Construction of 1100 MW Power Plants

Challenges for the Next Generation of Plant Construction Teams

Rob Droste and Thomas Maas

Kurzfassung

Bau von 1100-MW-Kraftwerken – Herausforderungen für die nächste Generation von Konstrukteuren

In ganz Europa wurden Erneuerungsprojekte gestartet, um sämtliche Stromerzeugungsanlagen zu modernisieren. Die Herausforderungen, mit denen die meisten Projekte konfrontiert sind, stehen damit im Zusammenhang, dass die spezifizierte Qualität erreicht und die geltende Gesetzgebung beachtet werden müssen. Die vorgeschriebenen wesentlichen Sicherheitsanforderungen sollten während der Designphase implementiert werden und während der Beschaffungsphase und der Errichtung des Kraftwerks sollte ein korrektes Follow-up sichergestellt werden. Angesichts der unterschiedlichen Rollen der Regierung in der Gesetzgebung über den Umweltschutz und die Sicherheit am Arbeitsplatz muss der Hersteller die ausgeführten Arbeiten organisieren und dokumentieren, um die Übereinstimmung mit diesen Gesetzen nachzuweisen. Aufgrund von Budgeteinschränkungen werden zahlreiche Komponenten und/oder Bauteile in Niedriglohnländern hergestellt. Dies wirkt sich auf die gelieferte Qualität dieser Produkte aus.

Für die Projekte von E.ON Kraftwerke wurde Total Quality Management unter Verwendung von Risikomanagement und Methoden zur ständigen Verbesserung implementiert. Da ein Projekt ein Umwandlungsprozess ist, greift das Projekt auf Design-Checks (wie HAZOP (PAAG), SIL-Klassifizierung (Safety Integrity Level), Ergonomieprüfung, Constructability Review, Reliability and Maintainability (RAMS)) zurück, um die Qualität des Designs sicherzustellen. Zur Minimierung der Menge unperfekter Produkte und Kraftwerkbauteile stellt der Gesamthersteller dem Lieferanten während der Konstruktionsphase sogenannte Resident Engineers zur Seite. Durch dieses Managementsystem können die Erbringung von Qualität und die Einhaltung der geltenden Gesetze garantiert werden.

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Introduction

Many utilities understand the necessity to supply sufficient and reliable power to all customers. Environmental requirements and increased energy demand in the whole of Europe call for modern and highly efficient power plants. Therefore, replacement projects have been started in order to increase efficiency of the entire production fleet. Based on the philosophy of differentiation in production, also new coal-fired power plants are part of these projects. This differentiation enables E.ON group to play a major role in power production in the next decade.

E.ON Kraftwerke started in 2005 with building a new 1100 MW coal-fired power plant in Datteln (North Rhine-Westphalia) to replace the existing plant. A similar power plant is currently being constructed (project start in 2007) at the Maasvlakte (port of Rotterdam) near two existing units.

The projects are organised as multi-contract projects. The project teams are the overall manufacturer of these power plants. For the delivery of the main components of the power plant, E.ON Kraftwerke has long-term relations and strong partnerships with major German companies, experienced in power plant construction. The boiler is constructed by the Hitachi Power Europe GmbH, the steam turbine and generator are ordered from Alstom Power Generation AG.

The paper at hand will share the experience of these projects with the activities made with new constructions of the last years.

Challenges

Most of the latest built coal-fired power plants in Europe were commissioned approximately 20 years ago. In these 20 years, the requirements for power plants have changed. More stringent environmental and labour safety requirements are now mandatory. Due to a different governmental role in environmental and labour safety legislation, the manufacturers/employers have to organise and document the work performed to prove compliance with these laws.

Therefore, such complex multi-contract projects, require good knowledge of current legislation and experience in execution of large projects. Also our major partners are seeing this necessity. Within the company, new management teams have been nominated to realise these projects and to capture best work practices. An organisation manual for such projects has been established and implemented with the help of consultancy companies.

