

EUROPEAN DIRECTIVES THROUGH THE INTEGRITY EVALUATION OF THE MECHANICAL EQUIPMENT

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Abstract: Hydroelectric generating units at hydro power plants consist of turbine and hydromechanical equipment, which components could be subject to a large number of European Directives. Responsibility of turbine manufacturer is to make sure that certain components of equipment are in agreement with requirements of the specific Directive. This paper offers the opportunity to perceive the possibility of applying the Pressure Equipment Directive 97/23/EC, Simple Pressure Vessels Directive 2009/105/EC, Machinery Directive 98/37/EEC and Low Voltage Directive 2006/95/EC for turbine equipment at hydro power plants 'Djerdap 1' and 'Djerdap 2', because components of the turbine regulator and of the lubrication system, of the runner and measurement and regulation system are individually subject to different Directives. The overview of the possible approach regarding the standardization and technical harmonization of turbine equipment components for easier assessment of their integrity is also presented in this paper.

Key words: turbine equipment, european Directives, standardization, integrity assessment.

1. INTRODUCTION

There is a possibility of application of the Pressure Equipment Directive [1], Simple Pressure Vessels Directive [2], Machinery Directive [3] and Low Voltage Directive [4] for turbine equipment at hydro power plants 'Djerdap 1' and 'Djerdap 2', because components of the turbine regulator and of the lubrication system, of the runner and measurement and regulation system are individually subject to different Directives.

Pressure Equipment Directive refers to the manufacturers of equipment such as pressure vessels, tanks, heat exchangers, steam generators, boilers, industrial pipeline installations, safety equipment and pressure fittings.

Machinery Directive refers to all machines or mechanical devices such as operating machines, all kinds of stationary or movable machines for processing and recycling, hand-guided or hand-held, pumps, compressors, testing machines, packing machines etc. Also, this Directive refers to all movable mining machines and lifting machines.

Responsibility of manufacturers is to make sure that all equipment parts are in compliance with requests of the adequate Directive.

Components of vertical and horizontal Kaplan turbines at hydro power plants 'Djerdap 1' and 'Djerdap 2', which are subject to certain Directives, are presented in Figures 1 and 2 [5].

2. PRESSURE EQUIPMENT DIRECTIVES

Pressure equipment or assemblies have to be designed according to the good engineering practice, in order to ensure safe operation. This equipment and/or assemblies have to be provided with adequate instruction manuals and have to carry manufacturer's identification labels. This equipment and/or assemblies must not be marked with compliance marks.

Before the placement of pressure equipment, comprised by categories from I - IV, on the market, equipment has to be subject to the prescribed compliance assessment procedure (module). Depending on the equipment category, manufacturer can choose one of modules. Manufacturers can make a choice between the procedure based on manufacturing process / product inspection and procedure based on quality assurance system. Modules, applicable to higher categories with respect to pressure, can also be applied to lower categories.

Modules for category II, III and IV products demand the involvement of "certified bodies", authorized by member states for issuing certificates and/or quality system monitoring and/or direct product testing. "Authorized Independent Organizations" can also be authorized by a member state for issuing welding qualifications, welding competence certificate and non-destructive testing certificate, as requested for pressure equipment and category II, III and IV assemblies. "User Inspectorates" can also be authorized by member states for performing tasks of authorized bodies within companies according to modules A1, C1, F i G (CE marking will not be attached to pressure equipment and assemblies assessed by User Inspectorates).

