400 Series:
Process Safety

Facility Siting

Standard Number: IVL EHS-407
Version: 1.0
Issue / Revision Date: 09 August 2024

Global Environmental, Health and Safety
Indorama Ventures

Table of Contents

1. Purpose 2
2. Scope 2
3. Responsibilities 2
4. Requirements 4
5. Training 5
6. Recordkeeping 6
7. References 6
8. Terms and Definitions 7
9. Revision History 7
Attachment A: Definitions and Glossary 8
Attachment B: Facility Siting Assessment Methodology 11
Attachment C: Consolidated Hazardous Chemical Listing 25
Attachment D: Building List / Facility Siting Summary (Example) 38
Attachment E: Process Plant Building Checklist 39
Attachment F: Emergency Response Toxic Gas Shelter Checklist 40
Attachment G: Consequence assessment parameters 43
Attachment H: Examples of Worst Credible Hazard Event Scenarios 47
Attachment I: Example Facility Siting Worksheet 51
Attachment J: Published Reference Tables for Consequence Assessment 52
Attachment K: Blast Resistant Modular Buildings 55
Attachment L: Examples of Safeguards for Flammable and Toxic Hazard Event Scenarios 57
Attachment M: NFPA 704 Hazard Rating Definitions 58

1. Purpose

This standard establishes Indorama Ventures minimum requirements for the assessment of Facility Siting risk associated with process related hazard scenarios and to reduce the risk to an acceptable level.

2. Scope

This standard applies to all Indorama Ventures owned/operated sites. This standard does not apply to joint ventures (JVs) in which Indorama Ventures is a minority owner, nor to third-party warehouses and tollers, unless specifically requested by the related Segment EHS Leader.

For the purpose of this standard, the term ‘EHS’ includes process safety, transportation, and security, as well as environmental, health and safety.

The standard includes a consequence-based screening assessment, followed by a more refined risk-based assessment, to focus increasingly complex modelling methodology toward those worst credible hazard scenarios that pose a risk to occupied areas.

Facility Siting in the context of this standard is addressing buildings and areas on site that are intended for occupancy, process control and emergency response.

This standard must be implemented by each site. Until implementation of this standard is complete, each site must at a minimum be in compliance with the local applicable regulations.

3. Responsibilities

Following is an overview of key responsibilities for this standard. Additional responsibilities, as applicable, are included in Section 4, Requirements.

3.1. Corporate EHS

3.1.1. Provide ongoing technical assistance related to this standard.

3.1.2. Periodically audit sites to determine compliance with this standard.

3.1.3. Review, update and communicate to all Indorama Ventures sites any updates or changes to this standard and associated documents and tools.

3.1.4. Periodically review this standard to ensure its continuing adequacy and suitability to Indorama Ventures operations.

3.1.5. Ensure this standard is consistently implemented from site-to-site within Indorama Ventures.

3.1.6. Communicate, as applicable, any lessons learned as a result of best practices identified or any non-compliances associated with implementation of this standard.

3.2. Site Head or Designee

3.2.1. Ensure implementation of and compliance with this standard including that it is adhered to and a site-specific program is developed so all personnel receive the proper training, resources, and communications.

3.2.2. Assist with the implementation of the site-specific program; in particular:

- Be thoroughly familiar with the requirements of this standard, the site-specific program, and any associated procedures and work practices.

- Provide support, resources and training needed to carry out the requirements of this standard and the site-specific program.
- Ensure required records are kept current, up to date, and maintained on file.
- Ensure compliance with site-specific program by employees and contractors (as applicable).

3.2.3. Ensure compliance with this standard for newly acquired and existing sites.

3.2.4. Approve Facility Siting Assessment Reports.

3.3. Segment EHS

3.3.1. Ensure that any site or local standard or procedure related to the same topic follows the corporate requirements at minimum.

3.3.2. Support the sites on any technical point related to the standard, including implementation.

3.3.3. Periodically evaluate sites' level of compliance with this standard

3.4. Program Owner

3.4.1. Be thoroughly familiar with the requirements of this standard and local regulatory requirements.

3.4.2. Develop and implement a site-specific program that meets the requirements of this standard and any local/regional regulatory requirements.

3.4.3. Periodically review and monitor for compliance with the requirements of this standard, and per local regulatory requirements, at least every five (5) years.

3.4.4. Develop an action plan to correct any non-conformance with local regulatory or Indorama Ventures requirements.

3.5. Facility Siting Assessor

3.5.1. Lead the Facility Siting Assessment and ensure it is in compliance with applicable legislative and regulatory requirements.

3.6. Employees and Contractors

3.6.1. All affected personnel must understand and follow the requirements of the site-specific program including being aware of and trained on, as applicable, the requirements associated with this standard.

3.6.2. Individuals shall be involved in the Facility Siting Assessment as technical resources when requested, such as the following:

- Personnel with knowledge of plant/unit operating history and practices (e.g., process operator, supervisor, or engineer).
- Personnel with knowledge of plant/unit repair history and maintenance practices (e.g., maintenance technician, supervisor, or engineer).
- Process Safety Specialist, internal or external, with knowledge of major accident hazards under evaluation.
- Other specialists as needed to attend all or part of the review, depending on the nature of the Facility and at the discretion of the Facility Siting Assessor.

3.7. In addition to the roles and responsibilities detailed above, the site-specific program must define and document the roles and responsibilities for all personnel who play a role in implementing the site-specific program, at a minimum:

- Supervisors
- Engineering and Maintenance
- EHS Personnel
- Other applicable functions, as staffed at individual site level

4. Requirements

The site shall develop and implement a site-specific program for completing and maintaining a Facility Siting Assessment that includes the following requirements:

4.1. A Facility Siting Assessor shall be appointed by the Site Head or appropriate delegate.

4.2. All buildings intended for occupancy shall be subject to a Facility Siting Assessment, including all permanent, portable and temporary buildings.

4.3. All buildings and assembly areas that have a role in emergency response (Emergency Response Areas) such as muster points, toxic gas shelters, incident command centers, as well as those that house emergency response equipment shall be subject to a Facility Siting Assessment.

4.4. All buildings that have a role in process control, especially for purposes of safe shutdown or during emergency operations, shall be subject to a Facility Siting Assessment.

4.5. The Facility Siting Assessment shall be done in accordance with the local agency regulations. If local agency regulations are not developed, the methodology in Attachment B, or an equivalent methodology, shall be used to carry out the Facility Siting Assessment.

4.6. The Facility Siting Assessment shall be carried out by a competent team of personnel as identified below, with access to all relevant data.

- Facility Siting Assessor (Assessment Leader).
- Process Operator, Supervisor, or Engineer with knowledge of plant/unit operating history and practices (required).
- Maintenance Technician, Supervisor, or Engineer with knowledge of the plant/unit repair history and maintenance practices (as needed).
- Process Safety Specialist, internal or external, with knowledge of major accident hazards under evaluation (as needed).
- Other specialists (as needed) may be required to attend all or part of the review, depending on the nature of the Facility and at the discretion of the Facility Siting Assessor.

4.7. All actions shall be identified, agreed, and responsibilities assigned to complete the actions within an agreed timescale in accordance with the Management of Actions Standard, IVL EHS-107.

4.8. Facility Siting Assessments shall be kept current through the Management of Change Standard, IVL EHS-204.

4.9. A record of all Facility Siting Assessments shall be maintained for the life of the Facility

4.10. Timing

4.10.1. An initial ‘baseline’ Facility Siting Assessment shall be carried out in accordance with the Facility Siting Assessment program for the Facility and revalidated at least every 5 years.

4.10.2. A Facility Siting Assessment can also be initiated from a modification as part of a Management of Change, IVL EHS-204. This includes modifications of assets, such as piping, vessels, tanks, etc., typically associated with projects, and modifications to the occupancy of new or existing buildings. Examples of changes in occupancy level which may be of concern are moving from routinely unoccupied or transient occupancy to now occupied, moving from a single individual occupancy to multiple individuals, or relocating a meeting area with impacts to peak occupancy.

4.10.3. A Facility Siting Assessment can also be initiated from a modification as a result of an Incident Investigation (see IVL EHS-106), Emergency Response Drill, etc.

4.10.4. A Facility Siting Assessment can also be initiated from a modification as a result of an initial or revalidated PHA (see IVL EHS-403).

4.10.5. A Facility Siting Assessment can also be initiated from a change in legislative and regulatory requirements.

4.11. Clarifications

4.11.1. Natural events would be considered an initiating cause and should be evaluated under Facility Siting.

4.11.2. Location and relocation of occupied portable or temporary buildings on a Facility shall be managed through the Management of Change standard, IVL EHS-204.

4.11.3. Risk from adjacent (non-Indorama Ventures) facilities should be considered (where possible) during the initial hazard identification process. It is the responsibility of the Facility Siting Assessor to take these risks into consideration during the Facility Siting Assessment.

It is the responsibility of the Site Head to approach these adjacent facilities for risk information. Where information is not provided by non-Indorama Ventures facilities, best effort should be made to assess potential hazards based on public information. The risks from adjacent facilities should be addressed in the Emergency Response Plans.

It is also the responsibility of the Site Head to communicate the potential for Indorama Ventures incident scenarios to impact adjacent (non-Indorama Ventures) facilities when the facility siting assessment determines that is the case. The facility Emergency Response Plans should address how to communicate with potentially impacted non-Indorama Ventures facilities during an actual emergency.

4.11.4. When developing and selecting risk management opportunities from several potential actions, keep in mind that actions which reduce the consequence severity are preferred. Secondly, engineering controls are preferred over administrative controls.

5. Training

Training requirements must be defined in the site-specific program. At a minimum, all training must be documented with the training date, the names of employees trained, the names of the trainer(s), the content of the training (or reference to content) and other site-specific/business segment requirements, when applicable.

5.1. Initial

Training on the requirements of this standard and the site-specific program must be provided to Indorama Ventures personnel based on their relevant responsibilities and shall be provided in the local language. At a minimum, personnel and/or management with direct responsibilities for this standard and site-specific program must be trained prior to conducting activities associated with the site-specific program.

The Facility Site Assessor must be trained in leading the assessments and in the specific methodologies being used.

5.2. Refresher

Refresher training shall be provided periodically according to the requirements of this standard, the site-specific program, and any local legal requirements, at appropriate intervals (e.g., changes to regulatory requirements), or at least once every three (3) years.

6. Recordkeeping

Records associated with the site-specific program and facility siting assessments must be controlled and retained in accordance with regulatory or site business segment record retention requirements, whichever is more stringent. Facility siting assessment reports relevant to the site shall be maintained for the life of the asset. Examples of records to be maintained include but may not be limited to completed facility siting assessments and any associated information/documentation referenced.

7. References

7.1. IVL EHS-106 Incident Investigation Standard

7.2. IVL EHS-107 Management of Recommendations / Actions Standard

7.3. IVL EHS-204 Management of Change Standard

7.4. IVL EHS-208 Risk Management Standard and Matrix

7.5. IVL EHS-403 Process Hazard Analysis Standard

7.6. IVL EHS-405 EHS Criticality Assessment Standard

7.7. IVL EHS-417 Process Safety Management Applicability Standard

7.8. American Petroleum Institute (API) recommended practice 752
‘Management of Hazards Associated with Location of Process Plant Buildings’

7.9. American Petroleum Institute (API) recommended practice 753 ‘Management of Hazards Associated with Location of Process Plant Portable Buildings’

7.10. American Petroleum Institute (API) recommended practice 756 ‘Management of Hazards Associated with Location of Process Plant Tents’

7.11. Chemicals Industry Association (CIA), Guidance for Location and Design of Occupied Buildings on Chemical Plans

7.12. American Petroleum Institute (API) recommended practice 581 ‘Risk-Based Inspection Technology’

7.13. “Guidelines for evaluating process plant building for external explosions and fires”, CCPS, AIChE, 1996.

7.14. Dow Fire and Explosion Index, 7th Edition, Published by the American Institute of Chemical Engineers

7.15. Dow Chemical Exposure Index, 2nd Edition, Published by the American Institute of Chemical Engineers

7.16. United States Environmental Protection Agency (USEPA) RMP*CompTM and the related manual of practice, “Risk Management Program Guidance for Offsite Consequence Analysis”, EPA 550-B-99-009. http://www.epa.gov/oem/docs/chem/oca-all.pdf

7.17. ALOHA®/CAMEO®, available to be downloaded at http://www.epa.gov/oem/content/cameo/aloha.htm

7.18. Design of Blast Resistant Buildings in Petrochemical Facilities, 2nd Edition, American Society of Civil Engineers (ASCE)

7.19. Supplementary Guidance for IEC 60079-10 and IEC 61241-10

7.20. National Fire Protection Association (NFPA) 704 ‘Standard System for the Identification of the Hazards of Materials for Emergency Response, 2012

8. Terms and Definitions

See IVL EHS Glossary and Attachment A

9. Revision History

Version	Date	Summary of Update	Owner	Approver	Next Review Date
Original	18 April 2022	Initial Release	Chad Wyble, Global Process Safety Program Director	Todd Hogue, VP, Global Head of EH&S	18 April 2025
1.0	09 August 2024	Updated implementation timeframe (Section 2) and Responsibilities (Section 3); made minor editorial updates.	Chad Wyble, Global Process Safety Program Director	Todd Hogue, VP, Global Head of EH&S	09 August 2029

Definitions and Glossary

A.1 Active Mitigation

These are administrative and engineered safeguards which rely on manual intervention, utility source, electrical or mechanical device to function properly. Examples include: operator activation of a switch, hardwired interlock shutdown, vent scrubber, or fail-safe spring actuated safety valve.

A.2 Blast Resistant Modular Building

A modular building specifically designed to resist damage from the blast overpressure which could occur from an accidental explosion. These buildings can be used for either permanent or temporary applications. Guidance on the definition and usage of Blast Resistant Modular Buildings is provided in Attachment K.

A.3 Building

A structure with a roof and 75% of the perimeter enclosed (Chevron Research & Technology Co, cited in Chemical Engineering Progress Sept. 1997). Any architectural structure fully or partially enclosing people should be reviewed for consideration as a building. Lightweight fabric enclosures, such as tents, are not considered buildings. Tents will fall under the requirements of API RP 756, Management of Hazards Associated with Location of Process Plant Tents.

A.4 Emergency Response Area

These are buildings, shelters, or staging areas designated in the facility’s emergency response plan or which house equipment necessary for responding to an emergency.

A.5 Emergency Response Planning Guideline (ERPG) Values

ERPG values are intended to provide estimates of concentration ranges where one reasonably might anticipate observing adverse effects as described in the definitions for ERPG-1, ERPG-2, and ERPG-3 as a consequence of exposure to the specific substance.

The ERPG-1 is the maximum airborne concentration below which it is believed that nearly all individuals could be exposed for up to 1 hr without experiencing other than mild transient adverse health effects or perceiving a clearly defined, objectionable odor.

The ERPG-2 is the maximum airborne concentration below which it is believed that nearly all individuals could be exposed for up to 1 hr without experiencing or developing irreversible or other serious health effects or symptoms which could impair an individual's ability to take protective action.

The ERPG-3 is the maximum airborne concentration below which it is believed that nearly all individuals could be exposed for up to 1 hour without experiencing or developing life-threatening health effects.

A.6 Essential Personnel

“Essential Personnel” are personnel with specific work activities that require them to be located in or adjacent to a hazardous process area for logistical and response purposes. The identification of essential personnel will vary with the phases of operation and work activities including but not limited to: normal operation, start-up, planned shutdown, emergency operations, etc.

Examples of essential personnel include but are not limited to operators and maintenance personnel.

Examples of person who are not essential personnel include, but are not limited to, designers, timekeepers, clerical staff, administrative support, and procurement staff.