Since all projects have a limited budget and a fixed start-up date, rework and repair work are a major risk and should be avoided. Due to the limited budget, many components and/or construction parts are bought and manufactured in low-cost countries. This can have impact on schedule and the product quality delivered. This has been the case with the Datteln project. When the first materials and plant components arrived at the construction site, major flaws were detected in materials and components. This lack of quality endangered the construction schedule thus making it impossible to construct and install major structures without performing extensive repair work. Plant integrity has been put at risk and compliance with specifications and applicable construction codes could not be established. Figure 1 shows repair work performed on one of the membrane walls. Figure 2 shows lack of penetration and a deviation of the standard for a prescribed weld detail on a hanger for a boiler in an 1100 MW power plant.

A New Approach

As plant components and product are manufactured in low-cost countries like Israel, China or Turkey, compliance with contracted specifications and local standards cannot be

Figure 1. Examples of rework performed on one of the membrane walls to repair non-conformities with regard to the specification.

Figure 2. Example of repair work on one of the boiler hangers due to non-conformity with regard to ISO 5817 (lack of penetration).

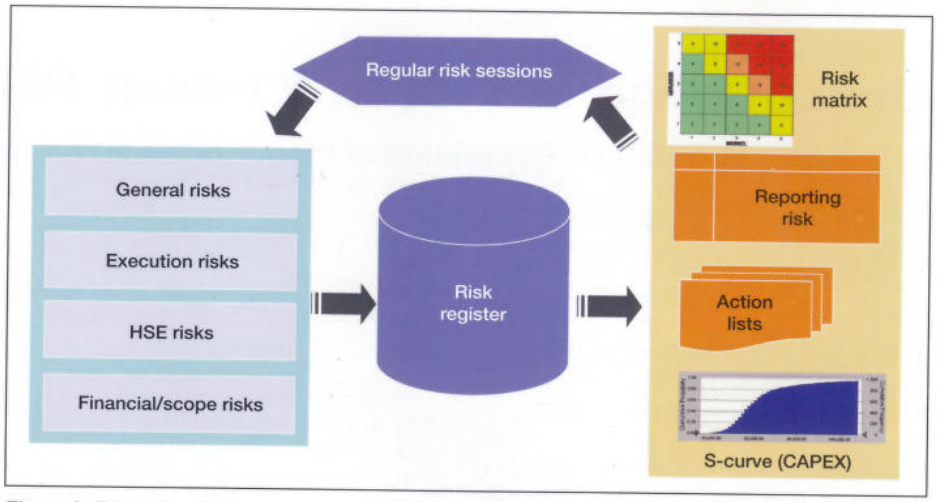

Figure 3. Principle of risk management in projects.

assumed automatically. A new approach must therefore be implemented and actually has been adopted by both the project team and its major suppliers. This approach is a well-known management philosophy, which has been neglected in the last decade: Total Quality Management (TQM).

Total Quality Management is a management concept developed by *W. Edwards Deming*. The basis of TQM is to reduce errors produced during manufacturing or servicing, increase customer satisfaction, streamline supply chain management, aim for modernisation of equipment and ensure workers have the highest level of training.

The roots of TQM can be traced back to the early 1920s when statistical theory was first applied to product quality control. This concept was further developed in Japan in the 1940s led by Americans, such as *W. Edwards Deming, Joseph Moses Juran* and *Armand Vallin Feigenbaum*. The focus widened from quality of products to quality of all issues within an organisation – the start of Total Quality Management. In the 1940s, Japanese products were perceived as cheep, shoddy imitations. Japanese industrial leaders recognised this problem and aimed to produce innovative high-quality products. *W. Edwards Deming* suggested that they can achieve their goal in five years; not many Japanese believed him. However, they followed his suggestions. Maybe the Japanese thought it was rude to say that they did not believe *W. Edwards Deming*, or maybe they thought it would be embarrassing if they could not follow his suggestions. Whatever reason it was, they took *W. Edwards Deming's* and other gurus' advice and never looked back [1, 2].

The project teams discuss and implement within the scope of the daily routine of project management the main objectives of TQM, Quality Assurance and Control system. Key words like predictability, reliability, reproducibility, transparency and compliance (specifications, rules, regulations and legislation) are part of the processes and procedures.

Total Quality Management (TQM)

The general idea of TQM is as simple as it is effective, doing it right the first time. The basic principles of the TQM philosophy are customer satisfaction, supplier satisfaction and continuous improvement of the business processes [3].

