Guideline IO-7.0: Conducting Risk Assessment Studies

PCFC- Entity (Business Unit) Name	:	Trakhees (Dept. of Planning & Development)
Department Name	:	Environment Health and Safety Department
Section Name	:	Operations
Document Reference Number	:	PCFC-TRK-EHS-IO-G07
Revision Number	:	00
Revision Date	:	December 2022
Classification	:	Public

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7.1 General:

Risk Analysis should be based on the various hazard assessment methods outlined in Table 1 (or any other approved method) and should include (but not limited to) the following:

1. As a first step in Risk Assessment, PHA (Preliminary Hazard Analysis) should be carried out followed by detailed examination by other known hazard analysis method such as HAZOP studies. The Risk Assessment Study should evaluate all possible risks arising within the premises/operations and/or off-site due to the operations and recommend necessary mitigation measures.
2. A detailed evaluation of regular/irregular operations, activities, tasks and main installations, including physico-chemical characteristics of materials being stored/handled/ processed, quantitative data on amounts, volumes, production/storage conditions etc. should be carried out.
3. Site suitability with regard to wind, flooding etc.
4. FAULT TREE and EVENT TREE analysis should be carried out to provide a graphic description of the accident sequences associated with plant operations and storage.
5. Evaluate/Clarify risks (Frequency, Severity and Probability) using accepted Risk Assessment Technique and Criteria leading to determination of risks to be eliminated or controlled.
6. Accident Consequence Analysis and its effects on human, environment and nearby installations and site should be analysed.
7. Provide for clarification of risks and identification of those to be eliminated or controlled.
8. Evaluate Fire & Explosion hazard using F & EI Index.
9. Evaluate Fire Protection System, Alarm System and Ventilation.
10. Hazardous Area Classification
11. Effects of emergency situations/major environmental events such as lightning, flooding, acts of mischief or sabotage should be analysed.
12. Evaluate occupational health hazards &environmental risks involved in process and operations.
13. For all of the above, measures should be developed and recommended for technical and organizational protection to bring down risks AS LOW AS REASONABLY PRACTICABLE.
14. Develop ON SITE & OFF SITE emergency action plan in co-ordination with PCFC – EHS.
15. Wherever a risk/operation/situation cannot be managed feasibly, it shall be the duty of the consultant to highlight the same in the report.

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7.2 Outline for Risk Assessment Study Report:

Risk (incorporating Health, Safety & Environment risks) Assessment study report should contain the following information as a minimum. In practice, the depth of the information required on each guideline topic given below will vary according to the circumstance of the individual facility.
It is important that the names of personnel who conducted the RA study be mentioned in the report.

- ✓ Background and objective.
- ✓ Information on hazardous substances (e.g. substance name monitoring method, hazards, composition of process etc.).
- ✓ Documentation and summary of Codes, Standards and Recommended Practices, which have been consulted during the design, stage of the project.
- ✓ Information on the installation (e.g. location, plot plan, process/flow diagram, personnel on site, local land used and population distribution etc.).
- ✓ Information on details of the plant and machinery including sketches (sectional view) of machinery and schematic of the process involved.
- ✓ Information required on management system (e.g. responsible person and Quality Control for safety training etc.).
- ✓ Information on major accidents (identification of potential major hazard events, process flow diagram, prevention and control systems, emergency procedure meteorological conditions, numbers at risk etc.).
- ✓ Prior to final approval of the Risk Assessment Study report, a technical presentation for EHS' Management should be given if required.
- ✓ After completion of the project, Risk Assessment constant shall conduct site visit to verify compliance/ implementation of RA recommendations and accordingly submit the Statement of Compliance to EHS.

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7.3 Working Methods for Hazard Assessment:

TABLE 1

Preliminary hazard analysis Matrix diagrams of interactions Use of checklist	Identification of hazards	Completeness of safety concept	Use of "thinking aids"
Failure effect analysis Hazard & operability study	Identification of possible failure and its consequences	Designs modification of system	Use of "searching aids" in schematic documents
Accident sequence analysis (inductive) Fault tree analysis (deductive)	Assessment of hazards according to their occurrence frequency	Optimization of reliability and availability of safety systems	Graphic description of failure sequences and mathematical calculation of probabilities
Accident consequence analysis	Assessment of accident consequences	Mitigation of consequences and development of optimum emergency plans	Mathematical modelling of physical and chemical process

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7.4 Specific Fire Protection Requirements to be addressed:

7.4.1 Fire hazard identification.

7.4.2 Severity analysis/Fire & Explosion Index (F & EI) and Toxicity Index (TI). **(Refer to TABLE 2)**

7.4.3 Mapping areas of risk / risk contours

7.4.5 Direct comparison with actuarial data and other risk criteria.

7.4.6 Criteria for assessing maximum release quantity and separation distances / quantifying dispersion.

7.4.7 Scenario development.

7.4.8 Probability analysis / the chances of fire and explosion.

7.4.9 Risk monitoring (if the risk is acceptable).

7.4.10 Identification of environmental problems that are related to fire protection.

7.4.11 Risk reduction analysis (if the risk is not acceptable) systems & methods and recommendations to prevent and/or reduce them to the acceptable level(s).

