DEVELOPMENT OF A NATIONAL RISK ACCEPTANCE CRITERIA FOR MANAGING MAJOR INDUSTRIAL HAZARDS

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DECLARATION BY CANDIDATE AND SUPERVISOR

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2. Dr.(Ms) M.Y.Gunasekera ……. Date : …….

DEDICATION

“Dedicated to my Father and late Mother”

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ABSTRACT

This work attempts to address the issue of managing risk to the safety of the public posed by Major Accident Hazards (MAH) from the Chemical Process Industry (CPI) in Sri Lanka. The research essentially focuses on the establishment of a suitable risk acceptance criteria as well as an appropriate framework that can be used in determining the level of safety offered by a particular MAH installation in Sri Lanka. The "level of safety" of an installation is then compared against the risk acceptance criteria to determine its acceptability in the Sri Lankan context.

The history of process safety management as is understood at present was investigated and the different risk regulation regimes currently in practice globally were identified. The role of risk assessment in each risk regulatory regime was investigated and the need for risk informed decision making was firmly established. The thesis then focuses on the prevalent categories of approaches in risk assessment. The different risk assessment approaches are investigated further. Out of those approaches, the consequence assessment and probabilistic risk assessment approaches or methods were chosen for the development of the risk assessment framework. The different risk metrics used to express the risk for each approach and the respective risk acceptance criteria were identified. Then appropriate risk acceptance criteria were developed for the two approaches. The establishment of a safety distance corresponding to 1% fatality of the public was adopted for the consequence based assessment method whereas a FN criteria line with an anchor point of $(10, 10^{-4})$ and slope -1 was chosen for the probabilistic risk assessment method.

The applicability of the different risk acceptance criteria in the Sri Lankan context is carried out for the case of propane storage tank. Data gaps and constraints are identified. Both methods adopt a conservative decision making approach. A significant constraint is the lack of a nationally verified and validated set of failure rate data for process equipment and ignition probability data; these are essential for establishing conditional probabilities when calculating accident frequencies. The usage of generic data for failure rates is not recommended due to the wide variability in different data sources. Further, allowing room for choosing an arbitrary set of failure rate data could create an opportunity for biasing the risk acceptance decision.

In this work, a framework is presented for applying the risk acceptance criteria developed. An FN curve based on upper bound data for the probabilistic risk assessment method and modified consequence assessment method are developed. The probabilistic risk assessment method is modified to accommodate the variability in generic failure rate data. The decision of acceptability is made by defining an FN curve using upper bound values of the FN curve and comparing it with the criterion line. A safety distance proportionate with the overall level of risk based on a relative risk reduction factor (RRRF) is introduced.

Keywords: Major Accident Hazard, Risk Acceptance, Criterion Line, Consequence analysis, Quantitative Risk Assessment, Failure rate

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LIST OF ABBREVIATIONS

Abbreviation	Description
CPI	Chemical Process Industry
AEGL	Acute exposure guideline level
ALARP	As low as reasonbly practicable
ALOHA	Areal location of hazardous areas
API	American Petroleum Institute
API RP	American Petroleum Institute Recommended Practice
ASME	American Society of Mechanical Engineers
BLEVE	Boiling liquid expanding vapor explosion
CA	Consequence Assessment
CAAA	Clean Air Act Amendment
CCPA	Canadian Chemical Producers Association
CCPS	Center for Chemical Process Safety
CFR	Code of Federal Regulations
CIMAH	Control of Industrial Major Accident Hazards
COMAH	Control of Major Accident Hazards
CRED	Center for Research on the Epidemiology of Disasters
DEGDIS	Dense gas dispersion
DMC - SL	Disaster Management Center - Sri Lanka
DTL	Dangerous toxic load
EIA	Environment Impact Assessment
EPA	Environment Protection Agency
ERD	Emergency Response Division
ERPG	Emergency Response Planning Guideline
ETA	Event Tree Analysis
EU	European Union
FF	Failure frequency
FMEA	Failure modes and effects analysis
FRED	Failure rate and event data
FTA	Fault Tree Analysis
HAZID	Hazard identification
HAZOP	Hazard and Operability
HEGADIS	Heavy gas dispersion from Area Sources
HI	Hydrocarbon Industry
IDLH	Immediately dangerous to life and health
IP	Institute of Petroleum
IPL	Independent Protection Layer

IR	Individual Risk
IRPA	Individual Risk per annum
KPI	Key Performance Index
LEL	Lower explosive limit
LFL	lower flammability limit
LOC	Loss of containment
LOPA	Layers of Protection Analysis
LPG	Liquefied Petroleum Gas
LUP	Land use planning
MAH	Major Accident Hazard
MIC	Methyl Iso Cyanate
NFPA	National Fire Protection Association
NIOSH	National Institute of Occupational Safety and Health
NOAA	National Oceanic and Atmospheric Administration
OGP	International Association of Oil & Gas Producers
OSHA	Occupational Safety and Health Administration
PFD	Probability of failure on demand
PSM	Process Safety Management
QRA	Quantitative Risk Assessment
RBI	Risk based insepction
RIVM	Netherlands National Institute for Public Health
RMP	Risk Management Plan
RRRF	Relative risk reduction frequency
SLOD	Significant likelihood of death
SLOT	Specified level of toxicity
SR	Societal Risk
TCDD	Tetrachlorodibenzoparadioxin
TNO	Netherlands organization for applied scientific research
UK	United Kigndom
UK HSE	United Kigndom Health and Safety Executive
UN	United Nations
VCE	Vapor Cloud Explosion