A.7 Facility Siting

An analysis, during the PHA, of the spatial relationship between where the hazards are located and where the people congregate. A facility siting analysis is intended to identify, assess, and manage the risk associated with potential process safety related hazard event scenarios that could negatively impact buildings and areas on site that are intended for occupancy, process control and emergency response.

A.8 Normal Occupancy

The occupancy load obtained by adding the hours each full- or part-time person spends in that building per week, based on an annual average. The routine presence of additional personnel in the building shall be considered, such as visitors, contractors, trainees, or maintenance employees.

A.9 Occupied Building

A building can be considered occupied if there are personnel assigned to it, or if there is a recurring function that draws groups of employees.

A few examples of occupied buildings (not an all-inclusive list):

- Control rooms
- Changing rooms or locker rooms
- Conference rooms
- Shelters-in-place
- Laboratories
- Offices
- Warehouses

If a building has a roof, but no walls, it would not be an occupied building. Examples of this are structures like bus stops, covered walks, and outdoor smoking areas.

Other buildings not considered occupied are those that do not have personnel assigned and only have personnel in them intermittently.
Also refer to API 752 and API 753 for more examples and clarifications of occupied buildings.

A.10 Other Personnel

Personnel with work activities that could be completed at locations remote to a hazardous process unit/area. Examples of other personnel include but are not limited to construction personnel, administrative support and procurement staff.

A.11 Passive Mitigation

These are highly reliable fixed engineered systems that require no human intervention, utility source, electrical or mechanical device to function properly. Examples include: flow reducing orifice plate, line size reduction, or a fixed dike system.

A.12 Peak Occupancy

The number of people potentially exposed for a given period (for example, a safety or toolbox meeting where operators/crafts come together for a short period or emergency shelter loading).

A.13 Portable or Temporary Building

Referencing API-753, any rigid structure that can be easily moved to another location within the Facility, regardless of the length of time it is kept at the site. Examples of portable or temporary buildings include wood-framed structures, container boxes and portable structures designed to be blast resistant.

Examples of portable or temporary buildings that are ‘not intended for occupancy may include, Tool trailers or storage sheds without attendant stationed inside, decontamination facilities, control equipment facilities, analyzer sheds, portable electrical substations and portable electric generators. Tents are not considered to be buildings. Tents will fall under the requirements of API RP 756, Management of Hazards Associated with Location of Process Plant Tents.

A.14 Assembly and Accountability (Shelter-in-Place)

The practice of providing designated Emergency Response Areas in the facility’s emergency response plan at which people are taught to assemble and to be accounted for in an emergency. If the Emergency Response Area is out of harm’s way then the people gathered there should stay put. If the Emergency Response Area is in danger of being impacted by the emergency, then the people assembled there are relocated to an alternate Emergency Response Area in a safe location. Having this practice as the first response keeps the roadways clear allowing emergency response team members access to the location of the emergency and making it easier to relocate any personnel who are actually in harm’s way.

A.15 Toxic Gas Shelter

These are buildings, or designated rooms in a building which are required to be occupied in case of a toxic gas release. Such rooms or buildings must be equipped with provisions to protect the people required to be there during a toxic gas release and a means for them to safely evacuate if conditions call for that.

A.16 Worst case

The term “worst case” refers to a hazard event scenario (process related incident) where the maximum quantity of a hazardous chemical is released from a vessel or pipeline that results in the greatest distance to a specified endpoint. The basis for this scenario is very conservative and is always without active mitigation measures, but passive mitigation measures such as a bund or dike which reduce the consequence of the scenario, should be credited.

Examples of several worst case hazard event scenarios include: total vessel rupture and instantaneous loss of contents into a bund or dike; full bore rupture of a pipeline; catastrophic rupture of a reaction vessel at maximum inventory and maximum process temperature.

A.17 Worst credible

The term “worst credible” refers to a hazard event scenario (process related incident) where the quantity and condition, e.g., pressure, temperature, composition, of a hazardous chemical released takes into account the process conditions and passive mitigation measures.

Worst credible hazard event scenarios are often derived from a review of process hazard analyses and related process incident history. Examples of several worst credible hazard event scenarios include: overfill of a tank at the maximum fill rate for a period of 10 minutes required for detection and isolation; pipe rupture of a compressed gas line as a result of corrosion under insulation; and gasket leak on start-up following a maintenance turnaround.

Attachment B: Facility Siting Assessment Methodology

B.1 Purpose

B.1.1 The Facility Siting Assessment shall identify and assess the risk associated with potential process safety related hazard event scenarios that could negatively impact buildings and areas on site that are intended for occupancy, process control and emergency response. To do this, it is essential that all relevant data is collated to allow assessment of the risk to the building occupants, and proposal of recommendations that reduce the risk to an acceptable level.

B.1.2 The Facility Siting Assessment Methodology is illustrated in Figure 1.

B.2 Facility Siting Assessment Team

B.2.1 The selection of the Facility Siting Assessment Team should be in accordance with Section 4.6 of this standard.

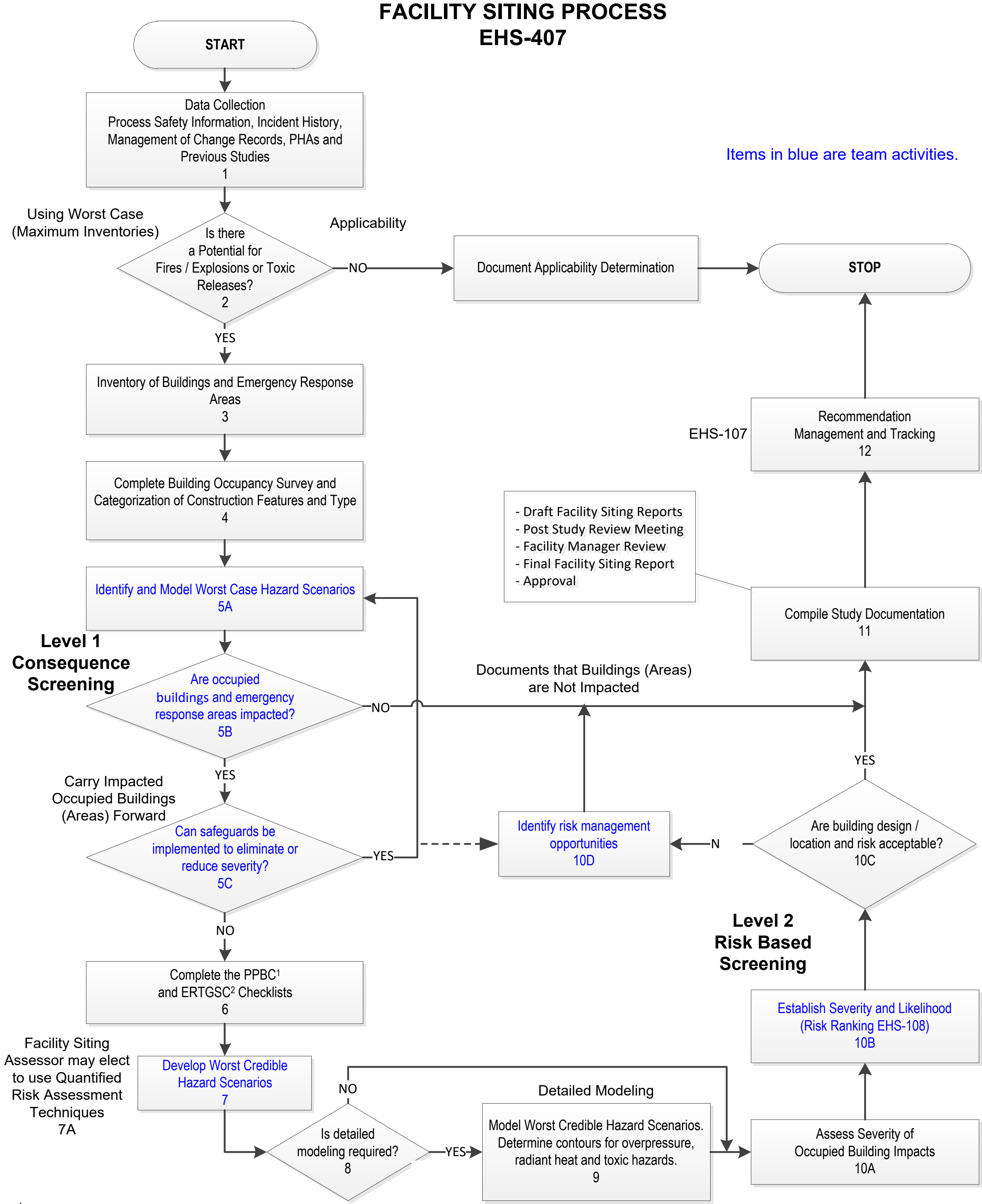
B.3 Recording the Assessment

B.3.1 The Facility Siting Assessor shall document the decision criteria and outcome identified for each step identified in Figure 1, Facility Siting Process Methodology.

B.4 Flowchart Supporting Descriptions

Referencing Figure 1, the following is a stepwise description of the Indorama Ventures' Facility Siting Assessment Methodology from hazard event scenario identification to brainstorming of risk minimization recommendations.

FIGURE 1
FACILITY SITING PROCESS
EHS-407



[1] API-752/CIA, Process Plant Building Checklist
[2] Emergency Response Toxic Gas Shelter Checklist

B.4.1 Step 1: Data Collection

The Facility Siting Assessor shall compile the current Process Safety Information (PSI) necessary to support the Facility Siting Assessment. This information should include, but is not limited to, that listed in Table B-1.

Table B-1
Facility Siting Assessment Data Collection

Data	Example
Hazard identification	▪ Previous Facility Siting studies ▪ Five-year process related incident history ▪ Process Hazard Analysis (PHA) / Process Hazard Review (PHR) reports ▪ Risk Management Program Hazard Assessments (US Only) ▪ Other PHAs (hazard studies) for the Facility ▪ Chemical Inventory
Process data	▪ Piping and Instrumentation Diagrams ▪ Process Flow Diagrams ▪ Process conditions: o Temperature o Pressure o Flowrate o Composition o Inventory of Hazardous Materials and related Material Safety Data Sheets (MSDSs)
Equipment data	▪ Physical size of equipment. ▪ Inventory of emergency response equipment ▪ Gas / fire detectors and emergency response time ▪ Physical size of plant structures ▪ Dimensions of tank bund / dykes ▪ Length and diameter of pipe work containing Hazardous Materials
Layout data	▪ Location of hazard scenarios relative to occupied buildings, i.e., Facility Plot Plan ▪ Location of emergency response equipment ▪ Location of gas detectors ▪ Location of fire detectors ▪ Location of /distance to off-site population ▪ Location of distance to on-site population ▪ Location of roads
External sources	▪ Potential hazards presented from adjacent (non-Indorama Ventures) facilities
Weather data	▪ Wind speed (avg. day time or night time, season) ▪ Wind rose ▪ Air temperature (avg. summer time high temperature) ▪ Topography (map showing elevation contours)
Building data	▪ Building type and role (i.e., Process Building, Control Room, Incident Command Center, Toxic Gas Shelters, Emergency Response Equipment, Office/Administrative Building, etc.) ▪ Building construction ▪ Number and type of building penetrations ▪ Number and type of building windows and doors ▪ Ventilation systems ▪ Number and location of occupants

Table B-1
Facility Siting Assessment Data Collection

Data	Example
	▪ Categorization of occupants as essential or non-essential to the safe operation of the process/unit ▪ Occupation pattern for all buildings
Assembly areas	▪ Emergency response areas identified in the facility emergency response plan

B.4.2 Step 2: Is there a potential for Fires, Explosions or Toxic Releases?

The Applicability Step screens out a Facility that does not have the potential for a process safety incident to impact occupied buildings and emergency response areas, and thus is not subject to the remaining Facility Siting Assessment requirements.

A list of hazardous substances with inherent chemical and physical properties of concern is provided as reference in Attachment C. It is formatted as an inventory table for use as a tool to document the comparable Facility inventory. This list is intended for use in the absence of more stringent or specific local regulatory criteria.

Based on the chemical inventory data gathered in Step 1, the Facility Siting Assessor shall determine if there is the potential for a fire, explosion, toxic hazard or reactive hazard scenario which could impact occupied buildings or emergency response areas. Refer to Attachment M for NFPA 704 Hazard Rating Definitions or applicable local or national criteria.

If the decision, Step 2, is ‘no’, i.e., there is no potential for flammable or toxic hazard scenarios at the Facility, then the Facility does not have to proceed further with the Facility Siting Assessment.

The Facility Siting Assessor shall document the applicability determination (i.e., a tabulated list of chemical inventories).

If the decision is ‘yes’, the Facility Siting Assessor shall document the applicability determination and continue to Step 3 of the Facility Siting Assessment Methodology (Figure 1).

Documentation for Step 2 shall include:

- A tabulated list of chemical inventories, and
- Identification of those chemicals with potential to impact occupied buildings or emergency response areas (i.e., fire, explosion, toxic or reactive).

B.4.3 Step 3: Inventory of Buildings and Emergency Response Areas

Step 3 addresses the development or update of the Facility’s Building List and delineation of the building’s role on site, i.e., administrative, process control, Toxic Gas shelter, emergency response areas, etc.

The Facility Siting Assessor shall update, the ‘Building List’ for the Facility, which shall include at a minimum all buildings intended for occupancy (see Requirement 4.2), all process control buildings (see Requirement 4.3), and all Emergency Response Areas (see Requirement 4.4).

The Building List shall be cross-checked with the current site map. If there are discrepancies, the Facility Siting Assessor shall develop a recommendation to update the site map. Temporary or portable buildings that are not intended to remain on the Facility do not need to be included on the site map, BUT any temporary building must be evaluated according to this methodology.

If a ‘Building list’ does not exist, a list shall be developed by the Facility Siting Assessment team. An example of a Building List is provided in Attachment D.

B.4.4 Step 4: Building Occupancy Survey and Categorization of Construction Features

Step 4 addresses the tabulation of an occupancy survey for each occupied building and categorization of the building type based on construction features. This information should be documented in the Building List (See Attachment D example).

The Facility Siting Assessor in consultation with Facility representatives shall document peak and normal occupancy on a weekly basis in hours for each building.

The Facility Siting Assessor shall document general building construction features and type of building in accordance with Table B-2. This will be used in Step 8 to evaluate potential damage levels.

Table B-2
Building Categorization [1]

Building Type [1]	Construction Features [1,2]	Examples [2]
B1	Wood- Frame Trailer or Shack	Temporary Offices
B2	Steel-frame/metal siding pre-engineered building.	Workshops, warehouses. Industrial metal-clad buildings only. Brick-clad steel-frame buildings are Type B4
B3	Un-reinforced masonry bearing wall building	Administration building, cafeteria, substation. Single or multi-story. Roof is solely supported by the walls.
B4	Steel or concrete framed with unreinforced masonry infill or cladding	Same as B3 except the roof is supported by a frame, independent of the walls.
B5	Reinforced concrete or reinforced masonry shear wall building	Substantially designed building, but not specifically designed for blast.

1 “Management of Hazards Associated with Location of Process Plant Buildings, API Recommended Practice 752, November 2003, Appendix C
2 “Guidelines for Evaluating Process Plant Buildings for External Explosions and Fires”, CCPS.

B.4.5 Step 5: Level 1 Consequence Screening

Note: If worse credible scenarios are fully established, the Facility Siting Assessor has the discretion of skipping directly to Step 6.

The Level 1 Screening methodology presented is for performing a conservative worst case consequence based screening of hazard event scenarios and the potential impact(s) to occupied, process control and emergency response buildings/areas on site.

B.4.5.1 Step 5A: Identification and Modelling of Worst case Hazard scenarios

Using the data gathered in Step 1, the Facility Siting Assessor, in consultation with the Facility Siting Assessment team, shall identify potential worst case hazard scenarios involving those chemicals of concern identified in Step 2. Typical worst case hazard event scenarios include catastrophic vessel rupture or full bore pipeline rupture with instantaneous release of all contents taking only passive mitigation measures into account, as a minimum. Consideration should also be given to local natural perils. Local legislation or applicable regulatory requirements may dictate additional criteria for these scenarios.