7.4.12 Hazard and Operability Study (HAZOP)

7.4.13 Event trees

7.4.14 Case histories, where appropriate

7.4.15 Compliance with codes, procedures and regulations including manufacturing requirement & management under ASME code for boilers & pressure vessels.

7.4.16 Toxicity relationships

7.4.17 Damage from fire and radiant heat

7.4.18 The TNT equivalence

7.4.19 Primary and secondary blasts relationships

7.4.20 Top event frequency estimation

7.4.21 Design & construction procedures

7.4.22 Maintenance Operations

7.4.23 Education & Training of staff

7.4.24 Emergency / Evacuation Plans (on site & off site plans)

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Guideline Notes:

1. The scale that measures severity such as death, injuries, property damage, and areas reached by flames shall be specified.
2. Calculations specifying the severity measure used for a particular fire shall be included.
3. Active and passive fire protection measures shall be included.
4. The consultants shall be solely subject to the laws of the UAE for losses or damages in terms of life and property stemming from design errors, implementation errors, deficiencies of inspections, failure to construct in compliance with the required standards, failure to comply with rules of Professional ethics, failure to use knowledge and experience to the contracting entity, and similar reasons; and successively (severally) liable with the contractors where the consultants have undertaken control and inspection services on works. The consultants shall be caused to complete and compensate for any such losses or damages pursuant to the laws of the UAE.
5. EHS Department or any other departments of PCFC and their Directors, Officers and other concerned personnel shall not be held responsible or liable for any such losses or damages, errors, deficiencies and failures on the part of the Consultants.

7.5 Fire & Explosion Index (F&E) System:

7.5.1 Material Factor (MF)

The Material Factor (MF) is derived from the following table:

	$N_r = 0$	$N_r = 1$	$N_r = 2$	$N_r - 3$	$N_r = 4$
$N_f = 0$	1	14	24	29	40
$N_f = 1$	4	14	24	29	40
$N_f = 2$	10	14	24	29	40
$N_f = 3$	16	16	24	29	40
$N_f = 4$	21	21	24	29	40

The MF for Combustible Dusts; Combustible Solids; Warehousing/Storage of Goods; Manufacturing, Construction and Other Occupancies are derived from separate tables.

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7.5.2 General Hazards (GH)

General process Hazards are factors that play a primary role in determining the magnitude of a loss incident. The items viz. (i) Chemical Processes (ii) Storage, Handling, Transfer and Manufacturing (iii) Confinement (iv) Access (v) Drainage (vi) Total General Hazards Factor, are investigated as contributing hazards.

7.5.3 Specific Hazards (SH)

The items viz. (i) Quantities of Materials Involved (ii) Pressure Conditions (iii) Toxic Materials Involved (iv) Explosion Potential/ Flammable Range & (v) Total Specific Hazards Factor that indicate existence of specific conditions as a major contributing factor in fire and explosion incidents are investigated.

7.5.4 Fire and Explosion Index (F&EI)

The F&EI calculation is calculated by giving credit for both general and specific hazards to the materials involved. The formula used is:

F&EI = MF x (1 + GH) x (1 + SH)

The resulting F&EI values are ranked into four categories:

1 - 45	**Light Hazard**
46 - 60	**Moderate Hazard**
61 - 95	**High Hazard**
96 - up	**Severe Hazard**

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7.5.5 TOXICITY INDEX (TI)

7.5.5.1 **TOXICITY NUMBER:** The toxicity number (Th) is derived from the NFPA health factor Nh (NFPA 704, 325M or 49). Nh is an integer number ranging from 0 to 4. The five degrees of hazards are related to the protective equipment normally available to fire fighters.

Nh	Th
0	0
1	50
2	125
3	250
4	325

7.5.5.2 **PENALTY FACTOR**: The Penalty Factor (Ts) is the second toxicity parameter used to determine the TI. The Ts value is derived from the 'Threshold Limit Values (TLV)'.

The American Conference of Governmental Industrial Hygienists draws up the TLV-values. TLV represents a time weighted average (TWA) air concentration to which workers can be exposed during a normal working week without ill effects. TLV is often indicated as a TWA-value, both are the same.

The penalty factor is determined from the table below:

Threshold Limit Values (TLVs)	Penalty Factor (Ts)
< 5	125
5-50	75
> 50	50

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7.5.5.3 **TOXICITY INDEX (TI):** The Toxicity Index is then calculated from Th and Ts plus the hazard factors of Fire & Explosion Index (F&EI). The TI is found from the following formula:

$$TI = \frac{Th + Ts\,(1 + GH + SH)}{100}$$

TI = (((Th+Ts)/100))*(1+GH+SH)

The resulting TI values are ranked into three categories:

1 - 5	**Light**
6 - 9	**Moderate**
10 - up	**High**

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