

SURVEY OF DESIGN STRATEGIES INCREASING SAFETY OF SHIP POWER PLANTS

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Abstract

There are many various sources of dissipated information supporting design of ship power plant from a safety point of view. As a rule, they have diverse forms and scopes and their use makes design of the operator's safety difficult for designers. Therefore, it is reasonable to collect and integrate all developing and existing design rules, taking into consideration the operator's safety, into one coherent system. This paper deals with the computer-aided system supporting design of the most dangerous zones for machinery operators. Its first module compares selected hazard zones from a danger point of view for operators. In depends on the obtained dangerous degree, the second module proposes various design strategies for the considered zones for example: withdrawing operators to more safe places, selection of suitable design features for machines, installations and their layouts, etc. In this paper, the examples of such strategies are presented as well.

Keywords: *ship power plant, computer-aided system, safety, hazard zone, design strategies*

1. Introduction

Effective ship power plant design that satisfies functional requirements and can be easily operated and maintained requires a vast amount of knowledge. Design, in turn, mainly depends on skills and possibilities of designers. As a rule, they specialize in designing different design properties (reliability, manufacturability, etc.) and they can apply design solutions proved in practice at the final design stage or present their proposals during so-called design reviews. More complexity of current ship power plants contests effectiveness of such design methods. This issue concerns such a design property like a safety as well.

One of the possible solutions for increasing the effectiveness of the design process is to build a computer-aided system supporting design process of safe ship power plants. Such the system has been developing in Gdynia Maritime University. It consists of two main modules:

- a system of hazard zones identification in ship power plants on a base of a their preliminary design,
- an expert system aiding design of the most dangerous zones from a safety point of view.

The main task of the first module is to compare selected hazard zones from a danger point of view for operators. The second module task is to propose detailed design solutions decreasing the impact of dangerous and harmful factors for operators of ship machinery. The concept of the first system is presented in [5]. The proposed paper deals with the second system that is the computer-aided system supporting design of the most dangerous zones from a safety point of view.

2. Assumptions of computer-aided system supporting the design of safe ship power plants

In the developed computer-aided system supporting a design process of ship power plants that should be safe for their operators, we have taken into consideration the following assumptions:

1. Design solutions taking into account the operator's safety can be 'built-in' into a ship power plant at any phases of the design process.
2. Scale of these solutions depends on the considered design phase of according to the rule: *the earlier design phase, the more general design solutions*.
3. Potential hazards appearing for operators of a ship power plant can come into being when the operators will be carried out any operational or maintenance activity involving the ship machinery.
4. The eventual design solutions have to be related to such ship power plant zones, in which can appear potential hazard situations for operators.
5. Identification of such hazard situations is carried out based on:
 - information concerning factors influenced the operator's safety can be received based on analysis of the design documentation developed for a given design phase of a ship power plant,
 - knowledge acquired from experts in the field of ship power plant design, operation and maintenance.
6. The set of operator's safety design strategies can be developed for each of the related design phases.
7. Such design strategies should allow to develop a set of detailed design solutions related to the related design phases.

The last two assumptions mean that we should not 'build-in' the detailed design solutions at the initial design phases and the general design solutions at the final design phases.

3. Design strategies increasing the safety of ship power plants operators

The first module of the developed computer-aided system makes possible carrying out the assessment of the potential hazard situations according to the rule: *the earlier design phase, the assessment more general*. In this assessment, both types of information distinguished in point 5 of assumptions are used. In depends on results of such assessment, we can take various design strategies into account during design of the considered zone with the potential hazard situations.

In order to develop such design strategies, we taken into account of so-called the operator's activity chain [7], which consisted of the following elements:

- an operator,
- an engine room component (part, unit, installation, etc),
- an operator's operational activity.

Combinations of these elements set up so-called the elementary hazard zones considered in the first module of the mentioned system. Moreover, they are potential sources of hazards for operators carrying operational or maintenance activities involving the ship machinery. Therefore, we can state that each of such elementary hazard zones can be more or less dangerous for the operators. Based on this statement, we could formulate the crucial design rules for the safety of ship power plant operators:

- to minimize time of carrying out operational or maintenance tasks by operators in the machinery room,
- to minimize impact of sources triggering hazards for operators carrying out operational or maintenance activities in the machinery room.