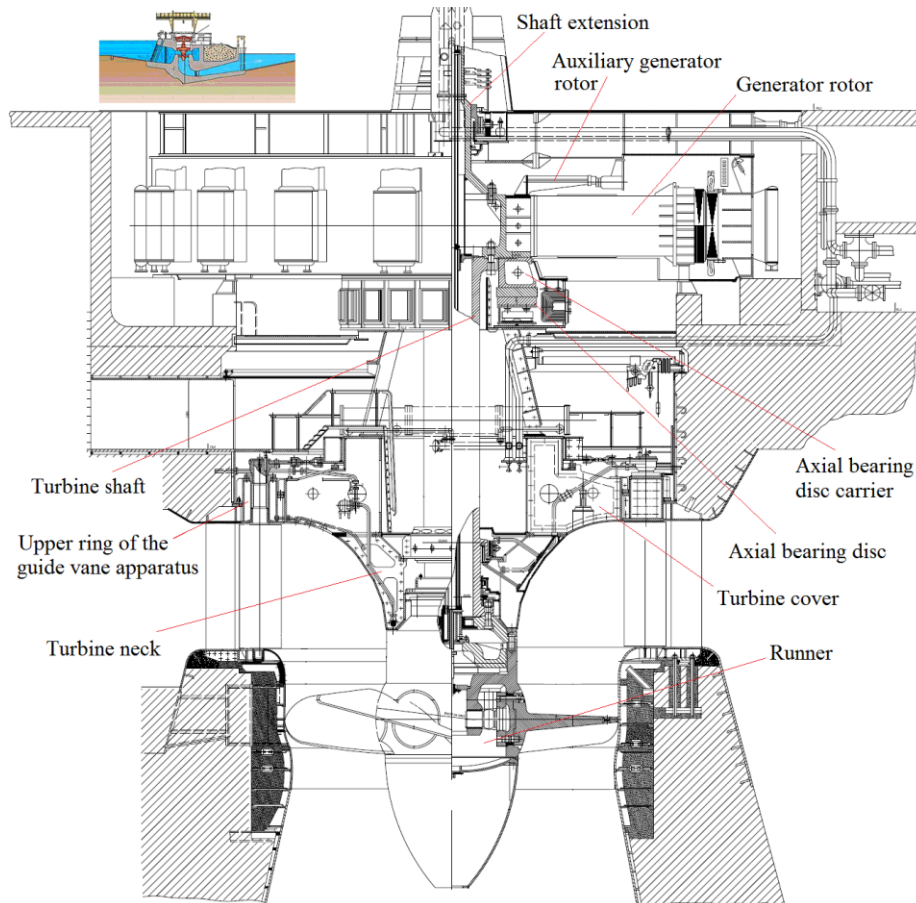


Fig. 1. Appearance of the vertical Kaplan turbine, nominal power 178 MW

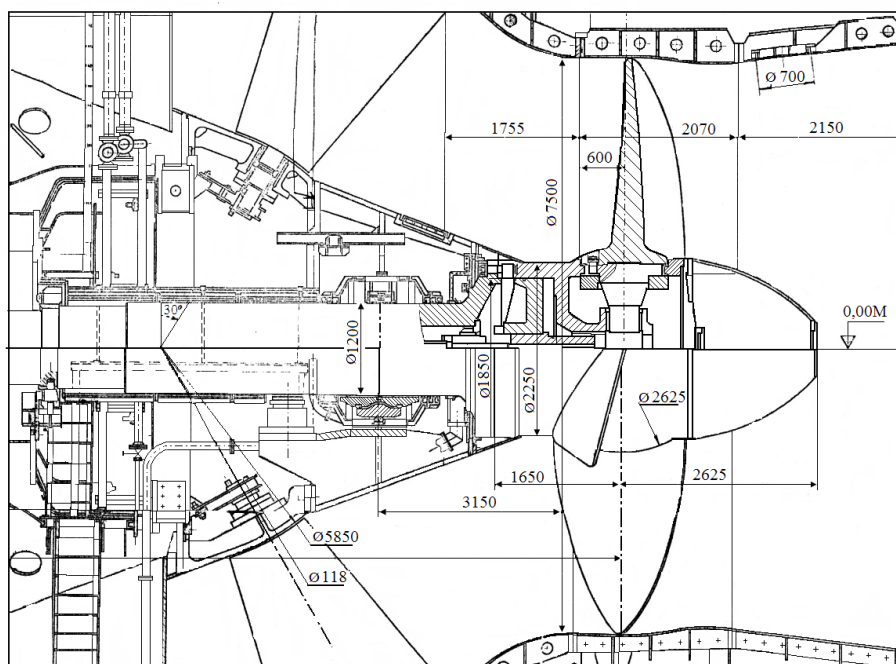


Fig. 2. Appearance of the horizontal Kaplan turbine, nominal power 28 MW

2.1 Basic Requirements for Pressure Equipment Safety

Pressure equipment has to be designed, constructed, tested and, if necessary, equipped and installed in such a way to ensure its safety when put into operation, in compliance with manufacturer's manual or predictable conditions. In order to reach the most acceptable solutions, manufacturer has to obey certain principles in the following order:

- eliminate or reduce the possibility of hazardous occurrences as much as possible;
- apply certain safety measures regarding the hazardous occurrences which can't be eliminated;
- inform the user of existing hazards, as well as if it's necessary to take special measures in order to lower the risk during the installment and/or operation.

If there's a possibility of predicting the misuse which is the potential cause of danger, pressure equipment has to be designed in order to neutralize the possibility of misuse.

