressed. These are that:

- For existing systems and installations, EMC requirements continue to be met when new systems are added to the installed base network.
- Those systems and installations that are installed new

meet the latest EMC requirements.

In addressing the first of these points, it should be remembered that the installed base comprises systems and installations which, when purchased, met the existing requirements but which may not meet the EMC standards that have been introduced. Where appropriate, procedures should be implemented which enable changes to be made while still attempting to meet current requirements. Ongoing compliance should be considered at the concept stage of development of the system and/or installation. With comparative measurements and analyses of the results, it is possible to assess continuing compliance as the network grows and evolves due to technology changes, engineering changes and equipment integration.

For the second of these points, new equipment and installations purchased or brought into service must comply with the latest requirements and/or regulations. However, as installations evolve, the evolution requires management of the way that systems are introduced and modified so that continuing compliance is achieved.

VENDOR ASSESSMENT

The manufacturer of an equipment will be largely dependent on the EMC performance of the supplier's components or equipment. In order to exercise control, the system or installation manufacturer has to specify to suppliers what kind of environment the equipment will be used in, and hence, what EMC performance requirements are expected. The definition of the environment as described above sets the benchmark against which modification and concessions are compared. Analyzing changes and recording the results all form the exercise of due diligence.

A supplier may request concessions against the EMC requirements. In such cases, an EMC risk analysis will need to be performed, in which the threat levels of the environment are compared with the performance levels referred to in the supplier's statements. Expert advice (internal or external) will be required in order to determine the likelihood that EMC will be affected as a result of changes from such a concession.

MAINTENANCE

Maintenance of equipment during its operational lifetime should be a requirement of all operators and installers in order to ensure that the essential protection requirements continue to be satisfied. Maintenance manuals for equipment should include provisions for detecting and rectifying EMC defects, in addition to the more common functional and safety checks. Maintenance will typically include a combination of both visual inspections and electrical tests. Items such as the correct treatment of shielding gaskets and the procedures for handling static sensitive devices during maintenance to prevent electrostatic discharge damage should be in place as a matter of course.

Maintenance of the network from an EMC point of view follows a similar path as that described for equipment, in the sense that manuals should be available which describe how EMC aspects are managed. The prime starting point for any maintenance is: has the environment been defined? Without this benchmark, any maintenance procedures are operating in the dark.

CONCLUSION

The objective of whole-life management is that, in placing equipment on the market or operating a network, it should continue to operate as intended to its end-of-life. To achieve that objective, a number of criteria must be satisfied. Differing requirements need to be addressed at each part of the equipment's design cycle, from commencement to installation and operation of the network. All aspects of manufacturing, supply, installation, and operation need to be considered in order that EMC aspects are properly covered. Thus, marketing personnel need to consider whether the requirements are genuine, when the equipment will be sold, and whether there is a compliant product already on the market. Equally, engineering professionals have a number of critical phases to address, e.g., what type equipment is to be supplied, should a shielded equipment practice be used, are there EMC analysis tools available, and are there sufficient EMC-aware engineers available in order to develop the product?

Overlaying the product design cycle must be a management structure whereby assurance of conformance to EMC requirements and regulations is achieved. This structure is identified via the operation of phase reviews, EMC confidence testing, EMC compliance testing, control of changes in design and manufacture, and conformance to a product plan. Control of purchasing and manufacture must be in place; otherwise changes to components or manufacturing methods could easily 'blow a hole' in a product's EMC compliance. An EMC control plan is the fundamental building block, which enables equipment designers and network operators to achieve and maintain compliance.

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