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Basic of Fault Tree (FT) Method

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Abstract: A fault tree described the logical relationship between events and causes. This method shows significant success in analyzing the root cause of an accident. This paper will review the basics of the Fault Tree (FT) method including the structure, factors that contribute and FT application.

Keywords: Accident, Basic, Analysis, Fault Tree

1. Fault Tree (FT) Method

The Fault Tree (FT) method has been used so many researchers to analyze the root cause and factors that affect the accidents. The applications can be seen in the industry where it is used to find the causes if an accident happens. The benefits of applying a fault tree are (i) easily identify the failure (ii) minimize the possibility of failure (iii) focus on the fault at a time. The structure of the FT consists of the top event, intermediate event and basic event. They are linked by logic gate symbols as shown in Figure 1.

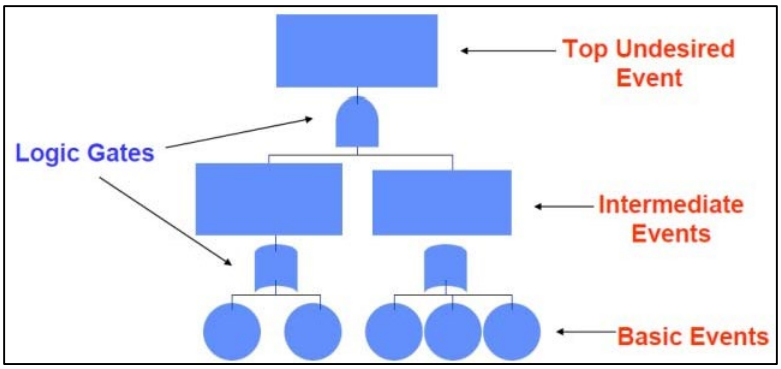

Figure 1: Fault Tree Structure [1]

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2. Accident Due to Human Errors

A structure and deductive methodology to study the possible causes of an undesired event which is stated as the top event, including a major accident causing safety hazards or an economic loss is known as the fault tree analysis method. Fault tree analysis (FTA) is used to measure the failure probabilities of all prevention barriers. The prevention barriers in the accident model were systematically analyzed with FTA to create a sequential causal relationship [2-3]. A structure consists of a top event that is placed at the top and followed by the tree that is constructing downwards. This structure is continuing until the primary events leading the top events. Primary events are considered as the binary which consists of two states and independents of fault tree analysis. The relationships between events are means of gates, in which AND-gates and OR-gates are mostly used [4-5].

In the engineering systems including in nuclear power plants or radioactive material, human being plays an essential role because they are involved not only in the specification, design, implementation, installation, start-up and maintenance but also in the system operation. This makes it is hard to build a system or events in which human error is eliminated [5-6]. Thus, human error, human reliability and the tendency to make mistakes are becoming a problem of fundamental [7]. The action done by an individual, which was not intended by the actor, not wanted by a set of rules or an external observer, or that led the task or system outside its acceptable limits is meant by human error [8].

Besides, the worker hardly to understood the real functionality and usefulness of the protective measures of the machinery or material if the worker does not receive clear and effective information and training about the risks and the operative use of the machinery or radioactive material. Thus, this will bring disaster or risk to others. The lack of operatives and proper procedures could be happening due to human misbehavior including willing actions and unwilling errors during a specific task. So, adopting misbehavior of humans is more attractive to purposely defeat and tamper with safety equipment to attain a higher simplicity and speed of use [9].

Human minds tend to assess intangible conditions that do not induce serious consequences as less risky. The ultimate goal of risk management is to ensure that actual risk and one coincide. On contrary, the human mind tends to perceive the risk in a subjective way assessing tangible situations, with a high frequency of occurrence or that could lead to serious consequences as riskier [10]. However, some issues are arising after implements some measures to cope with after accidences such as the relationship and the root cause of the accident are not understood in depth. The enhancement method is only for preventing a similar accident in the future and lots of possible latent errors may be ignored [11].