2.2 Basic Design Requirements

Pressure equipment has to be designed for adequate loads according to the use and other predictable conditions. Especially the following factors have to be taken into consideration:

- internal or external pressure,
- environmental temperature and operating temperature,
- static pressure and contents mass in operating and testing conditions,
- loads due to traffic, wind, earthquake,
- forces and moments induced by girders, supports, pipelines etc.
- corrosion, erosion, fatigue etc.,
- decomposition of unstable fluids.

Various loads can appear simultaneously and should be considered taking into account the possibility of their simultaneous appearance. Certain safety coefficients, as well as comprehensive methods, have to be used in order to determine adequate safety limits in respect to all known errors.

Allowable strains for pressure equipment have to be limited taking into account predictable errors in operating conditions. Safety coefficients have to be introduced in order to eliminate strength reduction induced during the production, as well as by operating conditions, strains and calculation models. Properties of the material, as well as its behaviour also influence strength reduction.

The above mentioned requirements can be fulfilled through the application of one of the following methods, or through the combination with other methods:

- design through the use of empirical formulas,
- design through the use of analytical procedures,
- design through the use of fracture mechanics.

2.3 Basic Production Requirements

Manufacturer has to provide proper implementation of all procedures that need to be fulfilled during the design process through the use of proper techniques and valid procedures, especially concerning the aspects presented in this paper.

Inseparable assembling of parts subject to pressure, as well as of parts directly attached to them, has to be performed by qualified personnel in compliance with adequate work procedures.

For category II, III and IV pressure equipment, work procedures and personnel have to be certified by a competent third party, chosen by the manufacturer, such as:

- a certified organization;
- an authorized body of the third party, authorized by the Ministry of Domestic Economic Relations.

In order to issue the certificates, organization or the authorized body has to perform tests and inspections cited in adequate national harmonized standards, or to acknowledge the results if someone else performed adequate tests and inspections.

Non-destructive testing of inseparable assemblies of pressure equipment should be performed by qualified personnel. For category III and IV pressure equipment, personnel qualification has to be certified by the authorized body of the third party, appointed by the Ministry of Domestic Economic Relations as stated in article 13 of the Book of Regulations.

2.4 Basic Material Requirements

Materials for components subject to pressure have:

- to possess appropriate properties for operating conditions which could be predicted, as well as for testing conditions,

- they have to be sufficiently ductile, strong and resistant to fracture,
- to be chemically resistant to fluids,
- not to be endangered by aging,
- to be convenient for adequate process actions,
- to be chosen in such a way as to ensure that there are no major undesirable effects during the interaction of different materials.

Manufacturer has to provide elements that refer to the compliance with required material specifications, in one of the following ways:

- by using the materials in compliance with harmonized standards,
- by using the materials covered by the approval for pressure equipment materials,
- by adequate material approvals.

2.5 Harmonized Standards

Harmonized standards are standards that refer to the same subject, approved by different standardization bodies, and they enable the mutual replaceability of products, processes and services, or the mutual acceptance of testing results, as well as sharing of the information in accordance with standardization and related activities [6]. The relation between Pressure Equipment Directive (PED) and the Standard is presented in Figure 3.

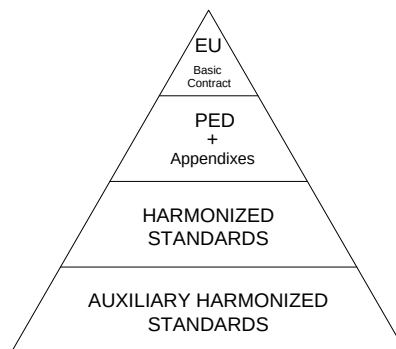


Fig. 3. Relation between the Directive and the Standard

3. MACHINERY DIRECTIVE

Machinery Directive, which also refers to mechanical devices, defines obligations regarding the design, traffic and putting into operation of safe machines and the issuing procedure of CE markings. Directive 98/37/EEC and Appendix 98/79/EEC contain 4 Chapters and 9 Annexes.

They refer to:

- manufacturers residing in EU Member States or
- authorized representatives of a manufacturer with an office in one of EU Member States, or some other machine importer from the EU.

Those who complete the machines through the use of parts produced by different manufacturers are also obligated to follow the Machinery Directive, as well as those who produce machines for their personal use. Obligations also apply to manufacturers or machine parts produced to be built into other machines, but individually can't function. Manufacturer or Importer of such machines or devices has to issue the certificate which confirms that such products can be put into operation after the technical safety inspection of the whole machine into which they are supposed to be built. Before putting the machine into operation manufacturer (or his authorized representative in the EU) has to provide technical documentation necessary for conformity assessment of products according to the requirements of the Directive and the Manual which is to be submitted along with the machine as an integral part of the product.

