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Fire-Risk Modelling of Machinery Space: An Application of Approximate Reasoning Approach (Fuzzy Averaging Method) in Passenger Ship Engine Room

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This preliminary fire-safety study intends to assess the potential hazards that would affect the operation of a ship engine room. The risks associated with such hazards are quantified and ranked in order of priority and assessed for decision-making purposes. This paper focuses on the fire-risk evaluation of the major hazards threatening the engine room overall rather than on specific areas of the design. The main objective is to propose a framework for modelling system fire safety using an approximate reasoning approach. A case study of the risk to a passenger-ship engine room due to fire during operations is used to illustrate the application of the proposed risk assessment model.

INTRODUCTION

High fire-safety in ships in general and machinery space in particular is a result of correct design and careful crew operations. When either one of these is missing, fire risks are significantly increased.

The available fuel in the engine room of a ship is usually limited to oil, which is stored or used in engines, boilers, lubricants, and stores. The tidiness of any engine room will, of course, affect the ease with which a fire may start and develop. Unless an engine room fire becomes serious, it may well be confined to the area in which the fire broke out. In the event that an escape of oil does become involved, the probability of fire being communicated to the accommodation is very much higher than fire spread in the reverse direction, because there is a good chance that there will be combustible materials in contact with, or in close proximity to, the accommodation side of the engine room casing. Heat rising from the engine room fire will cause the engine room casing to become hot, which in turn leads to ignition of combustibles by means of heat transfer by conduction or radiation. The most serious engine room fires thus occur when an escape of oil becomes ignited. The ease with which oil can be ignited by the introduction of an external source of ignition depends upon the flash point temperature of that oil. The flash point is the temperature to which the oil must be raised such that a flammable vapour-air mixture will be established at the surface of the liquid.

In general, ship fires have been widely investigated. Single fires are analysed (with varying accuracy) and reported to the International Maritime Organization (IMO) committees. Both the IMO and classification societies issue statistics and summaries of the fire reports. Increasing attention is also given today to the incidents and near-miss cases that could have led to disastrous consequences. Fortunately ship fires seldom result in catastrophes; often the losses are mainly economical with minor personnel injuries. However, some 100 to 200 fires are reported annually. Those fires involve human losses, significant ship damages or traffic interruption. One-third of these fires were initiated in engine rooms. Engine room fire safety has been investigated by many parallel methods. IMO and other authorities have guided the technical development by detailed regulations on ship structures and equipment. Many rules and guidelines apply to the machinery systems and machinery spaces (IMO, 1997).

FIRE SAFETY OF SHIP ENGINE ROOM

Fire safety can be defined and quantified in many ways. Statistical evaluation of fire safety is usually derived from a number of reported fires. These data can be used to calculate ignition probabilities with respect to figures for specified machinery spaces, ships of a certain age, various flags and categories. Yet this evaluation tool has some drawbacks. Near-miss cases are ignored although they could produce valuable information for producing fire-risk control measures. Experience confirms that various incidents are many times more frequent than actual fires. Further, some two-thirds of ignited fires are instantly suppressed and remain unreported.

Nippon Kaiji Kyokai (NKK) (1994) shows the identified locations in an engine room taken from data on fires that occurred in 73 ships classed with Nippon Kaiji (NK) in 1980–1992. Fires did not occur uniformly at all the locations in the engine room space. Fires in the engine room were concentrated in areas where flammable oils are likely to leak easily, and in the vicinity of an ignition source such as a high-temperature surface or where electric equipment is likely to generate sparks or overheating. Fuel oil pipes fitted to main or generator engines, burner-fuel injection pipes in boilers, exhaust gas pipes, turbochargers, and main switchboards are locations with a high fire risk. Countermeasures must be adopted on a top-priority basis at such high fire-risk areas. The sources of ignition are shown as follows (NKK, 1994):

- Fuel Oil (FO): 30 ships
  - Main Engine (M/E) FO piping: 8
  - Generator Engine (G/E) FO piping: 8
  - Boiler FO piping: 6

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KEY WORDS: Fire, risk, approximate reasoning approach, fuzzy averaging method, passenger ship, engine room, machinery space.