Next, to obtain a set of design strategies we associated all elements of operator's activity chain with the crucial design rules mentioned above. This way, we obtained a kind of a matrix contained

design strategies allowing to increase the safety of ship power plant operators. Such design strategies set up a kind of framework making possible to develop the detailed design rules, which could be used in design of the operator's safety. This framework is presented in Tab. 1.

In our opinion, the developed design strategies presented in Tab. 1 make possible to develop the detailed design rules, which could be used in design of the operator's safety. It is obvious that such design rules, taking into account the operator's safety, are applied in the most of design solutions in ship power plants of new built ships. However, the sources of information concerned these rules are dissipated.

Tab.1. The framework supporting to develop design strategies

Crucial design rules increasing the safety of ship power plant operators		Elements of operator's chain activity		
		Operator	Activity	Engine room component
Minimization of time of carrying out operational or maintenance tasks by operators	Exclusion of an operator from the machinery room hazard zone	Automation of operational or maintenance activities	Remote control of operational or maintenance activities	Withdrawing of engine room components to other zone
	Decreasing of time of operator's being in the machinery room hazard zone		Mechanization and grouping of operational or maintenance activities	Increasing of a maintainability level in the machinery room hazard zone
Minimization of impact of sources triggering hazards for operators	Exclusion of hazard sources from the machinery room hazard zone			Postponing of carrying out the required operation
	Decreasing of impact of hazard sources from the machinery room hazard zone		Reallocating of operational or maintenance activities to one zone with the less hazard level	Change of design properties of components situated in the machinery room hazard zone

Many of such rules can be found in domain books, for example in [1,6,8], in guidelines issued by International Maritime Organization (IMO) and classification societies, for instance [2,3]. Moreover, in many of new built ship power plants are applied design solutions taking into consideration the mentioned rules without any relations to the mentioned information sources [4]. In our opinion, the knowledge, intuition and experience of the designers have been employed in such cases. Therefore, it is reasonable to collect and integrate all developing and existing design rules, taking into consideration the operator's safety, into one coherent system. Such an approach does not exclude the possibility of devising and developing new design rules for the operator's safety. In order to do it, we could apply the presented fundamental design strategies increasing the operator's safety of ship power plants.

4. Survey of chosen design strategies increasing operator's safety in machinery room

4.1. Automation of operational or maintenance activities

Exclusion of an operator from the machinery room hazard zone can be carried out, for example by automation of:

- complement of cooling medium in gravity tanks,

- drainage of engine room bilges,
- activating boiler sootblowers (Fig. 1).

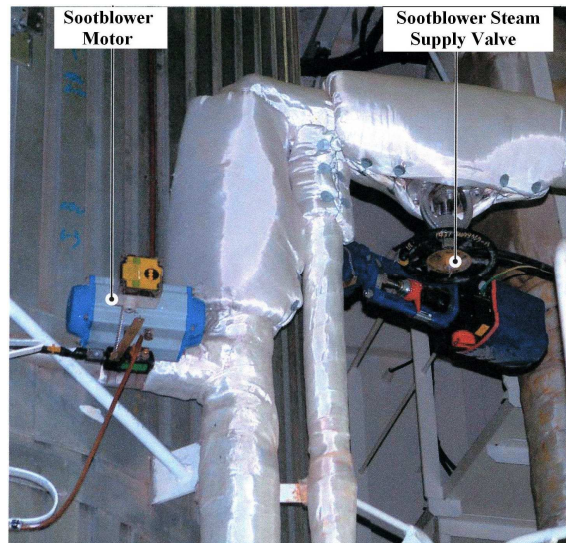


Fig.1. Automation of auxiliary boiler sootblowers

4.2. Remote control of operational or maintenance activities

In this design strategy, operators are withdrawing from hazard zones and their activities are carried out from a zone with the less hazard level by remote-controlled devices, for example:

- remote control of bilge, ballast or fuel valves (such control is realized most often by hydraulic power pack located in safety place in engine room) – of course the valves, besides the remote control, must have possibility of local control (Fig. 2a),
- remote control of fire dampers in ventilation systems (Fig. 2b).