Conformity determination procedure, required by the Directive, is presented in Figure 4. Chapter I defines the objective, application area, goods traffic and free flow of goods. In this chapter it is stated that this Directive is applicable to machines, and in Appendix I appropriate requirements regarding safety and health are stated. Application area of the Machinery Directive also refers to safety parts which are being released into traffic. Exceptions to this rule are also stated for cases when the risk that refers to machines or safety components is covered by another Directive. In those cases, when the risk is of electrical origin, such a machine is exclusively covered by Directive 73/23/EEC.

Chapter II defines conformity assessment procedures. Conformity assessment procedures, presented in this

Chapter, refer to Appendix V - Declaration of Conformity and Appendix 6 - Type-examination.

Chapter III defines CE marking. CE conformity marking has to be in compliance with regulations stated in Appendix III. Safety components don't have CE markings. All machines and safety components have to be in compliance with EC Declaration of Conformity.

In Chapter IV regulations that refer to activities regarding the application of this Directive are defined.

Contents of the Declarations of Conformity, CE marking, types of machines and safety components, minimum criteria to be met by EU members for Certification Body registration and transitory Regulations are defined by Appendixes.

3.1 Basic Requirements Regarding the Safety of Machines

Obligations derived from basic requirements for safety of machines and mechanical devices are also applicable to mechanical assemblies if certain danger exists. Basic requirements are obligatory, and they refer to:

- general (definitions, safety integration principles, materials and products, lighting, handling of machines),
- controlling and command devices,
- protective measures against mechanical hazards,
- requirements for protective devices,
- protective measures against other hazards,
- maintenance,
- general suggestions,
- food processing machines,
- hand-held and hand-guided machines,
- machines for wood and similar materials processing,
- work locations,
- handling devices,
- protective measures against mechanical hazards,
- protective measures against other hazards,
- special requirements for non-mechanical lifting devices,
- markings,
- manual,
- low visibility hazards,
- freedom of movement,
- lighting,
- adjustment parts,
- movement limitation,
- fire danger,
- dust, gas hazard etc.

3.2 Harmonized Standards

Standardization program CEN/CENELEC, with respect to requirements of the Directive [3], is divided into several groups (categories) in order to avoid repetition and to enable the logical reasoning which would lead to quicker shaping of the Standard and connection to other Standards. According to the adopted program of Standard hierarchy, they are divided into Standards of A, B and C type in the following fashion:

- type A Standards (Basic Health and Safety Standards) provide the basic concept, design principles and general aspects and can be applied to all machines and mechanical devices, but refer to one aspect of health or safety which can be used for a wide range of machines.
- type B1 Standards refer to individual safety aspects (e.g. surface temperature, noise, vibrations, safety distances);
- type B2 Standards refer to safety devices (e.g. two-hand controls, blockage devices, pressure-sensitive devices);
- type C Standards refer to specific types of machines and provide detailed safety requirements for singular machines or groups of machines (e.g. semi-automatic machines, agricultural machines, food industry machines etc.)

It's important to point out that the basic objective of this Directive and similar Standards is to provide safety and health care. They refer not only to the concept, design, construction and production of machines, but to their use and utilization. The ultimate objective is to make sure that it's allowable to work only with machines which during exploitation, maintenance and repair do not threaten the operators.

