OISD

Quantitative Risk Assessment/ HAZOP Study

By

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Coverage in this Presentation

- Fundamentals of QRA as differentiated from stand-alone Risk Analysis and HAZOP / HAZAN studies.
- Assessment of residual risk after factoring in quality of existing fire fighting system.
- ALARP principle of Risk Acceptance criteria.
- Effect of additional mitigation measures in existing locations to reach the acceptable ALARP zone

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RISK SERVICES

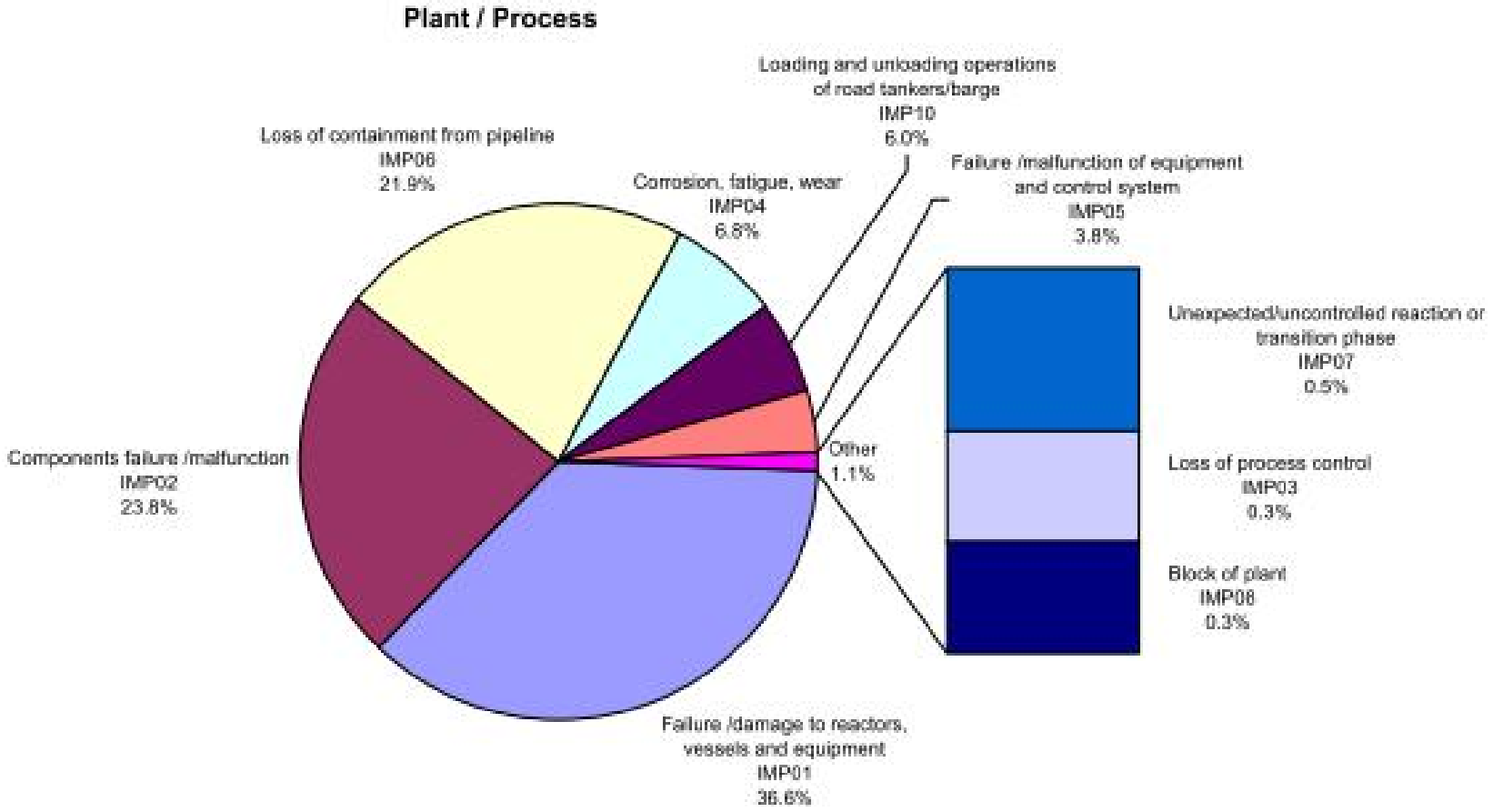
Definitions

- **Frequency** – Number of occurrences per unit time.
- **Hazard** – chemical or physical condition which has a potential to cause damage to people, property & Environment
- **Incident** – Loss of material or energy.
- **Event Sequence** – A specific unplanned sequence of events comprising of initiating events & intermediate events that may lead to an incident
- **Consequence –** Measure of expected effects of an incident outcome case.
- **Likelihood –** measure of expected frequency of occurrence