3. Accident Due to Equipment Error

Fault tree analysis (FTA) is the most extensively used risk analysis tool. Fault tree analysis tool that represents graphical of the possible event which used to study all system reliability and safety [12]. When the logic gates are used it allows the combination event and enables an illustration to imagine how individual faults, operator errors or both and cause a hazard. The probability can be assumed to assign the fault conditions and classify hazards or all system failures [13]. This risk analysis is essential to be done early in the development cycle, resulting in hazards and potential faults to make it identifiable and easy to adapt with error-reducing designs. Usually, the design should be the main method of control and followed by training and documentation. So, a risk analysis tool is a must to be done to make it smooth [14].

4. Domino Accident

Domino accident is defined as a consequence of the primary event accident which propagated to the nearby equipment and trigger one or more secondary that more severe than the primary one [15-17]. The domino effect still available until now and showing a rising tendency based on previous research [18]. However, some aspects such as active and passive safeguards, and the probability of ignition source are not included. A new methodology needs to be proposing to assess the frequency of domino effect occurrence considering the failure frequency for each unit process, damage probability due to escalation vectors and presence of safeguards [19].

The domino effect is manifested by different accident sequences for example from the explosion to fire, explosion fire continues with fire, fire to fire [20-21]. Domino accidents can be illustrated in a general sequence of events as shown in Figure 2. The primary event started with a failure of any process unit either loss of control operation or loss of containment. The domino effect may occur if a second process unit has a passive safeguard fail and close enough to the primary event.

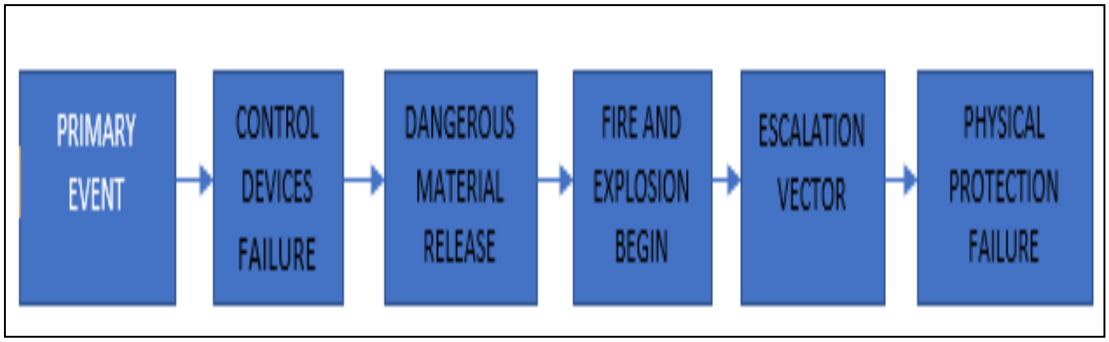

Figure 2: Domino effect general sequence event [14]

5. Application of Fault Tree Method in Natural Gas Leakage Accident

Based on previous research, a model of accident process by using safety barrier concept are used to prevent the accident for the offshore oil and gas environment like releasing natural gas. A development from the previous model has been created by providing the ability to reduce the uncertainty of the probabilistic assessment by using accident precursor data [22]. The enhanced model is developed by integrating fault tree and event tree analysis to shows the cause- consequence relationship graphically which is known as System hazard identification, prediction and prevention method (SHIPP) which valid for safety assessment. However, this method has a certain limitation that prevents maintenance inspection [23].

The fault tree is used to shows the causal relationships leading to failure of each safety barrier starting with release prevention barrier until emergency evacuation barrier as shown in Figure 3. In fault tree, the top event signifies the failure of the safety barrier.