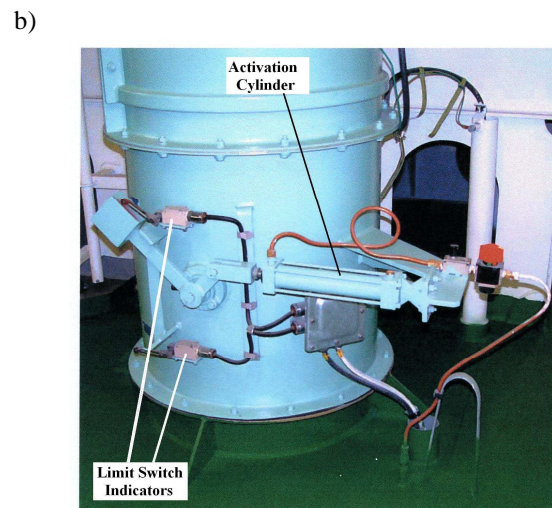
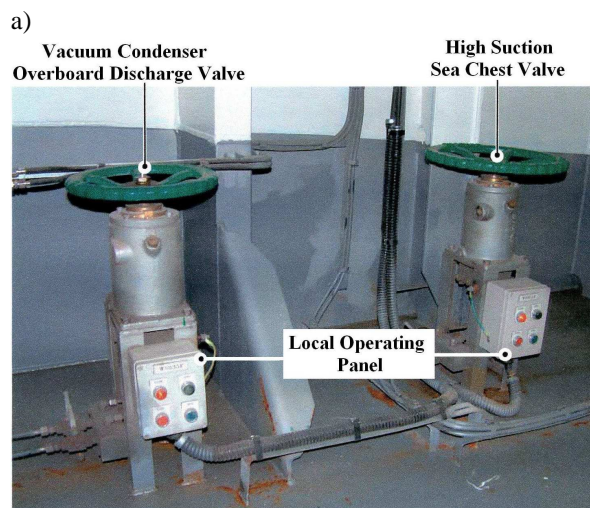


Fig. 2. Remote control of valves and fire dampers

4.3. Withdrawing of engine room components to other zone

In this design strategy, minimization of time of operational or maintenance tasks carried out by operators is realized by reallocating engine room components to machinery zones with the less hazards, for example grouping of engine room components in the separated spaces with the less

hazard level. It concerns systems like: hydrophore station of sanitary water, sewage treatment plant (Fig. 3), air condition plant, etc.



Fig. 3. Reallocating engine room components to machinery zones with the less hazards

4.4. Mechanization and grouping of operational or maintenance activities

In this design strategy, decreasing of time of operator's being in the machinery room hazard zone is realized by design of the compact manipulation spaces. Such spaces are presented in Fig. 4.

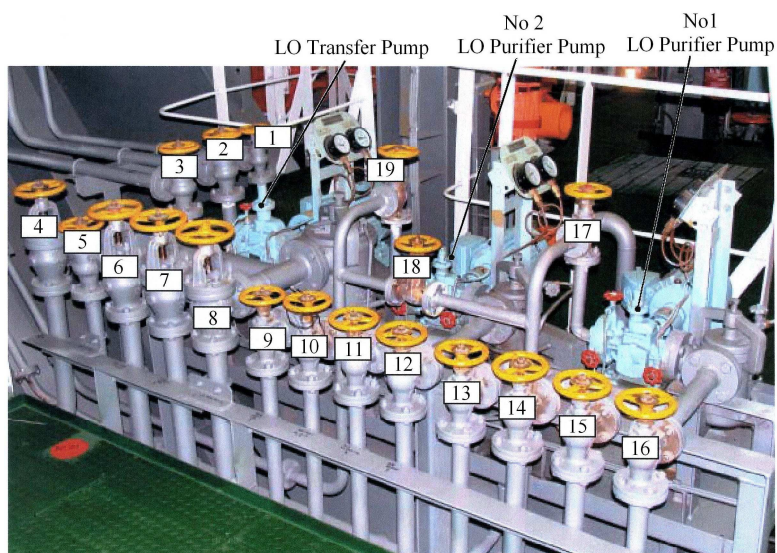


Fig. 4. Decreasing of time of operator's being in the machinery room by design of the compact manipulation spaces

4.5. Increasing of a maintainability level in the machinery room hazard zone

This strategy is realized by increasing of a maintainability level in the machinery room hazard zone, for example: increasing of operator's accessibility to places where is carried out a given operational or maintenance activity (Fig. 5).