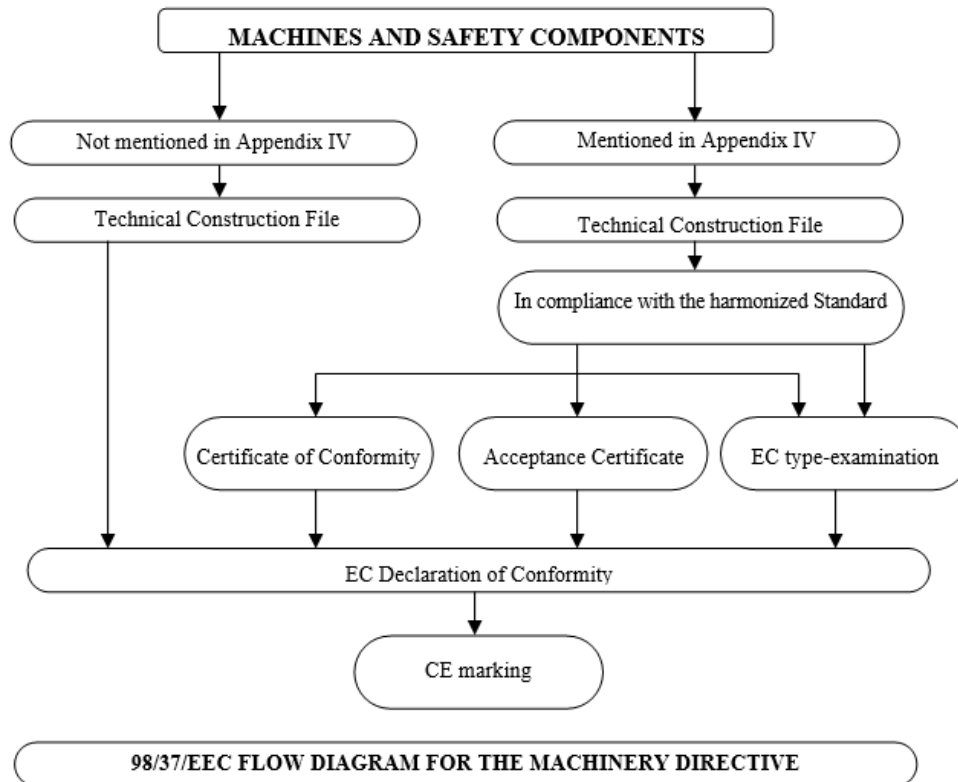


Fig. 4. Machine diagram and safety components

4. CONCLUSIONS

A large number of EU Directives and Technical Regulations define the safety of energetic objects, and that's why the energetic equipment manufacturer has to make sure that all equipment parts are in accordance with the requirements of the appropriate directive. Complexity of EU Directives implementation in energetics is obvious. The problem and the solution proposition are presented in Figure 5. Aligning the equipment with the directives in a better quality implies a series of activities, which is of high importance from the economic aspect.

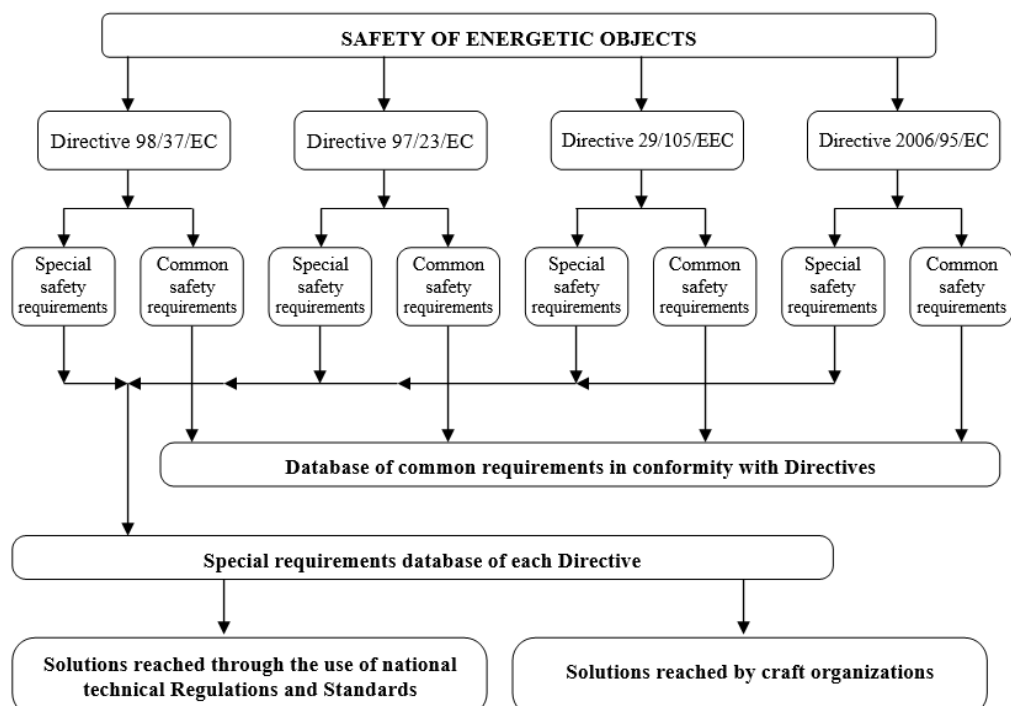


Fig. 5. Complexity of EU Directives implementation in Energetics chart

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