The first and major TQM principle is to satisfy the customer – the person who pays for the product or service. Customers want to get their money's worth from a product or service they purchase.

A second TQM principle is to satisfy the supplier, which is the person or organisation from whom you are purchasing goods or services. A company must look to satisfy their suppliers by providing them with clear instructions and requirements and then paying them fairly and on time.

The third principle of TQM is continuous improvement. You can never be satisfied with the methods used, because they always can be improved.

Within project organisations, this has been translated into programmes for Quality Assurance, Quality Control and Compliance. In general, this includes that the overall manufacturer defines the quality required for all products and plant components. Together with our major suppliers in both projects a programme of re-work and re-ordering of components has been discussed and implemented. This results in plant components which are in line with requirements, expectations and specifications. A lot of valuable time and effort can and has been saved by avoiding repair work and/or rejecting already manufactured and delivered materials. This process demands top management involvement by showing leadership and support initiatives in achieving high-quality products.

When implementing this systematic approach, the project remains in compliance with the ISO-9000 code for quality management systems.

Quality Assurance

Quality management starts with quality assurance. This part of the programme describes all work required to assure that the agreed quality is delivered. Based on the fact that prevention is better than detection, an extensive review and inspection programme has been defined. This programme provides priorities for project teams and determines the focus area. Risk sessions (HAZID, Risk Register, HAZOP, and Constructability Review, for example) are used as basis for this programme.

By supporting this quality assurance system with a clear defined process of risk identification and risk management, the continuity of this work is guaranteed. Decisions during the project by management teams are supported by a clear risk analysis. These analyses (see also Figure 3) are continuously updated to provide good knowledge of the changes in risk and focus area, according to the *W. Edwards Deming's* Plan-Do-Check-Act cycle as shown in Figure 4.

Key factor in creating a successful project is the integral approach of a project from the initial design phase until commissioning and start of commercial operation. A project is regarded as a transformation of raw materials into a fully-operational plant and the model needed to capture all essential steps in this transformation process as shown in Figure 5.

Explanation and integration into the project of this overall approach is not a simple task and a lot of effort is required. The project management needed to clarify that a lot of work and checks need to be performed during conceptual and basic design phase of the project. Therefore, clear design reviews and a well-defined process of controlling initial design activities are required. Design checks with the help of methods like HAZID, HAZOP ses-

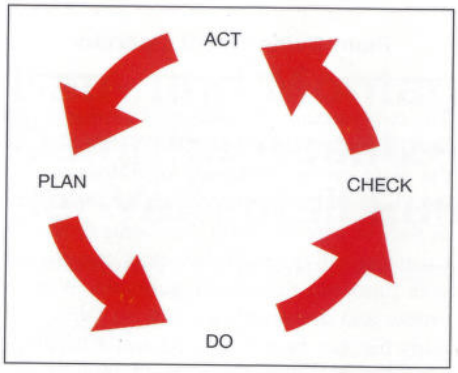

Figure 4. W. Edwards Deming's Plan-do-check-act cycle.

sions, Safety Integrity Level Classification, Explosion Protection, Ergonomics Review, Constructability Review, Reliability and Maintainability of new built power plants are introduced in both the organisations of the overall manufacturer as well as at all partners within the projects. Figure 6 shows the quality assurance pyramid, making the application and implementation of the project-specific procedures developed for the different phases in the new built projects clearer.

In order to support team members procedures, instruction and guidelines have been established and distributed. These include, but are not limited to, procedures for Inspection & Testing, Time Scheduling and Progress Reporting, CE Marking, Risk Management, Guidelines for Quality Control

Quality Control

An important part of quality management is checking that the products are conform to the required specifications; quality control. To minimise the amount of imperfect products and plant components, the overall manufacturer is providing the suppliers with so called resident engineers. Employers are in the workshop of selected suppliers to help them in the manufacturing of their scope of supply. These resident engineers provide support to the manufacturer in clarifying the contract and guidance during the design, procurement and construction phase of the project. Having direct access to the manufacturer´s work floor reduces the risk of rejection at the end of the production phase. It also ensures the manufacturer that his products and components can be shipped to the site according to schedule due to limited repair work.