Table B-3 summarizes the typical hazard scenarios of interest.

Table B-3
Examples of the hazards associated with process safety events

Hazard	Event
Physical overpressure and projectiles	▪ Vapour cloud explosion ▪ Dust explosion ▪ Mist (aerosol) explosion ▪ Vessel rupture ▪ Boiling Liquid Expanding Vapour Explosion
Thermal radiation	▪ Pool fire ▪ Jet fire ▪ Fireball ▪ Flare Stack ▪ Electrical Fire
Direct flame contact	▪ Flash fire
Toxic exposure	▪ Loss of containment giving release of toxic gas. ▪ Ingress of fumes into building ▪ Deliberate venting
Other Hazard Assessment Events to Consider	▪ Vehicle impact ▪ Flying objects (i.e., planes, helicopters) ▪ Land slide ▪ Flooding ▪ Subsidence ▪ Impact from missiles / debris ▪ Extreme weather, tornado, hurricane, or typhoon ▪ Earthquake

The Facility Siting Assessor shall quantify the potential flammable and toxic impacts of each worst case hazard event scenario using screening level software, at a minimum.

All modelling shall be performed by an individual competent in the methodology of choice.

Acceptable software packages and methods include but are not limited to:

- United States Environmental Protection Agency (USEPA) RMP*Comp™ or the related manual of practice, "Risk Management Program Guidance for Offsite Consequence Analysis", EPA 550-B-99-009. The software can be downloaded at http://www.epa.gov/oem/docs/chem/oca-all.pdf. This software has a minimum endpoint criterion of 0.1 miles (reported as < 0.1 miles). Thus, for events that require a more finite analysis on which to make decisions, another model should be considered.

- ALOHA®/CAMEO®, available to be downloaded at http://www.epa.gov/oem/content/cameo/aloha.htm. This suite of software terminates the toxic dispersion endpoint at no greater than 6 miles. If the toxic cloud has the potential to travel beyond 6 miles, another more detailed model should be considered.
- GASDISP and CMA-TiCl4 are in-house screening tools used by and available from Tioxide for toxic gas dispersion and TiCl4 emissions, respectively.
- The Dow F&EI and CEI are acceptable for this very top level screening, but unlike the others, they were not developed for formal hazard consequence assessments. The F&EI does not give quantified radiant or overpressure endpoint results, but instead yields an area of impact. The F&EI has been found to under predict potential flammable hazard zones for pressurized gases or flammables held above their boiling points when compared to more detailed analysis methods. A more detailed modelling analysis is recommended for high pressure or high temperature hazard event scenarios. In addition, the CEI model assumes a wind speed of 5 m/s. If the site conditions are significantly less than that, the CEI will under predict toxic endpoint distances.
- API RP-753 references the determination of hazard zones based on identified congested volumes associated with the location of portable or temporary buildings. This methodology is a relatively conservative approach for delineation of overpressure zones.
- SAFER is commercially available software developed by Dupont for use in modelling flammable and toxic events.
- DNV Technician's Process Hazard Analysis Software Tool (PHAST) and SAFETI are comprehensive models internationally recognized for the purposes of supporting this type of analysis. These are the recognized software packages within Indorama Ventures for detailed modelling.

Typical Input parameters for the consequence assessment software are provided in Attachment G.

The results of this modelling shall be presented as contours on the Facility map. This format is conducive for evaluating impacts on buildings and Emergency Response Areas, as well as for use as a "Hazard Map" for the Facility to address management of change issues in the future.

B.4.5.2 Step 5B: Are Occupied Buildings or Areas impacted?

Step 5B is a decision point involving the identification of occupied buildings, process control buildings, or Emergency Response Buildings/Areas within the flammable or toxic hazard zones quantified for the worst case hazard event scenarios. Those buildings that are outside of the hazard zones shall be screened-out from further consideration in the study. The hazard zones are determined by the minimum values of endpoints of concern in Attachment G. For models which do not allow for the use of endpoints in Attachment G, the appropriate endpoints provided by the model shall be used.

Step 5B also serves as a screening process for hazard event scenarios in that it focuses the team down to those process units that have the potential for process safety incidents that could result in impacts to occupied buildings and areas on site. These will be the process units the team will focus on in Step 7 when identifying worst credible hazard scenarios.

Using the "Hazard Map(s)" developed in Step 5A, the Facility Siting Assessor shall review the potential consequences, or impacts, to occupied and process control buildings and Emergency Response Buildings/Areas on site.

If "yes" an occupied building or area is impacted, it shall be carried forward as a building, or area, of interest through the remainder of the assessment.

If "no" an occupied building is outside the hazard zones, with no impacts, it is now screened-out from further assessment.

The Facility Siting Assessor shall document the outcome of the Level 1 Consequence Screening in the Attachment D Building List example or functionally equivalent form.

B.4.5.3 Step 5C: Are there safeguards to eliminate or reduce the severity?

Step 5C is a decision point which involves the brainstorming by the Siting Assessment Team on any "quick fixes or counter measures" that could be implemented to significantly reduce the severity or eliminate the hazard. These are typically inherently safer management practices or passive mitigation systems. Examples would be elimination, relocation or reduction of inventory or installation of a dike/bund.

If "yes" the team identifies such counter measures, the Facility Siting Assessor shall revisit the worst case hazard event scenario modelling and related consequence assessment.

If there are occupied buildings screened out of the process as a result of revisiting the modelling, the Facility Siting Assessor shall proceed to Step 10D and capture the counter measures identified as formal risk management opportunities

If "no", proceed to Step 6.

B.4.6 Step 6: Complete Process Plant Building and Emergency Response Toxic Gas Shelter Checklists

In Step 6, the Facility Siting Assessor and/or a competent team shall perform a checklist field survey of buildings to compare existing conditions against generally accepted good practice for occupied areas subject to flammable, explosive or toxic impacts.

The Facility Siting Assessor and/or a competent team shall conduct and document a field survey of each impacted occupied building on the Building List using the Process Plant Building Checklist (PPBC) (see Attachment E) or functionally equivalent tool.

For those buildings that are intended for use as an emergency response shelter or area for process control in the event of a toxic gas process related incident, an additional field survey shall be carried out and documented using the Emergency Response Toxic Gas Shelter Checklist (ERTGSC) (see Attachment F) or functionally equivalent tool.

The information collected on the Attachment E and F checklists, or functionally equivalent tools, will be used as tools in Step 10D to develop risk management opportunities/recommendations.

B.4.7 Step 7: Develop Worst Credible Hazard Scenarios

In Step 7, the Facility Siting Assessor guides the team through the identification of the worst credible hazard event scenarios. These scenarios are typically based on the relevant process hazard analyses (PHAs), plant and related industry process safety incident history, or the experience of members of the Facility Siting Assessment Team. They are considered to be more credible by individuals involved in operating the process than the worst case hazard event scenario(s).

Attachment H provides some typical worst credible hazard event scenarios often considered when brainstorming with hazard identification teams.

The Facility Siting Assessor shall document the basis for selection of the worst credible hazard event scenario(s) that will be carried forward in the assessment. This may be done by creating a table in the final report listing each scenario and the associated basis.

The Facility Siting Assessor shall also clearly document the basis for modelling the worst credible hazard event scenario(s) including but not limited to: release mechanism, chemical inventory, process conditions, active and passive mitigation systems, and weather conditions. (Reference Attachment G)

B.4.7.1 Step 7A: (Optional) Probability Based Elimination of Worst case Hazard scenarios.

At the discretion of the Facility Siting Assessor, or if required by local legislation, the team may use quantified risk assessment techniques (e.g., Numerical Hazard Analysis or Layers of Protection Analysis) to screen from worst case hazard event scenarios to worst credible hazard event scenarios. The purpose of this step is to eliminate worst case hazard event scenarios that would be considered ‘non credible’ based on frequency or likelihood.

Examples of worst case hazard event scenarios that could be screened out using quantified risk assessment techniques at this stage are provided in Table B-4.

Table B-4
Bases for Screening Worst case Hazard scenarios

Worst case Hazard scenarios	Basis for Screening Out Non-Credible Hazard scenarios
Rupture of large bore, all welded pipelines.	Generic failure rates may indicate an extremely low event frequency.
Catastrophic rupture of process vessels due to extreme process upset conditions.	Generic failure rates may indicate an extremely low event frequency.
Boiling liquid expanding vapour explosion (BLEVE).	For suitably fire insulated equipment the time for a vessel to BLEVE may be sufficient to allow people in buildings to be evacuated.
Extreme weather conditions.	Buildings may not be designed for these conditions and evacuation is preferred.
Failure of inherently safe design features.	Process cannot exceed equipment design pressure.
Events involving failure of multiple independent layers of protective systems.	Large numbers of instrumented and mechanical system required to fail at the same time.
Structural collapse.	Generic failure rates may indicate an extremely low event frequency if there is no obvious failure mechanism.

B.4.8 Step 8: Is detailed modelling required?

In Step 8, the Facility Siting Assessor, in consultation with the Facility Siting Assessment Team, shall determine if more detailed consequence modelling of the worst credible hazard event scenarios is required to make informed decisions regarding hazard zones, consequences, safeguards and risk reduction recommendations. Detailed modelling may also be required to comply with regulatory requirements.

The Facility Siting Assessor shall consider and advise the team on the limitations of the models used to meet the Level 1 Consequence Screening to make this decision.

If the decision is 'yes", more detailed modelling of the worst credible hazard event scenario(s) is required, proceed to Step 9.

If the decision is 'no', then the Hazard Map with the contours from the modelling of the worst case hazard event scenarios will be conservatively referenced when evaluating building impacts and risk ranking severity for the worst credible hazard event scenarios. Proceed to Step 10.

B.4.9 Step 9: Detailed Modelling of Worst Credible Hazard Event Scenarios

When more detailed consequence modelling is required, fire, explosion and toxic gas hazards shall be assessed using recognized consequence assessment software tools.

Acceptable software packages and methods include but are not limited to:

- DNV Technician's Process Hazard Analysis Software Tool (PHAST) and SAFETI are comprehensive models internationally recognized for the purposes of supporting this type of analysis. PHAST/SAFETI shall only be run by a competent person.
- Baker Risk's SafeSite3G™ is a proprietary software tool that can be used for modelling blast overpressures and developing potential over pressure contour maps from multiple potential release sources.

Detailed modelling allows more accurate and generally less conservative assessment of explosion overpressure, toxic gas dispersion and thermal radiation load than when using screening level software. Suggested input parameters for the consequence assessment modelling are provided in Attachment G.

The results of the modelling shall be presented as contours on the Facility map. This format is conducive for evaluating impacts on buildings and Emergency Response Areas, as well as use as a "Hazard Map" for the site to address management of change issues in the future.

In limited cases where additional modelling details are needed, computational fluid dynamics (CFD) modelling may be used at the direction of the Global PS Center of Excellence group.

B.4.10 Step 10: Level 2 - Risk Based Screening

Using the Hazard Map(s) developed in Step 9, the Facility Siting Assessor shall guide the team through:

- An identification of occupied buildings, process control areas, and Emergency Response Buildings/Areas still impacted by the worst credible hazard event scenarios**.**
- A qualitative assessment of the severity of the impact(s), or damage level(s), based on the building type and construction features inventoried in Step 4.
- Documentation of existing safeguards associated with prevention, mitigation, or emergency response to each hazard event scenario.

- A risk ranking of each hazard event scenario, basing severity on the consequences without safeguards and likelihood with taking safeguards into account and referencing the Risk Management Standard and Matrix in IVL EHS-208.
- A determination on the action required for additional safeguards based on the Risk Action Level (i.e., EHS – 1, 2, 3, 4).
- Brainstorming of risk management opportunities.

The Screening Level 2 assessment should be documented using "What-If" Process Hazard Analysis (PHA) methodology and study worksheets (see Attachment I for an example worksheet).

B.4.10.1 Step 10A: Assess Severity of Occupied Building Impacts

Using the Hazard Map(s) developed in Step 9, the Facility Siting Assessment team shall document the occupied buildings, control buildings, and Emergency Response Areas still impacted by flammable or toxic hazards after modelling of the worst credible hazard event scenarios. This assessment can be documented in the Building List, reference the Attachment D example.

For flammable impacts, the Facility Siting Assessor shall guide the team through a semi-quantitative evaluation of the impacts and potential building damage levels based on the Building Type and construction features surveyed in Step 4. Reference tables providing comparable impacts to endpoint criteria are provided in Attachment J.

The results of Step 10A will be used to risk rank the hazard event scenario in Step 10B.

a. Overpressure Impacts

The Facility Siting Assessment Team shall determine if the building design is adequate to protect occupants from the hazards of overpressures due to explosions.

When evaluating overpressure impacts, the Facility Siting Assessor may reference the Tables J-1, J-2, and J-3 in Attachment J. Table J-1 provides a correlation for the team between overpressures, Building Type, building damage, and probability of serious injury or fatality of occupants. Table J-2 provides a correlation between overpressures and consequences to building construction components.

Table J-3 provides a system for categorizing the damage to a typical building, i.e., non-blast resistant design. The Facility Siting Assessor can use this damage level scale to convey relative severity to team members and Facility management.

If the potential overpressure is more than that the building is designed to withstand, good engineering judgment should be utilized to estimate the potential impact on the building. In these circumstances, the Facility Siting Assessor may recommend seeking assistance from a competent professional with expertise in building structural design and blast damage. This should be recorded as a recommendation from the study.

b. Thermal Radiation Impacts

The Facility Siting Assessment team shall determine if the building design is adequate to protect occupants from the thermal radiation relating to fire hazards. Reference Table J-4 in Attachment J provides a correlation for the team of radiant heat levels versus consequences to individuals and building construction materials.

The team should also include an assessment of the potential for internal fires due to ignition of combustible building fabric, fittings and furniture due to exposure to thermal radiation transmitted through windows.

The Facility Siting Assessment team shall assess the risk of ingress of flammable gas to buildings, as a source of ignition. This can be achieved by applying the same principles as those described in the Emergency Response Toxic Gas Shelter Checklist (ERTGSC) (see Attachment F).

c. Toxic Gas Impacts

In the event that an on-site occupied building is within a toxic hazard zone, the Facility Siting Assessment team shall review the building design and engineering and administrative controls, i.e., emergency procedures, to assess if personnel can evacuate effectively to a designated emergency assembly and accountability location or if they must be able to access a toxic gas shelter.

Any building or enclosure intended to be used as a toxic gas shelter shall be assessed in relation to the Emergency Response Toxic Gas Shelter Checklist (ERTGSC) completed in Step 6 (see Attachment F). The checklist includes a list of essential features that shall be incorporated into the design of a toxic gas shelter.

In the event that the potential toxic gas hazard zone extends off-site, the Facility Siting Assessment team shall assess the potential impact to people off-site as well. Table J-5 in Attachment J provides guidance for off-site consequences.

B.4.10.2 Step 10B: Establish Severity and Likelihood (Risk Ranking)

In Step 10B, the Facility Siting Assessor shall guide the team through risk ranking the severity and likelihood of building impacts for each hazard event scenario referencing Risk Management Standard and Matrix, IVL EHS-208.

Using Table 1, Consequence Definitions of IVL EHS-208, the Facility Siting Assessor shall facilitate the determination of severity of the consequences. Severity is ranked without consideration for active safeguards. The severity ranking shall be based on the potential impacts to the occupied buildings identified in Step 10A and the occupancy rates documented in Step 3. A category ranking of one through five shall be selected.

Using Table 2, Frequency Definitions of IVL EHS-208, the Facility Siting Assessor shall facilitate the determination of the frequency of occurrence. Existing safeguards shall be considered and documented in making this determination using semi-quantitative methods where practical. A category ranking of A through H shall be selected.