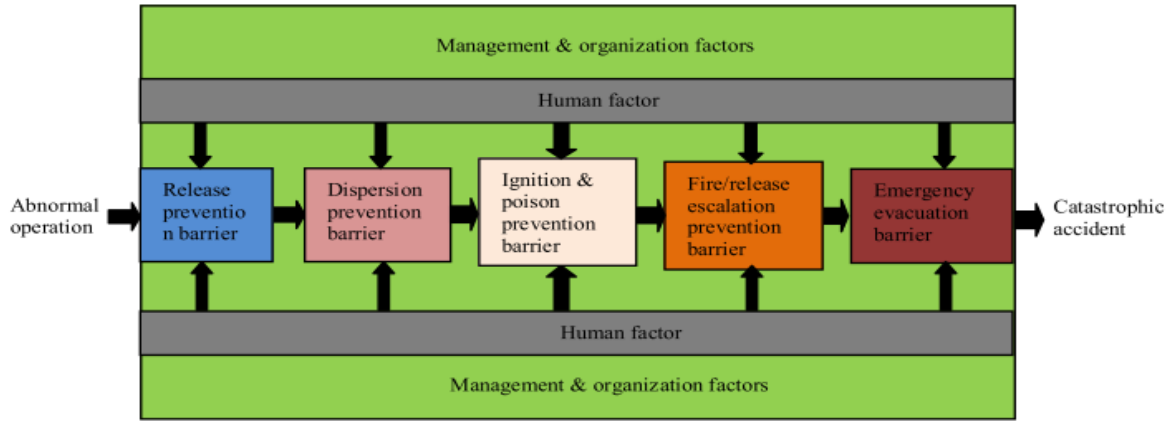

Figure 3: Natural gas accident model

The integration of fault tree and event sequence diagram analyses deliver a general picture of the cause consequence methods of potential accident situations. This model minimizes the degree of uncertainty in prediction using Bayesian updating mechanism and plant real-time data [24]. The accident sequence initiate from loss of containment. The instant causes for release prevention barrier failure (Figure 4) are identified which included technical faults, process disturbance, maintenance failures, operation error and external loads.

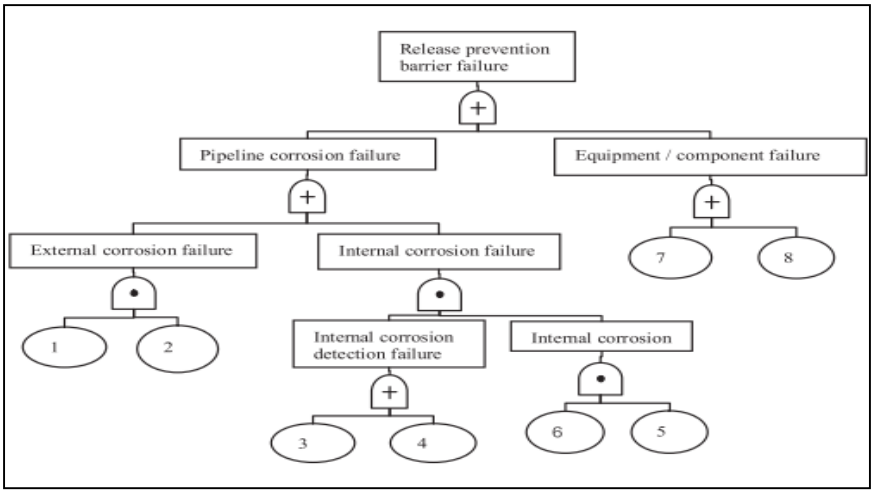

Figure 4: Fault tree analysis of release prevention barrier failure for the starting chain

For preventing the spreading of material or energy dispersion, prevention barrier limits are introducing to the extent of the hazardous events. Also, to prevent and ease the dispersion of material such as gas detection, venting and isolation, passive and active barriers are applied. Next, ignition prevention in gas processing is important to avoid the worse effect from the hazardous event on nearby equipment. To protect the operator, the poison prevention barrier is used and lastly, the emergency evacuation barrier is used to protect the whole system by emergency shut down.

6. Conclusion

In conclusion, a fault tree can be applied in the various aspect that helps identify potential causes of system failures before the failures occur. The application shows there are a lot of factors that contribute to the success of FT.

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