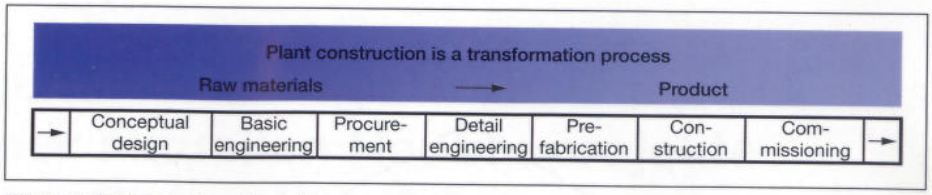

Figure 5. Project as transformation process.

Compliance

One of the main project targets is and remains the compliance to contract specifications and to applicable local (e.g. specific German and Dutch rules) and European rules and regulations. A roadmap to ensure compliance has been developed in close co-operation with our main suppliers and is currently implemented. Implementation of the European CE Marking Directives (as the Machine Directive, Pressure Equipment Directive, Construction Product Directive, Lift Directive and ATEX95 Directive, for example) has proven to be not an easy task. Also implementation of social labour safety directives cannot be automatically assumed. Once again the risk management system has been very helpful by clearly defining, in advance, the need of implementing the essential safety requirements. These essential safety requirements should be implemented during the design phase and proper follow-up during procurement and construction of the power plant should be ensured.

In order to achieve compliance a programme has been developed and implemented. Based on the legal requirements, the steps to be taken by the manufacturer of the product concerned are:

- The manufacturer defines clearly and completely the product concerned;
- The manufacturer determines which CE marking directives apply to that product;
- The manufacturer determines which fundamental (essential) requirements are applicable pursuant to the relevant CE marking directives;
- The manufacturer conducts a risk and conformity assessment;
- The manufacturer determines which harmonized standards may be applicable;
- The manufacturer adopts measures, which will reduce the number and extent of any so-called existing (or residual) risks or limit them as far as possible;
- The manufacturer will test the product and draw up a handover test and protocol;
- The manufacturer will create a technical construction file;
- The manufacturer draws up instructions of maintenance and operation;
- The manufacturer prepares a declaration of conformity;
- The manufacturer affixes the CE marking (if allowed by the governing EU directives).

Essential Safety Requirements

The European Directives are established in order to protect the user of consumer products against any harm coming forth by owning or using the products concerned. In its essence European Directives are health- and safety-related. This is clearly visible in the set of rules described in Annex I of the CE Marking Directives, also called Essential Safety Requirements. Also social labour safety directives are implemented to improve and safeguard the health and safety of workers at work. These requirements are mandatory since they have been issued as European law

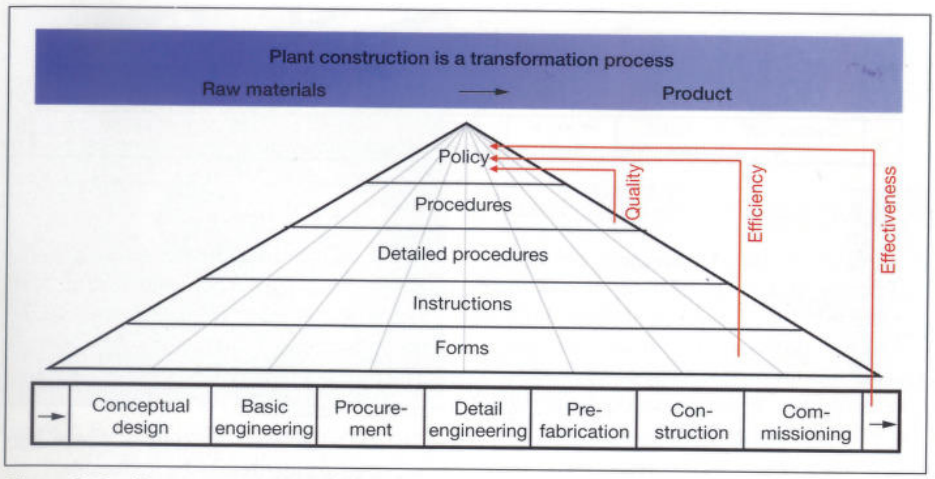

Figure 6. Quality assurance pyramid for a project.

with the obligation for all EU countries to implement these requirements in national law. In Germany the labour safety directives have been implemented with the new release of the "Arbeitsschutzgesetz (ArbSchG)" and the "Betriebssicherheitsverordnung (BetrSichV)". All CE Marking Directives also have their own implementation in German national law articles. In the Netherlands this has been arranged with a renewal of the "Arbeidsomstandighedenwet" and the "Warenwetbesluit drukapparatuur" to implement the PED Directive, for example.