At the discretion of the Facility Siting Assessor, or if required by local legislation, a Quantitative Assessment (in accordance with IVL EHS-406; SIL Target Assessment Methodology – Attachments C and D) may be performed as the basis for the frequency risk ranking. A Quantitative Assessment**:**

- Can be applied by expanding on the data collected during the Consequence Screening step.
- Shall be conducted in a manner consistent with recognized government or industry standards, an example of which is provided by Reference 7.11 (Guidelines for evaluating process plant building for external explosions and fires", CCPS, AIChE, 1996).
- Shall take into account all hazard event scenario~~s~~ that could impact on an occupied building or Emergency Response Area. The individual risk probabilities from the different scenarios and the average number of people who occupy the building are to be included in the evaluation to determine the aggregate risk for the potential loss of life.

DNV Technician's Process Hazard Analysis Software Tool (PHAST) and SAFETI are comprehensive models internationally recognized for the purposes of supporting this type of analysis.

The Facility Siting Assessor shall document the risk ranking for each hazard event scenario including severity, frequency, risk ranking and EHS Risk Level per IVL EHS-208 using the Attachment D example or equivalent form.

B.4.10.3 Step 10C: Are the building design / location and risk acceptable?

The severity and likelihood ranking shall be compared with the risk tolerance targets on Figure 2 of IVL EHS-208. The risk to the building occupants is considered acceptable only if an IVL EHS-2 Risk Level or lower is obtained.

If the decision is yes', then this means the degree of protection provided by the building design and location minimizes the risk of serious injury or fatality to the occupants to an acceptable level based on the worst credible hazard event scenario identified by the team. No further assessment of the building is required. Proceed to Step 11.

If the decision is 'no', then this means the combination of building design and location is not acceptable based on the worst credible hazard event scenario. The Facility Siting Assessment Team should then brainstorm additional engineering or administrative safeguards, or risk management opportunities that can be applied.

The Process Plant Building Checklist (PPBC) (see Attachment E) and the Emergency Response Toxic Gas Shelter Checklist (ERTGSC) (see Attachment F) are intended as tools to assist the Facility Siting Assessor with evaluating desirable building features that are considered good design practice in minimizing toxic, flammable or explosive impacts. Review of the Process Plant Building Checklist (PPBC) or Emergency Response Toxic Gas Shelter Checklist (ERTGSC) may provide ideas for the team.

Blast resistant buildings are allowed provided they comply with the requirements of Attachment K, Blast Resistant Modular Buildings.

A listing of typical safeguards that may be used in brainstorming is provided in Attachment L. Proceed to Step 10D.

B.4.10.4 Step 10D: Identify Risk Management Opportunities

The Facility Siting Assessor shall document all risk management opportunities, or recommendations, identified by the Facility Siting Assessment Team during the Level 1 Consequence Screening and the Level 2 Risk Based Screening.

B.4.11 Step 11: Compile Study Documentation

The Facility Siting Assessor shall prepare the Facility Siting draft report based on the information and assessments developed during the course of the study. This intermediate report shall be identified as “Working Copy” to differentiate it from the final report.

The Facility Siting Assessor shall participate in a post study meeting with the Facility Siting Assessment Team to review the draft report and prepare the presentation for the Site Head.

This presentation and report with prioritized recommendations shall be presented to the Site Head.

The Facility Siting Report shall not be finalized without approval of the Site Head.

A Facility Siting Assessment report should include the following sections:

a. Executive summary with objective, methodology and key findings.
b. Recommendations with key issues identified and need for recommendations to be closed out.

c. Methodology with reference to this standard and any alternative approaches used for the review.
d. Building List and occupancy.
e. Hazard or contour maps illustrating the potential areas with flammable and toxic impacts.
f. Results for all occupied buildings, process control buildings, and Emergency Response Buildings/Areas being assessed with location of information in the report.
g. Conclusions with main findings.
h. Appendix with hazard identification and risk assessment table. The table should comprise the following headings (an example is provided in Attachment I):
    i. Scenario reference number.
    ii. Scenario: Description of the process related incident.
    iii. Consequences: Description of the immediate and ultimate consequences with respect to occupants of buildings.
    iv. Existing safeguards: Existing measures to prevent, control or mitigate the process related incident including building design features.
    v. Risk: Assessed as per Risk Management Standard and Matrix (IVL EHS-208).

Copies of the report shall be issued to the appropriate departments at the direction of the Site Head, or designee, but shall be made available to all employees.

B.4.12 Step 12: Recommendation Management and Tracking

The Site Head is responsible for ensuring a process is in place for actively addressing the recommendations, developing related action plans, and tracking those plans to completion in accordance with the Management of Recommendations / Actions Standard, IVL EHS-107.

Attachment C: Consolidated Hazardous Chemical Listing

CAS Number	CASK Chemical Name	Site Inventory (pounds)	NFPA 704 Classification[1]			Toxic Substance[2]	Flammable Substance[2]	US Ref. List Type[3]	Synonyms
			N_H	N_F	N_R				
57-14-7	1,1-Dimethyl Hydrazine		4	3	1	x	x	RMP/PSM	Dimethylhydrazine, Hydrazine, 1,1-dimethyl-
106-99-0	1,3-Butadiene		2	4	2		x	RMP	
504-60-9	1,3-Pentadiene		0	4	2		x	RMP	
106-98-9	1-Butene		1	4	0		x	RMP	
97-00-7	1-Chloro-2,4-Dinitrobenzene		3	1	4	x		PSM	
590-21-6	1-Chloropropylene		2	4	2		x	RMP	1-Propene, 1-chloro-
109-67-1	1-Pentene		1	4	0		x	RMP	
106-99-0	1,3-Butadiene		2	4	2		x	-	
463-82-1	2,2-Dimethylpropane		0	4	0		x	RMP	Propane, 2,2-dimethyl-
97-02-9	2,4-Dinitroaniline		3	1	3	x		PSM	
107-01-7	2-Butene		1	4	0		x	RMP	
590-18-1	2-Butene-Cis		1	4	0		x	RMP	2-Butene, (Z)-
624-64-6	2-Butene-Trans		1	4	0		x	RMP	2-Butene, (E)-
503-17-3	2-Butyne		-	4	-		x	PSM	
557-98-2	2-Chlropropylene		2	4	2		x	RMP	1-Propene, 2-chloro-
563-46-2	2-Methyl-1-Butene		2	4	0		x	RMP	
115-11-7	2-Methylpropene		1	4	0		x	RMP	1-Propene, 2-methyl-
646-04-8	2-Pentene, (E)-		1	4	0		x	RMP	
627-20-3	2-Pentene, (Z)-		1	4	0		x	RMP	
563-45-1	3-Methyl-1-Butene		2	4	0		x	RMP	
75-07-0	Acetaldehyde		2	4	2	x	x	PSM/RMP	
64-19-7	Acetic acid (glacial)		2	2	0			-	
67-64-1	Acetone		1	3	0		x	PSM	
74-86-2	Acetylene		0	4	3		x	RMP	Ethyne
107-02-8	Acrolein		4	3	3	x	x	PSM/RMP	2-Propenal
107-13-1	Acrylonitrile		4	3	2	x	x	RMP	2-Propenenitrile
79-10-7	Acrylic Acid		3	2	2	x		PSM	
814-68-6	Acrylyl Chloride		3	3	1	x	x	PSM/RMP	2-Propenoyl chloride

CAS Number	CASK Chemical Name	Site Inventory (pounds)	NFPA 704 Classification[1]			Toxic Substance[2]	Flammable Substance[2]	US Ref. List Type[3]	Synonyms
			N_H	N_F	N_R				
Varies	Alkylaluminums		3	4	3	x	x	PSM	
107-18-6	Allyl Alcohol		4	3	1	x	x	RMP	2-Propen-1-ol
107-05-1	Allyl Chloride		3	3	1	x	x	PSM	
107-11-9	Allylamine		4	3	1	x	x	PSM/RMP	2-Propen-1-amine
7446-70-0	Aluminum chloride (anhydrous)		3	0	2	x		-	
7664-41-7	Ammonia (Anhydrous)		3	1	0	x		PSM/RMP	
7664-41-7	Ammonia (Conc. 20% or greater)		2	1	0	x		PSM/RMP	
6484-52-2	Ammonium Nitrate		0	0	3			-	
7790-98-9	Ammonium Perchlorate		1	0	4	x		PSM	
7787-36-2	Ammonium Permanganate		0	0	3	x		PSM	
628-63-7	Amyl Acetate		1	3	0		x	-	
71-41-0	Amyl Alcohol		1	3	0		x	-	n-Amyl Alcohol, 1-Pentanol
62-53-3	Aniline		3	2	0	x		-	
7784-34-1	Arsenous Trichloride		3	0	0	x		RMP	
7784-42-1	Arsine		4	4	2	x	x	PSM/RMP	
71-43-2	Benzene		1	3	0		x	-	
542-88-1	Bis(Chloromethyl) Ether		4	3	1	x	x	PSM/RMP	
10294-34-5	Boron Trichloride		4	0	2	x		PSM/RMP	Borane, trichloro-
7637-07-2	Boron Trifluoride		4	0	1	x		PSM/RMP	Borane, trifluoro-
353-42-4	Boron Trifluoride Compound with Methyl Ether (1:1)		4	4	1	x	x	RMP	Boron, trifluoro[oxybis[methane]]-, (T-4)-
7726-95-6	Bromine		3	0	0	x		PSM/RMP	
13863-41-7	Bromine Chloride					x		PSM	
7789-30-2	Bromine Pentafluoride		4	0	3	x		PSM	
7787-71-5	Bromine Trifluoride		4	0	3	x		PSM	
598-73-2	Bromotrifluoroethylene		2	4	2		x	RMP	Ethene, bromotrifluoro-

CAS Number	CASK Chemical Name	Site Inventory (pounds)	NFPA 704 Classification[1]			Toxic Substance[2]	Flammable Substance[2]	US Ref. List Type[3]	Synonyms
			N_H	N_F	N_R				
106-97-8	Butane		1	4	0		x	RMP	
71-36-3	Butanol		2	3	0		x	-	1-Butanol, n-Butanol, Butyl Alchohol
25167-67-3	Butene		1	4	0		x	RMP	
106-88-7	1,2-Butylene oxide		2	3	2		x	-	
	2,3-Butylene oxide		2	3	2		x	-	
71-36-3	Butyl Alcohol		1	3	0		x	-	
123-86-4	Butyl Acetate		2	3	0		x	-	
141-32-2	Butyl Acrylate		3	2	2	x		-	n-Butyl Acrylate
111-36-4	Butyl Isocyanate		3	3	2	x	x	-	
123-72-8	Butyraldehyde		3	3	0	x	x	-	Butanal
75-91-2	Butyl Hydroperoxide (Tertiary)		3	2	2	x		PSM	
614-45-9	Butyl Perbenzoate (Tertiary)		2	3	3	x	x	PSM	
75-15-0	Carbon Disulfide		3	4	0	x	x	RMP	
630-08-0	Carbon Monoxide		3	4	0	x	x	-	
56-23-5	Carbon Tetrachloride		3	0	0	x		-	
75-44-5	Carbonyl Chloride		4	0	1	x		PSM	
353-50-4	Carbonyl Fluoride		4	0	2	x		PSM	
463-58-1	Carbonyl Sulfide		3	4	1		x	RMP	Carbon oxide sulfide (COS)
9004-70-0	Cellulose Nitrate (Concentration >12.6% Nitrogen)		2	3	3	x	x	PSM	
7782-50-5	Chlorine		4	0	0	x		PSM/RMP	
10049-04-4	Chlorine Dioxide		3	0	4	x		PSM/RMP	Chlorine oxide (ClO2)
7791-21-1	Chlorine Monoxide		3	4	3	x	x	RMP	Chlorine oxide
13637-63-3	Chlorine Pentafluoride		4	0	1	x		PSM	
7790-91-2	Chlorine Trifluoride		4	0	3	x		PSM	
79-11-8	Chloroacetic Acid		3	1	0	x		-	
108-90-7	Chlorobenzene		2	3	0		x	-	

CAS Number	CASK Chemical Name	Site Inventory (pounds)	NFPA 704 Classification[1]			Toxic Substance[2]	Flammable Substance[2]	US Ref. List Type[3]	Synonyms
			N_H	N_F	N_R				
96-10-6	Chlorodiethylaluminum		3	4	3	x	x	PSM	Diethylaluminum chloride
67-66-3	Chloroform		2	0	0	x		RMP	Methan, trichloro-
542-88-1	Chloromethyl Ether		4	3	1	x	x	RMP	Bis(chloromethyl) ether, Dichloromethyl ether, Methane, oxybis[chloro-
107-30-2	Chloromethyl Methyl Ether		3	3	2	x	x	PSM/RMP	Methane, chloromethoxy-
76-06-2	Chloropicrin		4	0	3	x		PSM	
None	Chloropicrin And Methyl Bromide Mixture		4	0	3	x		PSM	
None	Chloropicrin And Methyl Chloride Mixture		4	0	3	x		PSM	
None	Collodion		1	4	0		x	PSM	
4170-30-3	Crotonaldehyde		4	3	2	x	x	RMP	
123-73-9	Crotonaldehyde, (E)-		4	3	2	x	x	RMP	2-Butenal, (e)-
98-82-8	Cumene		2	3	1		x	-	
80-15-9	Cumene Hydroperoxide		1	2	4	x		PSM	
460-19-5	Cyanogen		4	4	2	x	x	PSM/RMP	Ethanedinitrile
506-77-4	Cyanogen Chloride		4	0	2	x		PSM/RMP	Cyanogen chloride ((CN)Cl)
675-14-9	Cyanuric Fluoride		4	1	2	x		PSM	
287-23-0	Cyclobutane		1	4	0		x	PSM	
291-64-5	Cycloheptane		0	3	0		x	-	
110-82-7	Cyclohexane		1	3	0		x	-	
108-91-8	Cyclohexylamine		3	3	0	x	x	RMP	Cyclohexanamine
287-92-3	Cyclopentane		1	3	0		x	-	
75-19-4	Cyclopropane		1	4	0		x	RMP	
7782-39-0	Deuterium (Heavy Hydrogen)		0	4	0		x	PSM	
110-22-5	Diacetyl Peroxide (Concentration >70%)		1	4	2	x		PSM	
334-88-3	Diazomethane		4	3	3	x	x	PSM	

CAS Number	CASK Chemical Name	Site Inventory (pounds)	NFPA 704 Classification[1]			Toxic Substance[2]	Flammable Substance[2]	US Ref. List Type[3]	Synonyms
			N_H	N_F	N_R				
94-36-0	Dibenzoyl Peroxide		1	4	4	x	x	PSM	
19287-45-7	Diborane		4	4	3	x	x	PSM/RMP	Diborane(6)
110-05-4	Dibutyl Peroxide (Tertiary)		1	3	2	x	x	PSM	
7572-29-4	Dichloro Acetylene		3	3	2	x	x	PSM	
4109-96-0	Dichlorosilane		3	4	2	x	x	PSM/RMP	
77-73-6	Dicyclopentadiene		3	3	1	x	x	-	
96-22-0	Diethyl ketone		1	3	0		x	-	3-Pentanone
628-37-5	Diethyl Peroxide		-	4	4		x	PSM	
96-10-6	Diethylaluminum Chloride		3	4	3	x	x	PSM	
109-89-7	Diethylamine		3	3	0	x	x	-	
111-40-0	Diethylene Triamine		3	1	0	x		-	
557-20-0	Diethylzinc		3	4	3	x	x	PSM	
None	Difluoro-1-Chloroethane		0	4	0		x	PSM	
75-37-6	Difluoroethane		1	4	1		x	RMP	Ethane, 1,1-difluoro-
105-64-6	Diisopropyl Peroxydicarbonate		0	4	4	x	x	PSM	
105-74-8	Dilaluroyl Peroxide					x		PSM	
75-18-3	Dimethyl Sulfide		1	4	0		x	PSM	
124-40-3	Dimethylamine		3	4	0	x	x	PSM/RMP	Methanamine, N-methyl-
108-01-0	Dimethylethanolamine		3	2	0	x		-	
75-78-5	Dimethyldichlorosilane		3	3	1	x	x	PSM/RMP	Silane, dichlorodimethyl-
97-02-9	2,4-Dinitroanaline		3	1	3	x		-	
528-29-0	Dinitrobenzene (ortho)		3	1	4	x		-	
528-29-0	1,2-Dinitrobenzene		3	1	4	x		-	
	1,2-Dinitrobenzol		3	1	4	x		-	
97-00-7	Dinitrochlorobenzene		3	1	4	x		-	1-chloro-2,4-dinitrobenzene
121-14-2	2,4-Dinitrotoluene		3	1	3	x		-	
	2,5-Dinitrotoluene		3	1	3	x		-	
	2,6-Dinitrotoluene		3	1	3	x		-	