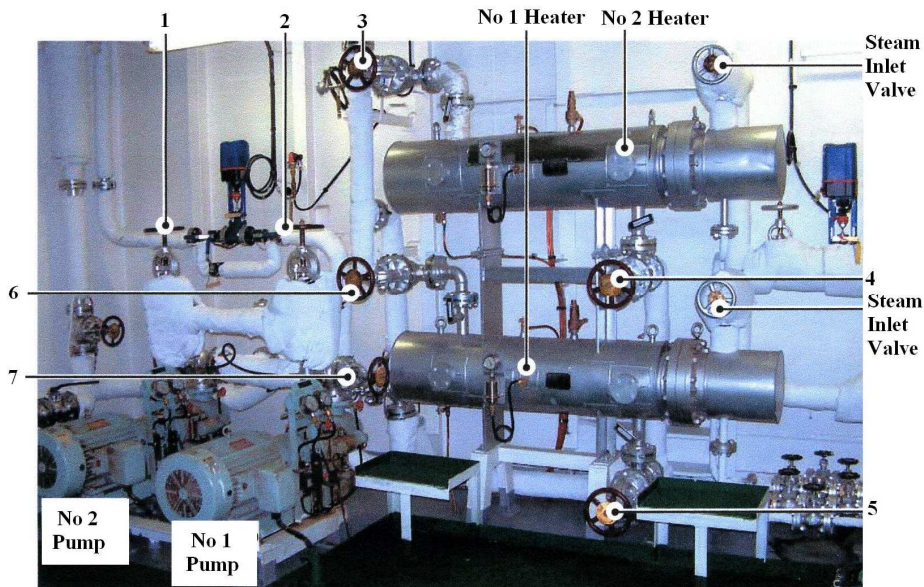


Fig. 5. A boiler fuel oil module with the high maintainability level

4.6. Postponing of carrying out the required operations until the operational stages of ship and/or her machinery permit their execution

In this strategy, decreasing of impact of hazard sources from the machinery room hazard zone is realized by applying of functional redundancy for ship machinery (pumps, heaters – Fig. 4, 5, coolers, tanks, compressors – Fig. 6, etc.).

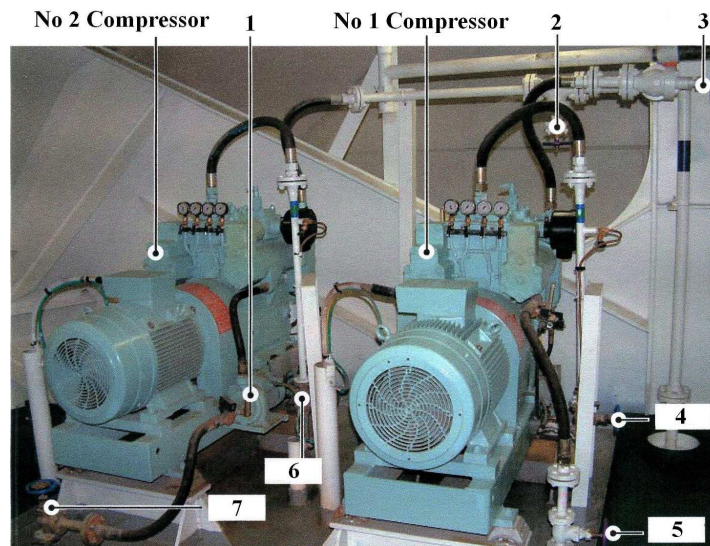


Fig. 6. Decreasing of impact of hazard sources by applying of functional redundancy

4.7. Reallocating operational or maintenance activities to one zone with the less hazard level

In this strategy, decreasing of impact of hazard sources from the machinery room hazard zone is realized by reallocating of operational or maintenance activities to one zone with the less hazard level (Fig. 7).

