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Derivation of a societal risk acceptance criterion for major accident hazard installations in Sri Lanka

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ABSTRACT

The usage of risk acceptance criteria for preventing major accident hazards (MAH) in chemical industrial installations is not widely practiced in Sri Lanka at present. This paper attempts to derive a societal risk acceptance criterion for MAH installations in the Sri Lankan context. In the absence of a precedent for a "societal risk acceptance criteria" in Sri Lanka a reference criteria or baselines were developed initially based on historical data using an empirical deductive approach. Disasters resulting from natural and technological events were considered. The level of risk is presented in the form of a Cumulative Frequency, F (N) vs Fatalities, N curve or FN curve. Two FN curves for natural disasters were compared with one FN curve for technological disasters to select a suitable reference or baseline. The selected baseline was then compared with internationally accepted societal risk acceptance criteria for the two major characteristics of the criteria line, slope and anchor point. Based on this comparison a line having a slope of −1 and an anchor point of (10, 10^{-4}) is proposed as an initial estimate for the societal risk acceptance criterion.

1. Introduction

Human history has witnessed numerous disasters attributed to natural causes. Furthermore, history is also littered with disasters stemming from wars which are essentially due to manmade causes. However, the advent of the industrial revolution introduced a new source of events resulting in high consequence losses and damage to society. This relatively new source is directly anthropogenic and can be classified as technological disasters. Technological disasters can be classified as a subset of manmade disasters and described as high consequence events stemming from technological sources.

The world at present functions within a complex mix of technologies with some technologies having the potential to cause significant harm to human beings and the society as a whole, if not managed properly. Sri Lanka too is part of this global network with new technologies being introduced to the country as part of its economic development. These technologies while bringing new benefits to the nation also introduce new challenges to be managed and controlled. This is especially significant with regard to establishments in the Chemical Process Industry (CPI) and the Petroleum Industry which are already known to be sources of major accident hazards (MAH) (Clough et al., 2010) such as crude oil refining, tank farms, distribution terminals for petroleum products and manufacturing facilities for agrochemicals. Such installations are referred to as major accident hazard (MAH) installations in this work.

Risk acceptance criteria fall into either of the two broad categories, namely individual or societal. Societal risk acceptance criteria are considered to be most appropriate where a large number of people are at risk (Vannem, 2012). Societal risk is defined as, "the relationship between frequency and the number of people suffering from a specified level of harm in a given population from the realization of specified hazards" (Jonkman et al., 2003). However, the estimation of the level of societal risk alone would not be sufficient. The level of acceptable societal risk too needs to be established as risk perception of the society is strongly dependent on the question, "how safe is safe enough?" The process of answering this question leads to the establishment of a societal risk criterion upon which risk acceptance decisions can be based.

This study identifies a reference level or baseline against which acceptable societal risk criteria can be established for the Chemical Process Industry (CPI) in Sri Lanka considering data on disasters happened until 2014 and proposes a societal risk acceptance criterion based on the selected baseline.

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2. Process for the derivation of the risk criterion

The process or methodology for deriving the risk acceptance criterion is elaborated in this section. In the process of deriving a risk acceptance criteria the following five aspects are established.

a. Definition of MAH installations.
b. Selection of an approach for deriving the risk criteria.
c. Definition of the concept of risk.
d. Selection of a measure of risk.
e. Selection of a suitable presentation of risk.
f. Establishing a framework for deriving the risk criterion.

2.1. *MAH installations*

At present, a clear definition for the term MAH installation with reference to Sri Lanka is not available in literature. Therefore, in this work the following definitions are considered for the purpose of derivation of societal risk acceptance criterion,

1. Major accident—an uncontrolled occurrence due to the release of a chemical substance or petroleum product resulting in either a toxic effect, fire or explosion causing fatalities of 10 or more (Ball et al., 1998)
2. Major accident hazard—the intrinsic property of a dangerous substance or physical situation, with a potential for creating damage to human health or the environment (Health & Safety Executive UK, 2015)
3. Installation—a technical unit within a location under the control of an operator in which dangerous substances are produced, used, handled or stored; it includes all the equipment, structures, pipe work, machinery, tools, private railway sidings, docks, unloading quays serving the installation, jetties, warehouses or similar structures necessary for the operation of that installation (Health & Safety Executive UK, 2015).

Large scale development projects or projects in environmentally sensitive areas in Sri Lanka are subjected to an Environmental Impact Assessment (EIA) process at present.

The amendment to the National Environmental Protection Act No.47 of 1980 named as Act No.56 of 1988, introduced the EIA process to Sri Lanka. However, the EIA process became fully operative with the publication of the required orders and regulations in 1993 in the Government Extraordinary Gazette No.772/22 of 1993. The Gazette No.772/22 of 1993 specifically provides a list of "prescribed projects" which are to be subjected to an EIA process. This work considers the following subset of categories of industries stated in the aforementioned Gazette No.772/22 of 1993,

1. Basic industrial chemicals.
2. Pesticides and fertilizers.
3. Petroleum and petrochemicals.

The scope of this definition considers only installations sited onshore.

2.2. *Selection of an approach for deriving the risk criteria*

Establishing societal risk criteria for a particular society is strongly dependent on historical, legal and political factors related to that society resulting in varying approaches adopted by different societies (Hartford, 2009). Sri Lanka does not have a generally accepted precedent in the use of a societal risk criteria for MAH installations. This poses a significant challenge in deriving risk criteria due to the lack of a baseline upon which the societal risk criteria can be developed. Hence, a baseline is required to be established for the level of risk from major accident events in the country.

Approaches in deriving risk criteria can be classified into four categories (Vrijling et al., 2004) as follows,

1. Criteria based on risk-cost-benefit measures, e.g. in complex and expensive health services.
2. Criteria based on past performance or revealed preferences, e.g. in major hazards licensing and rail road safety of high speed lines.
3. Criteria based on societal or laymen's preferences, expressed preferences, e.g. in asbestos abatement or approaches to dioxin caused health problems.
4. Criteria based on natural standards, e.g. in some environmental risk criteria.

The second approach stated above, that of criteria based on past performance is adopted in this work. This approach is adopted due to the need to justify the criteria in the context of public perception and demonstrate that the criteria leads to a level of risk lower than that posed by major sources of catastrophic disasters in Sri Lanka. An empirical deductive method is adopted. Three deductive methods have been identified in literature namely, expert evaluation, bootstrapping and formal analysis (Johansen, 2010). Expert evaluation involves the best available experts deciding on the level of acceptable risk based on their professional experience while integrating the risk perception of society. A bootstrapping approach considers the levels of risk tolerated in the past as a basis for evaluating future risk. Formal analysis considers the detailed analysis of tradeoffs between risk and benefits related to a risk problem.

The expert evaluation approach is highly subjective. It is strongly dependent on the judgment of the expert(s) where biases can be introduced when technical issues have to be weighed against public concerns and political interests.

Formal analyses in contrast are more transparent yielding logical recommendations which can be evaluated. Techniques such as cost-benefit analysis (CBA) and decision analysis are tools which are incorporated within formal analyses. However, the implementation of these methods requires highly trained experts and are time consuming and expensive. In spite of the apparent rigor introduced in the analysis the decision as to the level of acceptable safety ultimately becomes judgmental in nature. Hence, this approach too is not considered as appropriate for deriving a societal risk criterion in this work.

The bootstrapping approach in comparison to the two methods discussed above, considers a broad range of hazards and allows the evaluation of the risks and benefits achieved in the past. The main weakness of this approach is the lack of depth and the bias towards the status quo (Johansen, 2010). However, this approach is adopted in this paper for determining the level of risk.