CAS Number	CASK Chemical Name	Site Inventory (pounds)	NFPA 704 Classification[1]			Toxic Substance[2]	Flammable Substance[2]	US Ref. List Type[3]	Synonyms
			N_H	N_F	N_R				
142-84-7	Dipropylamine		3	3	0	x	x	-	
110-05-4	Di-tert-butyl peroxide		3	2	4	x		-	
109-93-3	Divinyl Ether		2	4	2		x	PSM	
106-89-8	Epichlorohydrin		3	2	2	x		RMP	Oxirane, (chloromethyl)-
74-84-0	Ethane		1	4	0		x	RMP	
141-43-5	Ethanolamine		3	2	0	x		-	
141-78-6	Ethyl Acetate		1	3	0		x	-	
107-00-6	Ethyl Acetylene		1	4	3		x	RMP	1-Butyne
140-88-5	Ethyl Acrylate		2	3	2		x	-	
64-17-5	Ethyl Alcohol		0	3	0		x	-	Ethanol
100-41-4	Ethylbenzene		2	3	0		x	-	
75-00-3	Ethyl Chloride		1	4	0		x	RMP	Chlroroethane; Ethane, chloro-
541-41-3	Ethyl Chloroformate		4	3	1	x	x	-	
60-29-7	Ethyl Ether		1	4	1		x	RMP	Ethane, 1,1'-oxybis-
353-36-6	Ethyl Fluoride		-	4	0		x	PSM	
75-08-1	Ethyl Mercaptan		2	4	0		x	RMP	Ethanethiol
1338-23-4	Ethyl Methyl Ketone Peroxide (Concentration >60%)		2	0	0	x		PSM	Methyl ethyl ketone peroxide
100-74-3	4-Ethylmorpholine		2	3	0		x	-	n-Ethylmorpholine
109-95-5	Ethyl Nitrite		4	3	0	x	x	PSM/RMP	Nitrous acid, ethyl ester
75-04-7	Ethylamine		3	4	0	x	x	PSM/RMP	Ethanamine, monoethylamine
74-85-1	Ethylene		1	4	2		x	RMP	Ethene
107-06-2	Ethylene Dichloride		2	3	0		x	-	
371-62-0	Ethylene Fluorohydrin		3	3	0	x	x	PSM	
75-21-8	Ethylene Oxide		3	4	3	x	x	PSM/RMP	Oxirane
107-15-3	Ethylenediamine		2	3	0	x	x	RMP	1,2-Ethanediamine
151-56-4	Ethyleneimine		4	3	3	x	x	PSM/RMP	Aziridine
7782-41-4	Fluorine		4	0	3	x		PSM/RMP	

CAS Number	CASK Chemical Name	Site Inventory (pounds)	NFPA 704 Classification[1]			Toxic Substance[2]	Flammable Substance[2]	US Ref. List Type[3]	Synonyms
			N_H	N_F	N_R				
50-00-0	Formaldehyde (Solution)		3	4	0	x	x	PSM/RMP	
	Formaldehyde 37%, 15% methanol		3	2	0	x		-	
	Formaldehyde 37% methanol-free		3	2	0	x		-	
110-00-9	Furan		1	4	1	x	x	PSM/RMP	
	Gas, Natural		1	4	0		x	PSM	
142-82-5	Heptane		1	3	0		x	PSM	
110-54-3	Hexane		1	3	0		x	PSM	
111-27-3	Hexanol		3	2	0	x		-	Hexyl alcohol
592-41-6	Hexene		1	3	0		x	PSM	1-hexene, hexylene
684-16-2	Hexafluoroacetone		3	0	2	x		PSM	
302-01-2	Hydrazine		3	3	3	x	x	RMP	
7647-01-0	Hydrochloric Acid (Conc. 37% or greater)		3	0	0	x		PSM/RMP	
74-90-8	Hydrocyanic Acid		4	4	2	x	x	PSM/RMP	Hydrogen cyanide
7664-39-3	Hydrofluoric Acid (Conc. 50% or greater)		4	0	0	x		PSM/RMP	
1333-74-0	Hydrogen		0	4	0		x	RMP	
10035-10-6	Hydrogen Bromide		3	0	0	x		PSM	
7647-01-0	Hydrogen Chloride (Anhydrous)		3	0	1	x		PSM/RMP	
74-90-8	Hydrogen Cyanide		4	4	2	x	x	-	Hydrocyanic acid
7664-39-3	Hydrogen Fluoride (Anhydrous)		4	0	1	x		PSM/RMP	
7722-84-1	Hydrogen Peroxide (52% by weight or greater)		2	0	1	x		PSM	
7783-07-5	Hydrogen Selenide			4		x	x	PSM/RMP	
7783-06-4	Hydrogen Sulfide		4	4	0	x	x	PSM/RMP	
7803-49-8	Hydroxylamine		2	1	3	x		PSM	
13463-40-6	Iron, Pentacarbonyl-		2	3	1	x	x	PSM/RMP	Iron carbonyl (Fe(CO)5), (TB-5-11)-

CAS Number	CASK Chemical Name	Site Inventory (pounds)	NFPA 704 Classification[1]			Toxic Substance[2]	Flammable Substance[2]	US Ref. List Type[3]	Synonyms
			N_H	N_F	N_R				
75-28-5	Isobutane		1	4	0		x	RMP	Propane, 2-methyl-
110-19-0	Isobutyl Acetate		1	3	0		x	-	
106-63-8	Isobutyl Acrylate		1	3	1		x	-	
78-83-1	Isobutyl Alcohol		1	3	0		x	-	
78-81-9	Isobutylamine		2	3	0		x	-	
78-82-0	Isobutyronitrile		3	3	0	x	x	RMP	Propanenitrile, 2-methyl-
78-78-4	Isopentane		1	4	0		x	RMP	Butane, 2-methyl-
78-79-5	Isoprene		1	4	2		x	RMP	1,3-Butadiene, 2-methyl-
78-80-8	Isopropenyl Acetylene		2	4	2		x	PSM	1-Buten-3yne, 2-methyl-
67-63-0	Isopropyl alcohol		1	3	0		x	-	
75-29-6	Isopropyl Chloride		2	4	0		x	RMP	Propane, 2-chloro-
108-23-6	Isopropyl Chloroformate		2	4	0	x	x	RMP	Carbonochloridic acid, 1-methylethyl ester
75-31-0	Isopropylamine		3	4	0	x	x	PSM/RMP	2-Propanamine
463-51-4	Ketene		4	2	3	x		PSM	
108-31-6	Maleic Anhydride		3	1	1			-	
96-33-3	Methacrylic Acid		3	2	2			-	
78-85-3	Methacrylaldehyde		3	3	2	x	x	PSM	
126-98-7	Methacrylonitrile		2	3	2	x	x	PSM/RMP	2-Propenenitrile, 2-methyl-
920-46-7	Methacryloyl Chloride		4	3	0	x	x	PSM	
30674-80-7	Methacryloyloxyethyl Isocyanatex		4	1	1	x		PSM	
74-82-8	Methane		1	4	0		x	RMP	
67-56-1	Methanol		1	3	0		x	-	
74-83-9	Methyl Bromide		3	1	0	x		PSM	
74-87-3	Methyl Chloride		1	4	0	x	x	PSM/RMP	Methane, chloro-, Chloromethane
79-22-1	Methyl Chloroformate		4	3	1	x	x	PSM/RMP	Carbonochloridic acid, methylester, methyl chlorocarbonate
115-10-6	Methyl Ether		1	4	1		x	RMP	Methane, oxybis-
540-67-0	Methyl Ethyl Ether		1	4	1		x	PSM	Ethane, methoxy-

CAS Number	CASK Chemical Name	Site Inventory (pounds)	NFPA 704 Classification[1]			Toxic Substance[2]	Flammable Substance[2]	US Ref. List Type[3]	Synonyms
			N_H	N_F	N_R				
78-93-3	Methyl ethyl ketone		1	3	0		x	-	
1338-23-4	Methyl Ethyl Ketone Peroxide (Concentration >60%)		2	0	0	x		PSM	
453-18-9	Methyl Fluoroacetate					x		PSM	
421-20-5	Methyl Fluorosulfate					x		PSM	
107-31-3	Methyl Formate		2	4	0		x	RMP	Formic acid, methyl ester
60-34-4	Methyl Hydrazine		4	3	2	x	x	PSM/RMP	Hydrazine, methyl-
74-88-4	Methyl Iodide		3	1	1	x		PSM	
108-10-1	Methyl isobutyl ketone		2	3	1		x	-	Hexone
624-83-9	Methyl Isocyanate		4	3	2	x	x	PSM/RMP	Methane, isocyanato-
74-93-1	Methyl Mercaptan		4	4	0	x	x	PSM/RMP	Methanethiol, Thiomethanol
1634-04-4	Methyl Tertiary Butyl Ether (MTBE)		2	4	0		x	-	
556-64-9	Methyl Thiocyanate			3		x	x	RMP	Thiocyanic acid, methyl ester
78-94-4	Methyl Vinyl Ketone		4	3	2	x	x	RMP	
74-89-5	Methylamine		3	4	0	x	x	PSM/RMP	Monomethylamine; Methanamine
75-79-6	Methyltrichlorosilane		3	3	2	x	x	PSM/RMP	Silane, trichloromethyl-
110-91-8	Morpholine		3	3	0		x	-	
8030-30-6	Naphtha		1	3	0		x	-	
13463-39-3	Nickel Carbonyl		4	3	3	x	x	PSM/RMP	
7697-37-2	Nitric Acid (Conc. 80% or greater)		3	0	0	x		PSM/RMP	
10102-43-9	Nitric Oxide		3	0	0	x		PSM/RMP	Nitrogen oxide (NO)
100-01-6	Nitroaniline (Para Nitroaniline)		3	1	3	x		PSM	
98-95-3	Nitrobenzene		3	2	1				
10102-44-0	Nitrogen Dioxide		3	0	0	x		PSM	
10102-44-0	Nitrogen Oxides (NO; NO2; N2O4; N2O3)		3	0	0	x		PSM	

CAS Number	CASK Chemical Name	Site Inventory (pounds)	NFPA 704 Classification[1]			Toxic Substance[2]	Flammable Substance[2]	US Ref. List Type[3]	Synonyms
			N_H	N_F	N_R				
10544-72-6	Nitrogen Tetroxide (also called Nitrogen Peroxide)		3	0	0	x		PSM	
7783-54-2	Nitrogen Trifluoride		1	0	0	x		PSM	
10544-73-7	Nitrogen Trioxide		3	0	0	x		PSM	
75-52-5	Nitromethane		1	3	4	x	x	PSM	
8014-95-7	Oleum (Fuming Sulfuric Acid)		3	0	2	x		PSM/RMP	Sulfuric acid (fuming), Sulfuric acid, mixture with sulfur trioxide
20816-12-0	Osmium Tetroxide		4	0	1	x		PSM	
7783-41-7	Oxygen Difluoride		4	0	3	x		PSM	Fluorine monoxide
10028-15-6	Ozone		4	0	4	x		PSM	
95-47-6	O-xylene		2	3	0		x	-	
106-42-3	P-xylene		2	3	0		x	-	
19624-22-7	Pentaborane		4	4	2	x	x	PSM	
109-66-0	Pentane		1	4	0		x	RMP	
79-21-0	Peracetic Acid		3	2	4	x		PSM/RMP	Ethaneperoxoic acid
7601-90-3	Perchloric Acid (Concentration >60% by weight)		3	0	3	x		PSM	
594-42-3	Perchloromethyl Mercaptan		4	0	0	x		PSM/RMP	Methanesulfenyl chloride, trichloro- , Trichloromethanesulfenyl chloride
7616-94-6	Perchloryl Fluoride		3	2	3	x		PSM	
75-44-5	Phosgene		4	0	1	x		PSM/RMP	Carbonic dichloride
7803-51-2	Phosphine		4	4	2	x	x	PSM/RMP	
7664-38-2	Phosphoric Acid		3	0	0			-	
10025-87-3	Phosphorus Oxychloride		4	0	2	x		PSM/RMP	Phosphoryl chloride
7719-12-2	Phosphorus Trichloride		4	0	2	x		PSM/RMP	Phosphorous trichloride
110-89-4	Piperidine		3	3	0	x	x	RMP	
463-49-0	Propadiene		0	4	3		x	RMP	1,2-Propadiene

CAS Number	CASK Chemical Name	Site Inventory (pounds)	NFPA 704 Classification[1]			Toxic Substance[2]	Flammable Substance[2]	US Ref. List Type[3]	Synonyms
			N_H	N_F	N_R				
74-98-6	Propane		1	4	0		x	RMP	
71-23-8	Propanol		1	3	0		x	-	n-Propyl alcohol. 1-Propanol, n- Propanol
106-96-7	Propargyl Bromide		3	3	4	x	x	PSM	
107-12-0	Propionitrile		4	3	1	x	x	RMP	Propanenitrile, Ethyl cyanide
109-61-5	Propyl Chloroformate		4	3	0	x	x	RMP	Carbonochloridic acid, propylester
627-3-4	Propyl Nitrate		2	4	3	x	x	PSM	
115-07-1	Propylene		1	4	1		x	RMP	Propene; 1-Propene
75-56-9	Propylene Oxide		3	4	2	x	x	RMP	Oxirane, methyl-
74-99-7	Propyne		2	4	2		x	RMP	1-Propyne
107-44-8	Sarin		4	1	0	x		PSM	
7783-79-1	Selenium Hexafluoride		3	-	-	x		PSM	
7803-62-5	Silane		1	4	3		x	RMP	
143-33-9	Sodium Cyanide		3	0	0	x		-	
1310-73-2	Sodium Hydroxide (lye)		3	0	1	x		-	
1313-60-6	Sodium Peroxide		3	0	1	x		-	
7803-52-3	Stibine (Antimony Hydride)		4	4	2	x	x	PSM	
100-42-5	Styrene		2	3	2		x	-	
7446-09-5	Sulfur Dioxide (Anhydrous)		3	0	0	x		EPCRA/ PSM/RMP	
5714-22-7	Sulfur Pentafluoride		4	3	2	x	x	PSM	
7783-60-0	Sulfur Tetrafluoride		3	0	2	x		EPCRA/ PSM/RMP	Sulfur fluoride (SF4), (T-4)-
7446-11-9	Sulfur Trioxide		3	0	3	x		PSM/RMP	
7664-93-9	Sulfuric Acid		3	0	2	x		-	
7783-80-4	Tellurium Hexafluoride		2	0	1	x		PSM	
75-91-2	Tert-Butyl Hydroperoxide		1	4	4		x	PSM	
75-64-9	Tert-Butylamine		2	4	0		x	PSM	
116-14-3	Tetrafluoroethylene		2	4	3	x	x	PSM/RMP	Ethene, tetrafluoro-