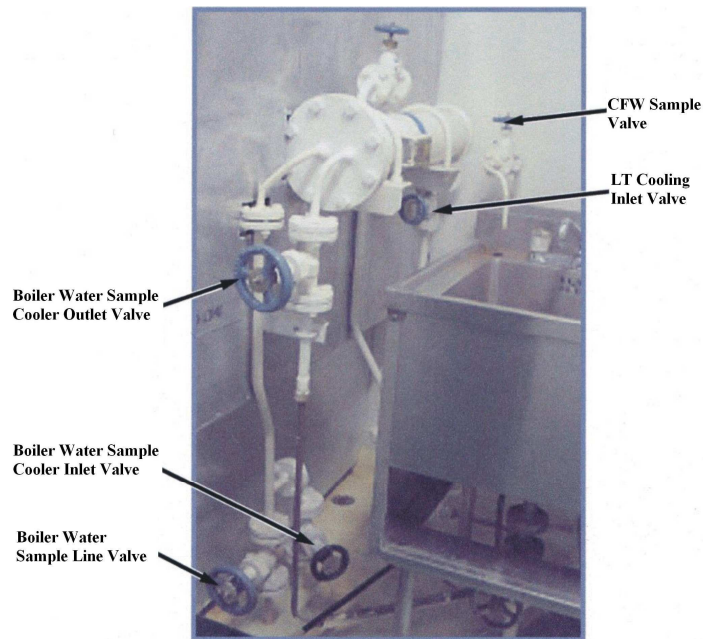


Fig. 7. Taking of water samples for the analyzing purpose from one place

4.8. Change of design properties of components situated in the machinery room hazard zone

In this strategy, decreasing of impact of hazard sources from the machinery room hazard zone is realized by changing of design properties of components situated in the machinery room hazard zone, for example:

- applying of thermal, acoustic and vibration isolations,
- applying of prevention screen, etc.

An example of thermal isolation of valves and pipes in the steam distributor is presented in Fig. 8.

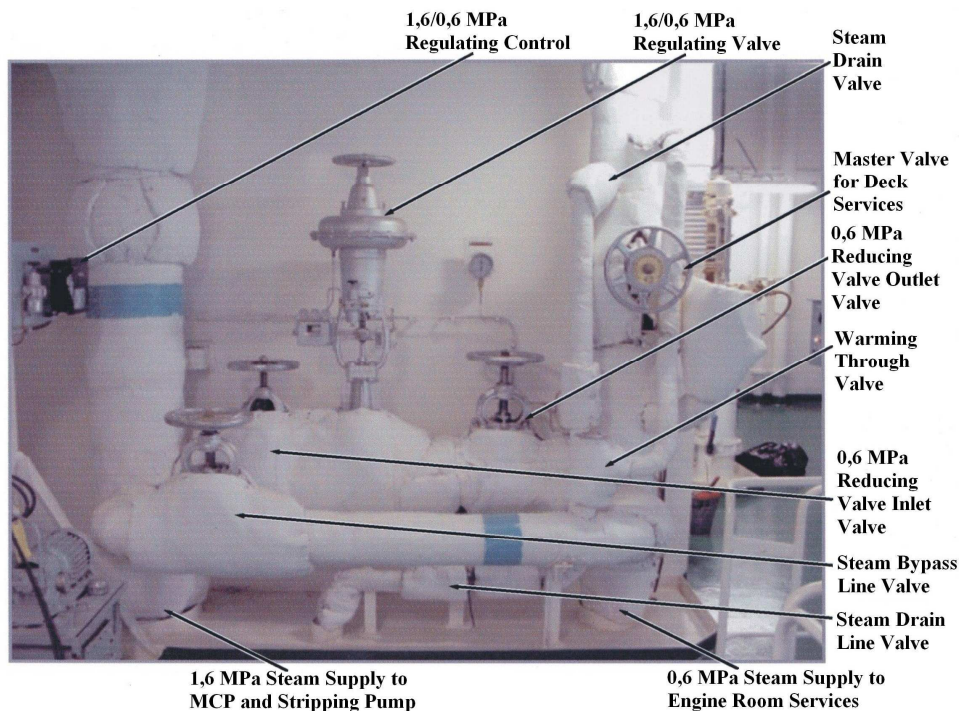


Fig. 8. Thermal isolation of valves and pipes in the steam distributor

5. Conclusion

The discussion about the information sources and the brief survey of chosen design strategies increasing operator's safety in machinery room allow us to state that:

- there are many various sources of dissipated information having diverse forms and scopes,
- their use makes design of the operator's safety difficult for designers of ship power plants.

Therefore, it is reasonable to collect and integrate all developing and existing design rules, taking into consideration the operator's safety, into one coherent system. Such an approach does not exclude the possibility of devising and developing new design rules for the operator's safety. In order to do it, we could apply the presented fundamental design strategies increasing the operator's safety of ship power plants.

In our opinion, the second module of the presented computer-aided system, that is an expert system aiding design of the most dangerous zones from a safety point of view, should meet such a requirement. As it was mentioned, such a system is developing in Gdynia Maritime University as the project funded by the Polish financial resources for scientific research.

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