top event. The constructor of the tree must keep in mind that the tree should be clear and understandable to other people.

Fault tree is built based on a set of symbols of events interconnected with cause and effect relation. Intermediate event presented graphically as a rectangle represent the states of the subsystems of the analyzed object and their correlations cause emerging subsequent intermediate events leading to the top event in question, which is the purpose of the analysis [6, 16].

To the most prominent primary events are included:

1. Basic events, presented graphically using circles, are components faults of the system in question. Considering the case of the main engine parts these are the failed components. Events can also represent the basic operator errors and reflect the influence of the environment.
2. Undeveloped events, presented graphically using diamonds, are faults not fully defined, that is, not fully known. Undeveloped events can be further improved by conducting appropriate tests allowing for a quantitative estimation of the event, becoming the elementary events.

Apart from FTA model events, transfer symbols are used that are presented using triangles – they allow a clear division of the system into subsystems causing the fault tree easier survey.

Logic gates combine events according to cause-effect relations recorded by the designer. Each gate has any number of inputs but only one output. Gates can be distinguished as: AND which requires the simultaneous occurrence of signals on all inputs to get an output signal, OR is a gate that requires the existence of only one of the input signal to get an output signal and gate "k-out-of-n" requiring occurrence at least *k* out of *n* of all input events.

Object of analysis

Presented later in this article, block diagrams of reliability and fault trees model main engine reliability structure of HYUNDAI MAN B&W Mk8 7S50MC-C which is a two-stroke marine engine, perpetual, crosshead, unilateral actions driven turbo exhaust gases for direct drive of variable pitch propeller. Table 1 shows the main parameters of the main engine subjected to analysis.

During the analysis of the object the possibility of one cylinder system off as a partial possibility of achieving goals was assumed. The engine is an example of the threshold structure. The view of engine from upper platform of engine room is shown in figure 1.

The oldest but still very popular graphic description of system structure is Reliability Block Diagram (RBD), the diagram can be easily transformed to equivalent binary model or fault tree [6, 18].

Table 1. Basic data subjected to the analysis of the main engine

Main engine data for MAN B&W 7S50MC-C		
Parameter	Value	Unit
Cylinder number	7	–
Cylinder bore	500	mm
Piston stroke	2000	mm
Nominal speed	117	rpm
Maximum speed	127	rpm
Nominal power	9076	kW
Maximum continuous power	11635	kW

Fig. 1. Engine MAN B&W 7S50MC-C from upper platform of engine room

Block diagrams of reliability and fault trees

When building RBD model some simplifications during the object analysis are made which affects the accuracy of the results [19]. Usually, each block corresponds to exactly one component of the system, however, in the case of complex structures it may prove as impracticable. In this situation, the blocks that correspond to the same element are equally described.

Modern vessel engines have complex structure [20, 21, 22, 23]. Shown in figure 2 block diagram of the reliability of the main engine consists of a serial structure and threshold, the individual components are mapped by blocks of reliability. In the serial part are common components to engine, while, in the threshold part are components associated with the cylinder block. Implemented node 6 of 7 in the presented model opens the threshold structure and means that 6 of 7 systems must remain without any fault to the system was able to pursue its goals.

For the analyzed object cause and effect relationships are modelled corresponding to analyzed structure [22] using the methodology of fault tree