CAS Number	CASK Chemical Name	Site Inventory (pounds)	NFPA 704 Classification[1]			Toxic Substance[2]	Flammable Substance[2]	US Ref. List Type[3]	Synonyms
			N_H	N_F	N_R				
10036-47-2	Tetrafluorohydrazine		2	1	3	x		PSM	
287-23-0	Tetramethylene		1	4	1		x	-	
75-74-1	Tetramethyl Lead		3	3	3	x	x	PSM/RMP	Plumbane, tetramethyl-
75-76-3	Tetramethylsilane		3	4	1		x	RMP	Silane, tetramethyl-
509-14-8	Tetranitromethane		3	1	2	x		RMP	Methane, tetranitro-
7719-09-7	Thionyl Chloride		4	0	2	x		PSM	
7550-45-0	Titanium Tetrachloride		3	0	2	x		RMP	Titanium chloride (TiCl4) (T-4)-
108-88-3	Toluene		2	3	0		x	-	
26471-62-5	Toluene Diisocyanate (Unspecified Isomer)		3	1	3	x		RMP	Benzene, 1,3-diisocyanatomethyl- ,Toluenediisocyanate (mixed isomers)
584-84-9	Toluene-2,4-Diisocyanate		3	1	3	x		RMP	Benzene, 2,4-diisocyanato-1-methyl-
91-08-7	Toluene-2,6-Diisocyanate		3	1	3	x		RMP	Benzene, 1,3-diisocyanato-2-methyl-
1558-25-4	Trichloro (Chloromethyl) Silane		3	4	2	x	x	PSM	
27137-85-5	Trichloro (Dichlorophenyl) Silane		3	4	2	x	x	PSM	
10025-78-2	Trichlorosilane		3	4	2	x	x	PSM/RMP	Silane, trichloro-
97093-8	Triethylaluminum		-	3	3		x	PSM	
121-44-8	Triethylamine		3	3	0	x	x	-	
75-50-3	Trimethylamine		3	4	0	x	x	-	
79-38-9	Trifluorochloroethylene		-	4	0	x	x	PSM/RMP	Ethene, chlorotrifluoro-
100-99-2	Triisobutylaluminum		3	4	3	x	x	PSM	TiBA
75-50-3	Trimethylamine		3	4	0		x	RMP	Methanamine, N,N-dimethyl-
75-77-4	Trimethylchlorosilane		3	3	2	x	x	RMP	Silane, chlorotrimethyl-
2487-90-3	Trimethyoxysilane		4	3	2	x	x	PSM	1,3,5-Trinitrobenzene
99-35-4	Trinitrobenzene		2	4	4		x	-	

CAS Number	CASK Chemical Name	Site Inventory (pounds)	NFPA 704 Classification[1]			Toxic Substance[2]	Flammable Substance[2]	US Ref. List Type[3]	Synonyms
			N_H	N_F	N_R				
108-05-4	Vinyl Acetate		2	3	2	x	x	RMP	Acetic acid ethenyl ester, vinyl acetate monomer
689-97-4	Vinyl Acetylene		2	4	3		x	RMP	1-Butene-3-yne
75-01-4	Vinyl Chloride		2	4	2		x	RMP	Ethene, chloro-
109-93-3	Vinyl Ether		2	4	2		x	PSM	
109-92-2	Vinyl Ethyl Ether		2	4	2		x	RMP	Ethene, ethoxy-
75-02-5	Vinyl Fluoride		1	4	2		x	RMP	Ethene, fluoro-
926-65-8	Vinyl Isopropyl Ether		2	4	2		x	PSM	
107-25-5	Vinyl Methyl Ether		2	4	2		x	RMP	Ethene, methoxy-
75-35-4	Vinylidene Chloride		4	4	2	x	x	RMP	1,1-Dichloroethylene
75-38-7	Vinylidene Fluoride		1	4	2		x	RMP	Ethene, 1,1-difluoro-
1330-20-7	Xylenes, mixed		2	3	0		x	-	(o-, m-, p-, isomers)

1 NFPA 704 Hazard Rating Definitions can be found in Attachment M.

2 Flammable and Toxic designations are representative of categorization in US RMP, 40 CFR 68, and PSM, 29 CFR 1910.119, regulatory listed chemicals. Chemicals with an NFPA Flammability Hazard Rating of 3 or 4 are also marked as flammable substances.

3 US Ref List Type designates the US regulatory origin of the chemical listed.

Note: This list was developed from several hazardous chemical lists. It is intended for reference only and is not considered exhaustive.

Attachment D: Building List / Facility Siting Summary (Example)

Step 3			Step 4						Step 6		Step 7				Step 10			Step 11
BLDG NO	DESCRIPTION	ROLE	CONSTRUCTION FEATURES	TYPE	OCCUPANCY				FLAMMABLE IMPACT (Yes/No)	TOXIC IMPACT (Yes/No)	MODEL SCENARIO NUMBER	MODEL	SOURCE	SCENARIO	RISK MATRIX			RISK MANAGEMENT OPPORTUNITIES / RECOMMENDATIONS
					ESSENTIAL PERSONNEL		OTHER PERSONNEL											
					TYPICAL (HRS/WK)	PEAK (HRS/WK)	TYPICAL (HRS/WK)	PEAK (HRS/WK)							S	L	R	
1	Contractors workshops	Occupied Workshop	Steel frame/metal siding pre-engineered Combination brick/cinderblock/sheet metal/transite (currently scheduled to be removed) panels and roofs. 2 regular glass windows on N side by railroad tracks.	B2	6,500	6,500	6,500			YES	6.3	PHAST	TK 2 - Oleum 65 wt.%, Sulfur Trioxide	10-minute release of Oleum through a quarter of a 1/8 inch gasket on a 2-inch discharge flange or fitting downstream o of the transfer pump. (Pressure 3.5 kg/cm^2)	4	C	EHS-3	

Attachment E: Process Plant Building Checklist

Process Plant Building Checklist (PPBC)					
Building: Date: Name:					
E,F,T	Question	Yes	No	NA	Comment
FT	1. Is the building located up wind of the hazard? Consider prevailing wind.				
EFT	2. Is the building included in an emergency response plan for fire and toxic release? Are the occupants trained on emergency response procedures? Are evacuation instructions posted?				
E	3. Are large office equipment or stacks of materials in the building secured?				
E	4. Are the lighting fixtures, ceilings, or wall-mounted equipment well supported? Are process controls mounted on interior walls?				
E	5. Is there heavy material stored on the ground floor only?				
E	6. Have all the exterior windows been assessed for potential injury to occupants?				
EFT	7. Are the doors on the sides of the building opposite from an explosion or fire source?				
FT	8. Is there exterior and interior fire suppression equipment available to the building?				
FT	9. Is there a detection system within the building or in the fresh air intake to detect hydrocarbons, smoke, or toxic materials?				
FT	10. Is the air-intake properly located? Consideration should be given to materials that are heavier than or lighter than air.				
FT	11.Can the ventilation system prevent air ingress or air movement within the building? Are there hydrocarbon or toxic detectors that shutdown the air intake? Does the building have a pressurization system?				
FT	12. Are there windsocks visible from all sides of the building?				
EFT	13. Is there a building or Facility alarm or communication system to warn building occupants (of an emergency)? Can the alarms be heard inside the building?				
T	14. Is there sufficient bottled air or fresh supplied air for the occupancy load?				
EFT	15. Are all sewers connected to the building properly sealed to prevent vapour ingress?				
Hazard Considerations: E=Explosion, F=Fire and T=Toxic.					
Form: EHSF-407-02					

Attachment F: Emergency Response Toxic Gas Shelter Checklist

Emergency Response Toxic Gas Shelter Checklist (ERTGSC)					
Building: Date: Name:					
No.	Question	Yes	No	NA	Comment
Essential features of a building used as a toxic gas shelter					
1	Doors and windows must close properly with adequate seal.				
2	Supplied air maintained and available for operators required to remain in the control room to bring the process to a safe state.				
3	Escape Air-packs available for safe evacuation.				
4	Any designated toxic gas shelter must have a means whereby occupants can call for assistance to the emergency management center.				
Non-essential but desirable features of a building used as a toxic gas shelter					
5	Doors must be fitted with an automatic closure and with non-shrink seals on all four edges.				
6	Frames of doors and windows must be of non-shrink type under normal use and have non-hardening mastic sealant applied to all four edges.				
7	Doors and windows must resist any overpressure that might accompany or precede the release of toxic gas from a pressurized source if the toxic risk resulting from a catastrophic failure is judged to be unacceptable.				
8	Penetrations for cables and ducts must be sealed.				
9	Service (e.g., water, gas, electricity) trenches, cellars or ventilated voids/cable ducts must be sealed.				

Emergency Response Toxic Gas Shelter Checklist (ERTGSC) (Continued)					
Building: Date: Name:					
No.	Question	Yes	No	NA	Comment
Non-essential but desirable features of a building used as a toxic gas shelter					
10	All mortar joints must be tight, especially around the windows and building entry points (i.e., conduit, wiring, plumbing, etc.)				
11	Joints between or associated with profiled cladding/inner wall and ceiling must be sealed with non-hardening mastic compound or stitch fixings.				
12	Toxic gas shelters must be clearly identified and all visitors (not accompanied by a host) and normal occupants of the site must be informed of their location.				
13	Doors should be of the "vestibule" design with an air lock, preferably designed for egress by people wearing breathing apparatus (BA).				
14	The number and size of windows should be minimised when close to the source of hazard. They should preferably be non-opening type.				
15	Gas leakage routes at the wall/roof joint should be eliminated. If there are any eaves, they should be fully closed.				
16	Service (e.g., water, gas, electricity) trenches, cellars or ventilated voids/cable ducts should be avoided, where practicable. The number of penetrations for cables and ducts should be minimized.				
17	Openings between toxic shelter and the roof space should be minimized.				
Form: EHSF-407-01					

Consideration should be given to how long the toxic gas shelter will be occupied, the infiltration rate of toxic vapours into the shelter, and whether escape masks are required (or if they can be provided by emergency services) or emergency rations, resuscitation equipment. An important factor to consider is there should be sufficient capacity to cope with all occupants during a toxic emergency.

The approximate physiological characteristics of humans, which require consideration for assessing the minimum volume of space per person, are respiration (exchange of carbon dioxide for oxygen), generation of heat and generation of moisture (affecting humidity). The conditions which govern the required volume are oxygen and carbon dioxide concentrations, temperature and humidity. Indicative minimum volumes necessary to meet these criteria are for example, a minimum of 7.5 liters/minute-person for oxygen limitation and 60.8 liters/minute-person for humidity limitation. Summary Table F-1 has been produced based on these:

Table F-1
Summary Table

Duration of stay in toxic gas shelter (minutes)	Volume of space to provide per person (m^3)	Volume of space to provide per person (ft^3)
5	0.4	14
10	0.8	28
15	1.0	35
30	1.9	67
60	3.7	130

Attachment G: Consequence assessment parameters

The parameters listed in the following table provide recognized guidance for consistent modelling of the consequences of process related incidents.

Where local conditions or regulatory requirements require other parameters to be used then the basis for parameter selection shall be recorded in the Facility Siting report.

Parameter	Process related incident	Acceptable value UK	Acceptable value US	Comment
Weather	Flammable and toxic gas dispersion	2 m/sec F stability 5 m/sec D stability Preferred: Summer meteorological conditions for the site.	1.5 m/sec F stability (worst case toxic or flammable). For flammables, if site specific meteorological conditions indicate wind speed of less than 1.5 m/sec more than 10% of the time, modelling should be performed at 1.0 m/sec, or the minimum validated limits of the model. Average summer wind speed and C/D stability (worst credible). If meteorological data is not available: 1.5 m/sec F stability (worst case) 3 m/sec D stability (worst credible)	D5 is generally the most frequent weather condition and should be used to calculate hazard ranges for day-time releases. Dispersion is reduced under stable atmospheric conditions, hence F2 weather, which characterizes night-time conditions, generally produces the greatest hazard range. B2 is generally used for non-temperate zones.
	Pool and jet fires	As above plus a case with a wind speed of 10 m/sec towards the target.		Additional wind speed case to allow for the distortion of flames.
Averaging period	Flammable and toxic gas dispersion	600 seconds toxic continuous release (plume) 10 seconds (burst or rupture) Flammable exposures are short averaging times. (Insert typical)	Toxic release: averaging time should generally be equal to or shorter than either the release duration or cloud duration 600 seconds (plume) 10 seconds (burst) Flammable release: averaging time should be very short.	The averaging period allows for the variability of atmospheric conditions causing the dispersing cloud to meander.
Humidity	Pool fire, jet fire and fireball	Minimum daily average percentage.	Average daily summer percentage (afternoon).	The higher the humidity the greater the attenuation of thermal radiation, e.g. in Europe may use 60% and US typically 70%.

Parameter	Process related incident	Acceptable value UK	Acceptable value US	Comment
Air temperatur e	Flammable and toxic gas dispersion Pool evaporation	Day-time average (maximum)	Non-cryogenic release: Day-time summer average Cryogenic release: Day-time winter average (worst credible)	For F2 weather modelling the night-time average (minimum) temperature should be used.
Solar flux	Pool evaporation	Average (summer) solar flux	Day time: 0.5 kW/m2 Night time or indoor: 0 kW/m2	The higher the solar flux the greater the evaporation rate from pools, e.g., in Europe may use 0.5 kW/m2.
Release duration	Flammable and toxic gas dispersion		Reference: API RP 581	
Hole size for gasket leak	Flammable and toxic gas dispersion		Reference: Supplementary Guidance for IEC 60079-10 and IEC 61241-10 Withdrawn, and API RP 581.	
Hole size for pipe rupture	Flammable and toxic gas dispersion		For smaller than 2-inch diameter: Full bore rupture For 2- to 4-inch diameter: Rupture equal to that of 2-inch diameter pipe For greater than 4-inch diameter: Rupture area equal to 20 % of pipe cross section area	
Extent of flammable cloud	Flash fire	50% of LFL	100% of LFL	The extent of a dispersing flammable cloud is taken as the distance to 50% of the Lower Flammable Limit (LFL) in EU to allow for pockets of flammable gas due to imperfect dispersion. 25% of the LFL is the endpoint of concern for Area Classification.
Stored energy in a flammable cloud	Vapour cloud explosion	TNO Blast Strength 7	Minimum threshold weight of vapour in the cloud Ref 5.15: For outdoor confined areas: 1 ton or greater for Class I or II	Per the latest edition of API 752, the TNT equivalency method shall not be used to assess outdoor VCE blast loads for building siting evaluations.

Parameter	Process related incident	Acceptable value UK	Acceptable value US	Comment
(hydrocarb on)			1000 lbs or greater for Class III For outdoor unconfined areas: 5 tons or greater for Class I, II or III For indoor confined areas where there is sufficient inventory of flammables released which can exceed the LFL, taking area volume and ventilation into account: 0.0 lbs	Unless detailed assessments show otherwise a TNO Multi-Energy Blast Strength 7 for a structure represents the worst case overpressure model. Class as referenced is per Table 1 of FM 7-42. Class I materials, such as propane and flammable liquids, present normal risks. Class II materials such as ethylene are more reactive and present greater risks than Class I materials. Class III materials such as acetylene are highly reactive and may be unstable. Class III materials present the greatest energy potential per unit weight of the three classes VCE is likely to occur when the flammable mass (the mass from source to LFL) in the vapor cloud is larger than or equal to the minimum threshold value, and on the level of confinement/congestion and material reactivity.
Stored energy in a process vessel	Vessel rupture explosion	Burst pressure a multiple of 4 of the vessel design pressure	In the event of an external fire, the maximum allowable working pressure (MAWP) or 1.21 times of opening pressure of safety valve should be used as the vessel burst pressure. In the event of runaway or decomposition reaction, the rupture pressure is MAWP multiplied by a safety factor. For most pressure vessels designed per ASME code, the safety factor is usually 4.	Supported by IRI.
Variation in pool depth and radius	Evaporating pool	1 – 10cm depth as dictated by containment area and release volume.	Undiked – 0.1 cm in depth Wet Soil 0.01 m Dry Soil 0.02 m	US 1 cm depth with no bund.