Since application of these law articles is mandatory; *under no circumstances* a product or installation may be placed on the market or be put into service in the absence of compliance with the essential requirements. It is the role, as well as the duty, of the manufacturer to determine which solution the manufacturer feels to be the most effective in order to meet the essential requirements.

European Harmonised Standards

In order to assist and support manufacturers with the production of consumer goods to be put on the market in Europe, harmonised standards are established and released. Application of these standards is voluntary; however, they can and will be of assistance to meet the essential requirements. The manufacturer must be aware that by application and implementing harmonised standards during design and production of his products no guarantee exists that all essential requirements are complied with. However, by doing so at least a presumption of conformity will be provided that the product complies with the essential requirements until the contrary is proven.

Required documentation:

In order to prove compliance with all European rules and regulations strict requirements regarding documentation must be followed. The documents described hereafter including there contents are to be made available when the product is put on the market.

- The manufacturer must establish a technical construction file which should reveal that the product conforms to the essential safety requirements.
- The manufacturer will issue an EC declaration of conformity
- The manufacturer will declare by issuing an EC declaration of conformity:
- that the product complies to all essential requirements of all relevant directives,
- that all steps of conformity assessment procedure have been taken,
- that harmonised standards are used.

Liability

Making products to be sold and used in the European common market nowadays is not an easy task. Strict rules and regulations are in existence and will be upheld. Manufacturers and producers of goods are facing strict rules based on the articles of law subject to product liability: The EC declaration of conformity mentions the manufacturer/producer of the goods to which the certificate belongs. Therefore, it is considered to be a *defect* when the CE marking is affixed when it should not be. It is regarded as a *defect* when it is not providing the safety that the person using the product is entitled to expect.

Another subject covered by the applicable articles of law subject to product liability is damage. When manufacturers are willingly and with full intent placing products on the European market not in compliance with the applicable European rules and regulations it is not regarded anymore as a product liability but as an unlawful act. It will be clear that the consequences of such act are much more severe, resulting in major penalties and even prison sentences.

Plant Owner/Plant Operator

The requirements for consumer products can also be transposed to the plant platform. Also the plant owners and plant operators can be held liable when not taking his responsibility or duty of care seriously. Accidents or unsafe situations will occur due to lack of compliance with European rules and regulations. When a proper and documented check on fabricated parts has not been executed and mitigating measures are not in place, then liability cases or unlawful acts can and will be prosecuted in case of incidents/accidents. Designers and manufacturers will than be convicted when proven that they should have identified the failures due to their professional background.

Liability will also occur if the plant owner or plant operator exactly prescribes (detailed specifications) how a machine should be constructed. If these conditions do not meet the Machinery Directive and other relevant directives once again liability cases or unlawful acts can and will be prosecuted in case of incidents/accidents.

Last but not least, in the situation of plant construction, where the plant owner is responsible for assembling separate components into one working machine the plant owner will be held liable for CE marking of the assembly of machines/equipment.

- The plant owner will perform a risk assessment,
- The plant owner will issue the technical construction file,
- The plant owner will issue the EC declaration of conformity,
- The plant owner will arrange the CE marking.

A Bright Future!

Our industry, power plant constructors, is faced with challenges, partly new, partly already familiar from years of experience in plant construction. The question remains, how will a new generation of managers and engineers take on these issues and become efficient and reliable plant constructors with a keen eye for efficiency and quality? Let us wait and see, and share our ideas with who ever will listen.

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[2] *Kaoru. I.:* Introduction to Quality Control.

[3] Basic Principles of Total Quality Management (TQM) by Ron Kurtus (28 May 2001). □