Parameter	Process related incident	Acceptable value UK	Acceptable value US	Comment
		Maximum of 50 meters unless plant detail justifies a lesser radius	Concrete 0.005 m Insulating concrete 0.005 m	
Endpoints of Concern	Toxic	Dangerous Toxic Load (DTL)	Emergency Response Planning Guideline (ERPG): See Attachment A Glossary for definition of ERPG-1, ERPG-2 and ERPG-3 Immediately Dangerous to Life or Health (IDLH)	
	Flammable Radiant Heat	4.9 (0.048), 8.2 (0.080), 12.8 (0.126), 14.7 (0.144), 25.6 (0.251) kW/m2 (kPa)	5.0, 12.5, 25, 37.5 kW/m2	
	Overpressure	0.580, 1.450, 2.900, 7.251 psi	0.5, 1, 2, 3, 5 psi	

Attachment H: Examples of Worst Credible Hazard Event Scenarios

Typical Hazard Scenarios[1, 2]

Process/Unit or Chemical Inventory	Scenario
Storage Tanks	
Overfilling	▪ Change in material being stored (lower specific gravity) when level indication is based on weight ▪ Failure of level indication ▪ Transfers by gravity from one tank to another
Overpressure	▪ Due to overfilling ▪ Use of compressed gas to clear vent line ▪ Use of compressed gas to pressure test a low-pressure vessel
Sucking In	▪ Plugging of flame arrestors on vent lines ▪ Closing off vents, i.e. covering a vent to minimize emissions, covering during cleaning and not removing before start-up, steam cleaning a tank during a rain storm ▪ Adding cold liquid to a tank containing hot liquid ▪ Corrosion of a pressure/vacuum valve ▪ Blockage of vent by polymerization of a vapor
Explosions	▪ Static electricity caused by the flow of flammable liquids, igniting vapor-air mixture in a head space ▪ Welding on and around tanks with flammable contents ▪ Fire in a bund containing a pressure vessel
Stacks	
Explosions	▪ Failure to purge with inert gas ▪ Blocked stacks
Leaks	▪ Small valves knocked open or vibrated open ▪ Drain valves left open ▪ Open-topped containers for collecting drips ▪ Failure of level glasses and sight glasses ▪ Screwed plugs blown out of equipment ▪ Hoses – wrong material, damaged, poor connections, disconnecting a hose before relieving pressure
Liquefied Flammable Gases (LPG)	
Major Leak	▪ Draining water from bottom of tank and valve handle breaks ▪ Drain valve opened to relieve pressure in tank and the flow of LPG froze valve open ▪ Leak from a gland on a high pressure reciprocating pump ▪ Rupture of a LPG pipeline ▪ Rapid propagation of a crack due to materials of construction and corrosion
Minor Leaks	▪ Drain valves – leaking, wrong materials of construction, screwed connections ▪ Flanged joints ▪ Pump seals ▪ Level glasses ▪ Sample Points ▪ Small branch lines inadequately supported
Pipe and Vessel Failures	
Pipe	▪ Corrosion and freezing in dead-ends ▪ Poor support – failure due to vibration, support to rigid with no allowance for expansion ▪ Bellows – poor installation or departure from design conditions

Process/Unit or Chemical Inventory	Scenario
	▪ Water hammer – flow of liquid is suddenly stopped, slugs of liquid in a gas line are set in motion ▪ Reuse of old pipe ▪ Incorrect grade of steel used ▪ Corrosion – internal or external ▪ Flange leaks
Pressure Vessel Failures	▪ Leak through a weep hole in multi-wall vessel ▪ Cycle fatigue – due to repeated temperature and pressure cycles ▪ Failure during pressure testing ▪ Vacuum caused by low boiling point liquids at low ambient temperatures
Equipment	
Centrifuges	▪ Ineffective nitrogen blanketing when handling flammable solvents ▪ Damage to basket if turning the wrong way
Pumps	▪ Gland failure ▪ Bearing failure ▪ Dead-heading ▪ Pump started remotely with both suction and discharge valves closed
Relief Valves	▪ Relief valve isolated ▪ Wrongly installed ▪ Relief valve removed during replacement ▪ Inadequately supported tail pipe ▪ Relief valve faults – identification numbers stamped on springs, thus weakening them, sides of springs ground down to make them fit, corroded springs, small spring put inside a corroded spring, use of washers to maintain spring strength, welding of springs to end caps, bending of the spindle to gag the valve, too many coils allowing little lift at set pressure
Tank Trucks and Cars	
Overfilling	▪ Wrong meter setting with automatic filling systems ▪ Operator leaves area during filling ▪ Multi-compartment tank truck/operator unaware ▪ Poor operator communication between shift change ▪ Incorrect setting of valve positions
Burst Hoses	▪ Tanker driving away before the hose is disconnected
Fires and Explosions	▪ Switch filling – a tank contains a flammable vapor from a previous load and is then filled with a safer higher boiling liquid and no special static electricity precautions are made ▪ Splash-filling of flammable liquids
Liquefied Flammable Gases	▪ Failure to connect vapor return line ▪ Connecting vapor return line to a filling line
Compressed Air	▪ Failure to release pressure after unloading
Tipping Up	▪ Emptying rear compartments first in multi-compartment tanker and trailer disconnected
Wrong Material	▪ Operator not reading shipping papers ▪ Shape and color of transport containers misidentified ▪ Adapters used to connect different hose fittings
Reverse Flow	▪ Reverse flow from: a product receiver or blowdown line back into the plant; into service mains; through pumps; from reactors; from drains
Exothermic Chemical Reactions	▪ Mild Exotherms – hydrogenation, hydrolysis, Isomerization, sulfonation, neutralization ▪ Moderate Exotherms – alkylation, esterification, addition reactions, oxidation, polymerization, condensation

Process/Unit or Chemical Inventory	Scenario
	▪ Critical-To-Control Exotherms – halogenation ▪ Particularly Sensitive Exotherms – Nitration
Endothermic Processes	▪ Calcination ▪ Electrolysis ▪ Pyrolysis or Cracking
Enclosed or Indoor Process Units	▪ Dust filters or collectors are located inside ▪ Flammable liquids handled at temperatures above their boiling point
Access for Emergency Equipment	▪ Access to area is restricted by physical obstructions ▪ Temporary closure of roadways during repair or construction
Drainage and Spill Control	▪ Diking exposed equipment within the dike ▪ Flat areas around the process unit which will allow spills to spread out ▪ Basin or trench that exposes utility lines
Toxic Materials	▪ Materials that on intense or short exposure could cause temporary incapacitation or possible residual injury, including those requiring the use of respiratory protective equipment ▪ Materials that on short exposure could cause serious temporary injury, including those requiring protection from all bodily contact ▪ Materials that on very short exposure could cause death or major residual injury
Sub-Atmospheric Pressure	▪ Process condition where air leakage in a system could create a hazard, such as air contact with moisture-sensitive or oxygen-sensitive materials or from the formation of flammable mixtures
Operation In or Near Flammable Range	▪ Tank storage of flammable liquids where air can be breathed into the tank during pump-out or sudden cooling of the tank ▪ Storage of combustible liquids at temperatures above their closed cup flash points without inerting ▪ Process equipment or process storage tanks that could be in or near the flammable range in the event of instrument or equipment failure
Dust Explosion	▪ The finer the dust, the greater the hazard
Relief Pressure	▪ Where operating pressures are above atmospheric, the higher the release rate and therefore the higher the hazard ▪ Relief pressure close to operating pressure
Low Temperature	▪ Carbon steel or **other** metals exposed to temperatures at or below their ductile/brittle transition temperatures
Quantity of Flammable/Unstable Materials	▪ Hazard increases as the quantities of flammable and unstable materials in the process unit are increased ▪ The scenario should be based on the quantity of material with the largest holdup in the process unit or connected unit
Corrosion and Erosion	▪ Consider external and internal corrosion rates ▪ Effects of minor impurities in the process steam that might cause greater than normal internal corrosion ▪ Chemical breakdown of paint ▪ Porosity of bricks and imperfections in plastic linings ▪ Risk of stress corrosion cracking
Leakage – Joints and Packing	▪ Pump and Gland Seals ▪ Pumps, compressors and flange joints ▪ Thermal and pressure cycling ▪ Materials that are penetrating in nature or an abrasive slurry ▪ Sight glasses, bellows, expansions joints
Use of Fired Equipment	▪ The presence of fired equipment in a process area adds an additional probability of ignition when flammable liquids, vapors or combustible dusts are released

Process/Unit or Chemical Inventory	Scenario
Hot Oil Heat Exchange System	▪ Most hot oil (heat exchange) fluids will burn and are frequently used above their flash points or boiling points, and represent an additional hazard in any process unit that uses them
Rotating Equipment	▪ Compressors in excess of 600 hp ▪ Pumps in excess of 75 hp ▪ Agitators (mixers) and circulating pumps in which failure could create a process exotherm due to lack of cooling from interrupted mixing of circulation of coolant or due to interrupted and resumed mixing ▪ Centrifuges

1 What Went Wrong? Case Histories of Process Plant Disasters, Trevor A. Kletz, Second Addition 1988

2 Dow Fire and Explosion Index 7th edition, Published by the American Institute of Chemical Engineers

Attachment I: Example Facility Siting Worksheet

Scenario Number	Hazards	Consequences	Risk Matrix			Safeguards	Risk Management Opportunities	Impacted Occupied Buildings and Emergency Response Areas	Comments
			S	L	RR				
PHA-1	Leak of flammable vapour from reactor overheads transfer line due to small bore branch failure.	Flammable vapour cloud collects in the reactor structure leading to a vapour cloud explosion. 1psi 50 meters 0.5 psi 85erbased on Blast Strength 7. Likely to cause severe damage to the Maintenance Cabin. Jet fire from release point. 5 kW/m^2 at 20 meters.	4	G	EHS-2	Flammable gas detection local to the reactor bay. Control Room building has no windows facing the reactor structure. Control Room rated for 4 psi overpressure.	Relocate the Maintenance Cabin remote from the plant area.	Control Room (Building type B5). Temporary Maintenance Cabin. (Building type B1).	

Attachment J: Published Reference Tables for Consequence Assessment

Table J-1
Peak Side-On Overpressure versus Consequences for Building Type [1, 2]

Building Type	Peak Side-on Overpressure Psi (bar)	Consequences	Vulnerability of Occupants (Probability of Serious Injury/Fatality)
Wooden frame trailer or shack **B1**	1 (0.069)	Isolated buildings overturn. Roof and wall collapse	0.1
	2 (0.14)	Complete collapse	0.4
	5 (0.34)	Building completely destroyed	1.0 [3]
Steel frame / metal siding pre-engineered buildings **B2**	1.25 (0.09)	Metal siding anchorage failure.	0.1
	1.5 (0.10)	Sheeting ripped off and internal walls damaged. Danger from falling objects	0.2
	2.5 (0.17)	Building frame stands, but cladding and internal walls are destroyed as frame distorts	0.4
	5 (0.34)	Building completely destroyed	1.0 [3]
Un-reinforced masonry bearing wall building **B3**	1 (0.069)	Partial collapse of walls that have no breakable windows	0.1
	1.25 (0.085)	Walls and roof partially collapse	0.2
	1.5 (0.10)	Complete collapse	0.6
	3 (0.21)	Building completely destroyed	1.0 [3]
Steel or concrete frame / unreinforced concrete or masonry infill or cladding **B4**	1 (0.069)	Failure of incident face	0.1
	1.5 (0.10)	Walls blown in	0.2
	2 (0.14)	Roof slab collapses	0.4
	2.5 (0.17)	Complete frame collapse	0.6
	5 (0.34)	Building completely destroyed	1.0 [3]
Reinforced concrete or masonry shear wall building **B5**	4 (0.28)	Roof and wall deflect under loading. Internal walls damaged	0.1
	6 (0.41)	Building has major damage and collapses	0.4
	12 (0.83)	Building completely destroyed	1.0 [3]

1 Management of Hazards Associated with Location of Process Plant Buildings, API Recommended Practice 752, November 2003, Appendix C

2 Guidelines for Evaluating Process Plant Buildings for External Explosions and Fires", CCPS. Conservative guide for risk-screening purposes only. These data include conservative assumptions about the duration of the blast. If risk screening indicates that further analysis is required, the building construction should be examined in detail to estimate its resultant damage.

3 Extrapolated from Figure 4.6, "Guidelines for Evaluating Process Plant Buildings for External Explosions and Fires", CCPS. Based on insufficient data, use with caution, per referenced source.

Table J-2
Side-On Overpressure Versus Consequences for Building Components

Building Component	Overpressure psig (bar)	Component Response or Consequence
Glass	0.2 (0.014)	Breaking of un-strengthened panes
Glass	0.5 to 1 (0.03 to 0.07)	Shattering with body penetrating velocities
Wooden frame	1 to 2 (0.07 to 0.14)	Structural failure
Steel cladding	1 to 2 (0.07 to 0.14)	Internal damage to walls, ceilings and furnishings
Concrete cladding	1 to 2 (0.07 to 0.14)	Shattering
Brick cladding	2 to 3 (0.14 to 0.21)	Blown-in
Unreinforced masonry	1 to 3 (0.07 to 0.21)	Wall collapse, possible shattering

Table J-3
Side-On Overpressure Consequence for Representative Buildings [1]

Consequence Category (Damage Level)	Description	Side-on Overpressure Threshold for Ordinary Building psi (bar)
1. Minor	Significant cosmetic damage to structure. Building repair is possible. Possible minor personnel injury due to glass breakage, scabbing, etc.	> 0.5 (> 0.03)
2. Moderate	Possible deformation of structural members, short of failure. Building may be reusable with repair. Possibly some debris. Personnel injury from debris is likely.	> 1 (> 0.07)
3. Major	Possible failure of isolated structural members. Partial building collapse. Building cannot be reused and must be replaced. Possible serious injury or fatality of some building occupants.	> 2 (> 0.14)
4. Catastrophic	Complete collapse of structure. Probable serious injury or fatality of many occupants.	> 3 (> 0.21)

1 "Guidelines for Evaluating Process Plant Buildings for External Explosions and Fires", CCPS. The overpressure-consequence relationship is given for typical buildings of ordinary construction (i.e., not blast-resistant design)

Table J-4
Radiant Levels Versus Observed Consequences

Radiant Heat Level (kW/m^2)	Observed Consequence
1.6	Will cause no discomfort for long exposure
4	Sufficient to cause pain to personnel if unable to reach cover within 20 seconds
9.5	Pain threshold reached after 8 seconds; second degree burns after 20 seconds
12.5	Minimum required for piloted ignition of wood, melting of plastic tubing
25	Minimum required to ignite wood at indefinitely long exposures (non-piloted)
37.5	Sufficient to cause damage to process equipment

Table J-5 Toxic Concentrations Versus Potential Off-Site Consequences	
Toxic Concentration (ERPG)	**Potential Off-Site Consequence**
ERPG-1	Severity Category 2 injury / illness
ERPG-2	Severity Category 3 injury / illness
ERPG-3	Severity Category 4 or 5 injury / illness

Attachment K: Blast Resistant Modular Buildings

K.1 Policy

K.1.1 Blast resistant modular buildings are allowed to be used in Indorama Ventures facilities under limited conditions described in this document. These buildings when properly used can provide protection to the occupants from potential external overpressure caused by an explosion.

K.2 General Guidance

K.2.1 Blast Resistant Modular Buildings (BRMs) are typically used in the following applications:

K.2.1.1 Permanent

a. Operator Shelters
b. Analyzer Buildings
c. MCC Buildings
d. Instrument/Computer Terminal Buildings

K.2.1.2 Temporary

a. Turnaround Management
b. Construction Project Management
c. Tool Trailers
d. Building Renovation

K.2.2 Facilities are required to perform Facility Siting Assessments which evaluate potential explosion impacts from accidental chemical releases. These assessments should produce overpressure contour maps for the site to use when locating buildings. These over pressure contour maps should be used when locating permanent or temporary modular buildings.

K.2.3 Building occupancy levels should be minimized in hazard impact zones. Locating people outside of impact zones is inherently safer than locating them within impact zones, even if a building is expected to protect occupants from the potential impacts.

K.2.4 If an occupied building is located within the fire zone of impact, the building's emergency plan should detail how its occupants will safely evacuate in the event of a fire.

K.2.5 Occupants of blast resistant portable buildings may be subject to injury in the event of a blast overpressure because the building if properly located will be designed to move. This puts the occupants at risk of injury from falling and or being struck by loose objects in the building. This injury potential should be minimized by securing objects such as desks, bookshelves and other furnishings.

K.3 Permanent Applications of Blast Resistant Modular Buildings

K.3.1 Permanently installed blast resistant modular buildings must be designed to withstand the expected blast overpressures which could occur from an accidental explosion. The site Facility Siting Assessment overpressure contour maps and/or other detailed modelling should be used to determine the potential overpressure at the building location.

K.3.2 Non-essential personnel should not be permanently located in blast resistant portable buildings. They should be relocated to permanent or temporary buildings outside of the blast impact zones. Therefore, occupied BRMs may only be installed as operator shelters (such as loading areas, etc.).

K.3.3 Permanently located blast resistant modular buildings must be installed according to manufacturer's recommendations and periodically inspected to assure that those recommendations are being maintained.

K.3.4 Ceiling fixtures in occupied blast resistant modular buildings subject to external overpressure should be anchored to structural members to protect occupants from the hazard of falling ceiling fixtures.

K.3.5 Furniture and other equipment in occupied blast resistant modular buildings should be anchored to structural members to the extent that is practical in order to protect occupants from the hazard of loose objects moving in case of an actual blast.

K.3.6 Blast Resistant Modular Buildings should be:

K.3.6.1 located outside of fire impact zones, and

K.3.6.2 designed to withstand expected explosion (overpressure) where fire or explosion hazards (respectively) exist in the process.

K.3.7 If an occupied BRM is located within the fire zone of impact, the building's emergency plan shall detail how its occupants will safely evacuate in the event of a fire.

K.3.8 Temporary trailers or modular buildings are only suitable for use as control buildings when located outside the flammable and blast impact zones.

K.4 Temporary Applications of Blast Resistant Modular Buildings

K.4.1 Portable trailers or modular buildings that are standard construction should not be used as permanent occupied buildings when any significant over-pressure (>7 kPa or 1.0 psi) potential exists:

K.4.1.1 Temporary installations must follow the temporary MOC process and may not remain for greater than 180 days at a single geographic location.

K.4.1.2 Any such buildings in locations subject to overpressure scenarios must be abandoned while the plant is:

a. Starting up;
b. Shutting down; or
c. Experiencing a significant operational upset.

K.4.1.3 If hazards at more than one plant could impact the portable building, this occupancy constraint applies to all plants with such hazards.

K.4.2 If a blast resistant portable building is used, it must be rated for greater than the potential overpressure of the area it is located in.. No portable buildings should be located within a ≥5 PSI overpressure area.

K.4.3 Occupants of blast resistant portable buildings may be subject to injury in the event of a blast overpressure because the building if properly located will be designed to move. This puts the occupants at risk of injury from falling and or being struck by loose objects in the building. This injury potential should be minimized by securing objects such as desks, bookshelves and other furnishings.

Attachment L: Examples of Safeguards for Flammable and Toxic Hazard Event Scenarios

Risk Reduction	Safeguard Examples
At source risk reduction	▪ Relocation of non-essential building occupants ▪ Relocation of the building including essential personnel ▪ Reduction in the inventories of hazardous materials ▪ Process risk reduction, e.g., additional instrumented systems, improved integrity of instrumented systems ▪ Reduction of process inventory
Blast protection (windows and doors)	▪ Application of plastic sheeting to windows ▪ Replacement of existing windows with toughened glass or polycarbonate sheeting ▪ Replacement of existing window frames ▪ Improved securing of window frames ▪ Removal of windows ▪ Strengthened metal doors, opening outwards only
Blast protection (structures)	▪ Removal of heavy ventilation units from building roofs ▪ Additional supports of building roofs ▪ Brick-in stilted sections of buildings ▪ Provision of blast walls ▪ Review the orientation of the building in relation to the source of the explosion hazard ▪ Remove temporary structures
Thermal radiation protection	▪ Removal of vulnerable windows ▪ Provision of alternative emergency exit routes ▪ Non-combustible materials of construction ▪ Screening of escape routes ▪ Enhanced fire detection, suppression or deluge systems ▪ Fire walls
Toxic gas	▪ Examples of building design features in relation to toxic gas are provided in Attachment D. ▪ Assembly and accountability planning ▪ Multiple Emergency Response Areas available dependent on wind direction

Attachment M: NFPA 704 Hazard Rating Definitions

M.1 Health Hazards

4 Materials that, under emergency conditions can be lethal. The following criteria shall be considered when rating materials:

- Gases whose LC_{50} for acute inhalation toxicity is less than or equal to 1,000 parts per million (ppm);
- Any liquid whose saturated vapor concentration at 68 °F (20 °C) is equal to or greater than ten times its LC_{50} for acute inhalation toxicity, if its LC_{50} is less than or equal to 1,000 parts per million (ppm);
- Dusts and mists whose LC_{50} for acute inhalation toxicity is less than or equal to 0.5 milligrams per liter (mg/L);
- Materials whose LD_{50} for acute dermal toxicity is less than or equal to 40 milligrams per kilogram(mg/kg);
- Materials whose LD50 for acute oral toxicity is less than or equal to 5 milligrams per kilogram (mg/kg).

3 Materials that, under emergency conditions can cause serious or permanent injury. The following criteria shall be considered when rating materials:

- Gases whose LC50 for acute inhalation toxicity is greater than 1,000 parts per million (ppm), but less than or equal to 3,000 parts per million (ppm);
- Any liquid whose saturated vapor concentration at 68 °F (20 °C) is equal to or greater than its LC50 for acute inhalation toxicity, if its LC50 is less than or equal to 3,000 parts per million (ppm) and that does not meet the criteria for degree of hazard 4;
- Dusts and mists whose LC50 for acute inhalation toxicity is greater than 0.5 milligrams per liter (mg/L), but less than or equal to 2 milligrams per liter (mg/L);
- Materials whose LD50 for acute dermal toxicity is greater 40 milligrams per kilogram(mg/kg), but less than or equal to 200 milligrams per kilogram (mg/kg);
- Materials that are corrosive to the respiratory tract;
- Materials that are corrosive to the eye or cause irreversible corneal opacity;
- Materials that are corrosive to skin;
- Cryogenic gases that cause frostbite and irreversible tissue damage.
- Compressed liquefied gases with boiling points at or below –55 °C (-66.5 °F) that cause frostbite and irreversible tissue damage.
- Materials whose LD50 for acute oral toxicity is greater than 5 milligrams per kilogram (mg/kg), but less than or equal to 50 milligrams per kilogram (mg/kg).

2 Materials that, under emergency conditions can cause temporary incapacitation or residual injury. The following criteria shall be considered when rating materials:

- Gases whose LC50 for acute inhalation toxicity is greater than 3,000 parts per million (ppm), but less than or equal to 5,000 parts per million (ppm);
- Any liquid whose saturated vapor concentration at 68 °F (20 °C) is equal to or greater than one-fifth (1/5) its LC50 for acute inhalation toxicity, if its LC50 is less than or equal to 5,000 parts per million (ppm) and that does not meet the criteria for degree of hazard 3 or degree of hazard 4;
- Dusts and mists whose LC50 for acute inhalation toxicity is greater than 2 milligrams per liter (mg/L), but less than or equal to 10 milligrams per liter (mg/L);
- Materials whose LD50 for acute dermal toxicity is greater than 200 milligrams per kilogram(mg/kg), but less than or equal to 1,000 milligrams per kilogram (mg/kg);

- Compressed liquefied gases with boiling points between –30 °C (-22 °F) and –55 °C (-66.5 °F) that can cause severe tissue damage depending on degree of exposure;
- Materials that are respiratory irritants:
- Materials that cause severe but reversible irritation to the eyes or are lacrimators;
- Materials that are primary skin irritants or sensitizers;
- Materials whose LD50 for acute oral toxicity is greater than 50 milligrams per kilogram (mg/kg), but less than 500 milligrams per kilogram (mg/kg).

1 Materials that, under emergency conditions can cause significant irritation. The following criteria shall be considered when rating materials:

- Gases and vapors whose LC50 for acute inhalation toxicity is greater than 5,000 parts per million (ppm), but less than or equal to 10,000 parts per million (ppm);
- Dusts and mists whose LC50 for acute inhalation toxicity is greater than 10 milligrams per liter (mg/L), but less than or equal to 200 milligrams per liter (mg/L);
- Materials whose LD50 for acute dermal toxicity is greater 1,000 milligrams per kilogram(mg/kg), but less than or equal to 2,000 milligrams per kilogram (mg/kg);
- Materials that cause slight to moderate irritation to the respiratory tract, eyes, and skin;
- Materials whose LD50 for acute oral toxicity is greater than 500 milligrams per kilogram (mg/kg), but less than 2,000 milligrams per kilogram (mg/kg).

0 Materials that, under emergency conditions would offer no hazard beyond that of ordinary combustible materials. The following criteria shall be considered when rating materials:

- Gases and vapors whose LC50 for acute inhalation toxicity is greater than 10,000 parts per million (ppm);
- Dusts and mists whose LC50 for acute inhalation toxicity is greater than 200 milligrams per liter (mg/L);
- Materials whose LD50 for acute dermal toxicity is greater than 2,000 milligrams per kilogram(mg/kg);
- Materials whose LD50 for acute oral toxicity is greater 2,000 milligrams per kilogram (mg/kg).
- Essentially nonirritating to the respiratory tract, eyes, and skin.

M.2 Flammability Hazards

4 Materials that will rapidly or completely vaporize at atmospheric pressure and normal ambient temperature or that are readily dispersed in air, and which will burn readily. This includes:

- Flammable gases;
- Flammable cryogenic materials;
- Any liquid or gaseous material that is liquid while under pressure and has a flash point below 73 °F (22.8 °C) and a boiling point below 100 °F (37.8 °C) (e.g., Class IA flammable liquids);
- Materials that ignite spontaneously when exposed to air;
- Solids containing greater than 0.5 percent by weight of a flammable or combustible solvent are rated by the closed cup flashpoint of the solvent.

3 Liquids and solids that can be ignited under almost all ambient temperature conditions. Materials in this degree produce hazardous atmospheres with air under almost all ambient temperatures or, though unaffected by ambient temperatures, are readily ignited under almost all conditions. This includes:

- Liquids having a flash point below 73 °F (22.8 °C) and having a boiling point at or above 100 °F (37.8 °C) and those liquids having a flash point at or above 73 °F (22.8 °C) and below 100 °F (37.8 °C) (e.g., Class IB and Class IC liquids);

- Materials that on account of their physical form or environmental conditions can form explosive mixtures with air and that are readily dispersed in air;
- Flammable or combustible dusts with representative diameter less than 420 microns (40 mesh);
- Materials that burn with extreme rapidity, usually by reason of self-contained oxygen (e.g., dry nitrocellulose and many organic peroxides);
- Solids containing greater than 0.5 percent by weight of a flammable or combustible solvent are rated by the closed cup flashpoint of the solvent.

2 Materials that must be moderately heated or exposed to relatively high ambient temperatures before ignition can occur. Materials in this degree would not under normal conditions form hazardous atmospheres with air, but under high ambient temperatures or under moderate heating might release vapor in sufficient quantities to produce hazardous atmospheres with air. This includes:

- Liquids having a flash point at or above 100 °F (37.8 °C) and below 200 °F (93.4 °C) (i.e., Class II and Class IIIA liquids);
- Solid materials in the form of powder or coarse dusts of representative diameter between 420 microns (40 mesh) and 2 mm (10 mesh) that burn rapidly but that generally do not form explosive atmospheres with air;
- Solid materials in a fibrous or shredded form that burn rapidly and create flash fire hazards, such as cotton, sisal and hemp;
- Solids and semisolids that readily give off flammable vapors;
- Solids containing greater than 0.5 percent by weight of a flammable or combustible solvent are rated by the closed cup flashpoint of the solvent.

1 Materials that must be preheated before ignition can occur. Materials in this degree require considerable preheating, under all ambient temperature conditions, before ignition and combustion can occur. This includes:

- Materials that will burn in air when exposed to a temperature of 1,500 °F (815.5 °C) for a period of 5 minutes or less;
- Liquids, solids and semisolids having a flash point at or above 200 °F (93.4 °C) (i.e., Class IIIB liquids);
- Liquids with a flash point greater than 95 °F (35 °C) that do not sustain combustion when tested using the Method of Testing for Sustained Combustibility, per 49 CFR Part 173 Appendix H, or the UN Recommendations on the Transport of Dangerous Goods, 8th Revised Edition.
- Liquids with a flash point greater than 95 °F (35 °C) in a water-miscible solution or dispersion with a water noncombustible liquid/solid content of more than 85 per cent by weight.
- Liquids that have no fire point when tested by ASTM D 92, Standard Test Method for Flash Point and Fire Point by Cleveland Open Cup up to the boiling point of the liquid or up to a temperature at which the sample being tested shows an obvious physical change;
- Combustible pellets with a representative diameter greater than 2 mm (10 mesh);
- Finely divided solids less than 420 um that are nonexplosible in air at ambient conditions, such as low volatile carbon black and polyvinylchloride (PVC)
- Most ordinary combustible materials;
- Solids containing greater than 0.5 percent by weight of a flammable or combustible solvent are rated by the closed cup flashpoint of the solvent.

0 Materials that will not burn. This includes any material that will not burn in air when exposed to a temperature of 1,500 °F (815.5 °C) for a period of 5 minutes.

M.3 Reactive Hazards

4 Materials that, in themselves, are readily capable of detonation or explosive decomposition or explosive reaction at normal temperatures and pressures. This includes:

- Materials that are sensitive to localized thermal or mechanical shock at normal temperatures and pressures.
- Materials that have an instantaneous power density (product of heat of reaction and reaction rate) at 482 °F (250 °C) of 1,000 W/mL or greater.

3 Materials that in themselves are capable of detonation or explosive decomposition or explosive reaction, but that require a strong initiating source or that must be heated under confinement before initiation. This includes:

- Materials that have an instantaneous power density (product of heat of reaction and reaction rate) at 482 °F (250 °C) at or above 100 W/mL and below 1,000 W/mL;
- Materials that are sensitive to thermal or mechanical shock at elevated temperatures and pressures.

2 Materials that readily undergo violent chemical change at elevated temperatures and pressures. This includes:

- Materials that have an instantaneous power density (product of heat of reaction and reaction rate) at 482 °F (250 °C) at or above 10 W/mL and below 100 W/ml.

1 Materials that in themselves are normally stable but that can become unstable at elevated temperatures and pressures. This includes:

- Materials that have an instantaneous power density (product of heat of reaction and reaction rate) at 482 °F (250 °C) at or above 0.01 W/mL and below 10 W/mL.

0 Materials that in themselves are normally stable, even under fire conditions. This includes:

- Materials that have an instantaneous power density (product of heat of reaction and reaction rate) at 482 °F (250 °C) below 0.01 W/mL;
- Materials that do not exhibit an exotherm at a temperature less than or equal to 932 °F (500 °C) when tested by differential scanning calorimetry.