Definitions

- **Risk Assessment** – process by which results of risk analysis are used to make decisions either through relative ranking of risk reduction strategies or through comparison with risk targets
- **Guide words** are simple words or phases used to qualify or quantify the intention and associated parameters in order to discover deviations.
- **Parameter** is an aspect of the process that describes it physically, chemically, or in terms of what is happening
- **Intention** defines how the system is expected to operate at the nodes
- **Deviations** are departures from the design intention that are discovered by systematically applying the guidewords to each parameter at each node

Analysis of World wide accidents



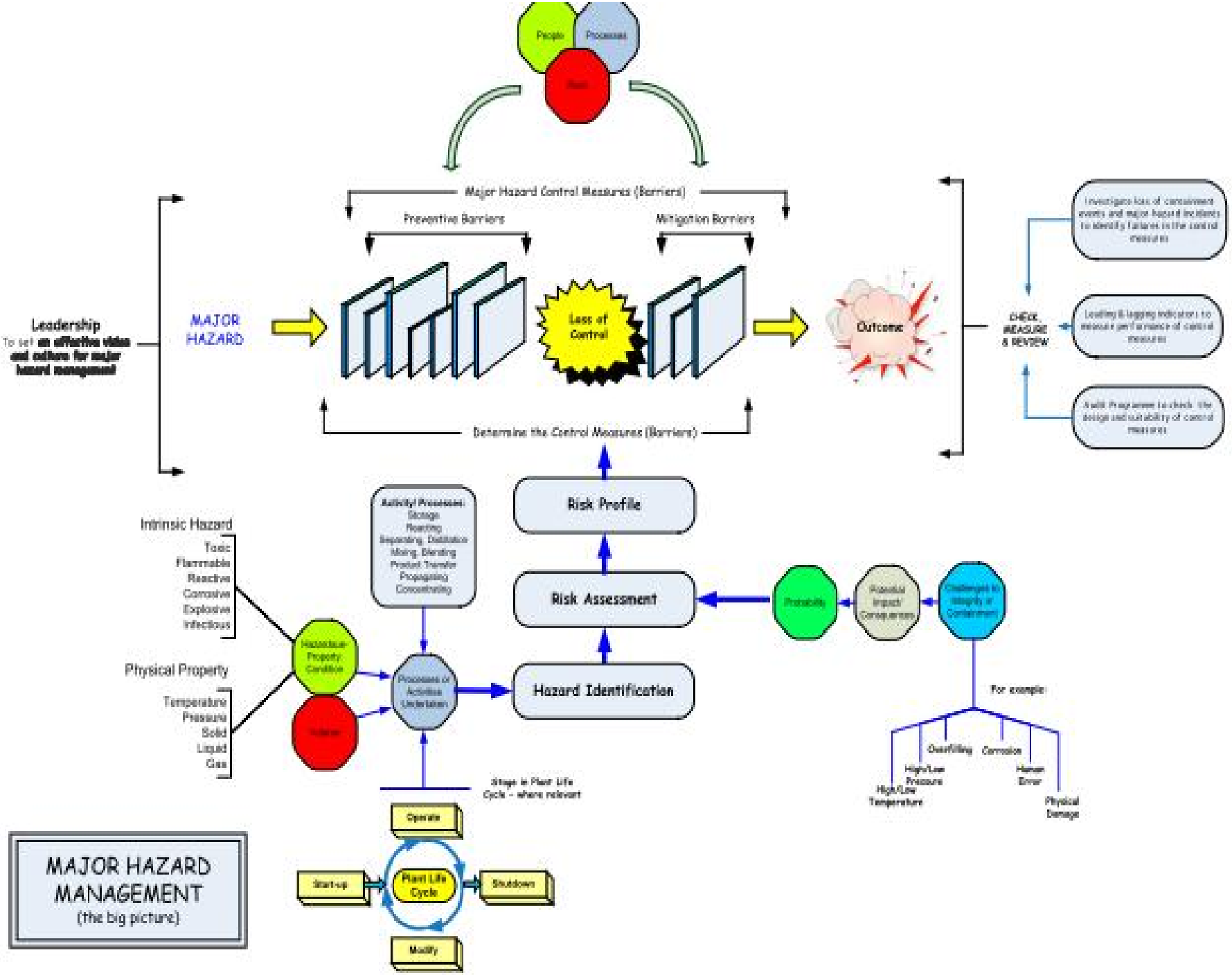


Figure 5 Major Hazard Management System – Overview

Difference – QRA/HAZOP

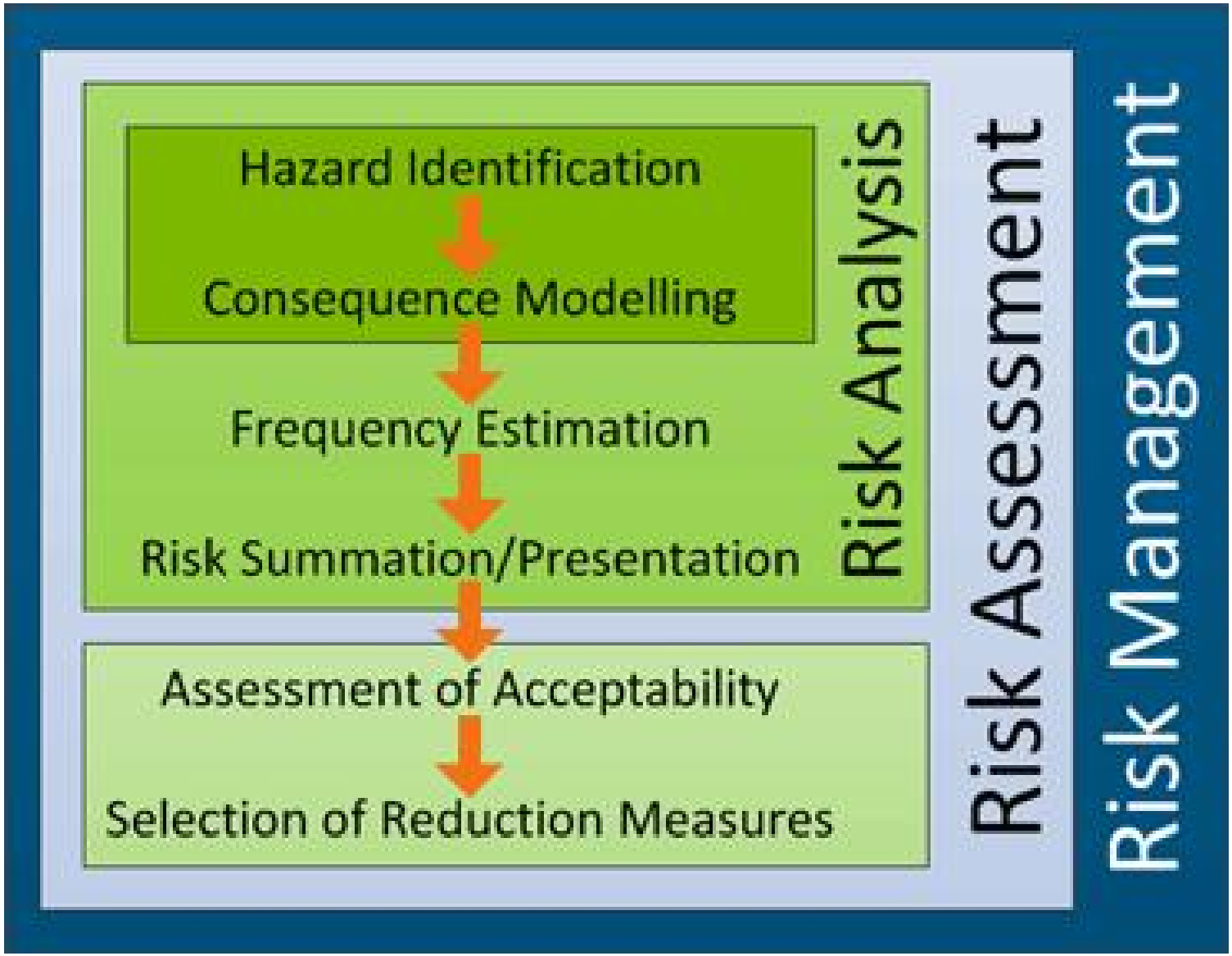
QRA	HAZOP
QRA provides numerical (quantitative) estimates to understand risk exposure to people and environment.	HAZOP provides qualitative estimates to understand risk exposure to people, Assets and environment.
QRA studies account for potential releases of hazardous material, their consequences (e.g., fire, toxic, explosion, etc.) and estimated frequency of occurrence.	Hazop study accounts for abnormal/ Hypothetical Events and their effects in downstream as well as upstream
Quantitative Risk is calculated to people in the form of IRPA/ Social Risk	People/ Assets / Environmental Risk analysed qualitatively
Recommendations of QRA are based on the mitigating system to reduce the consequence/ Likelihood and overall risk.	Types of Recommendations are Safety Instruments, Alarms, trips, Operating Procedure to keep the system in safe operation mode.

Difference – QRA/HAZOP

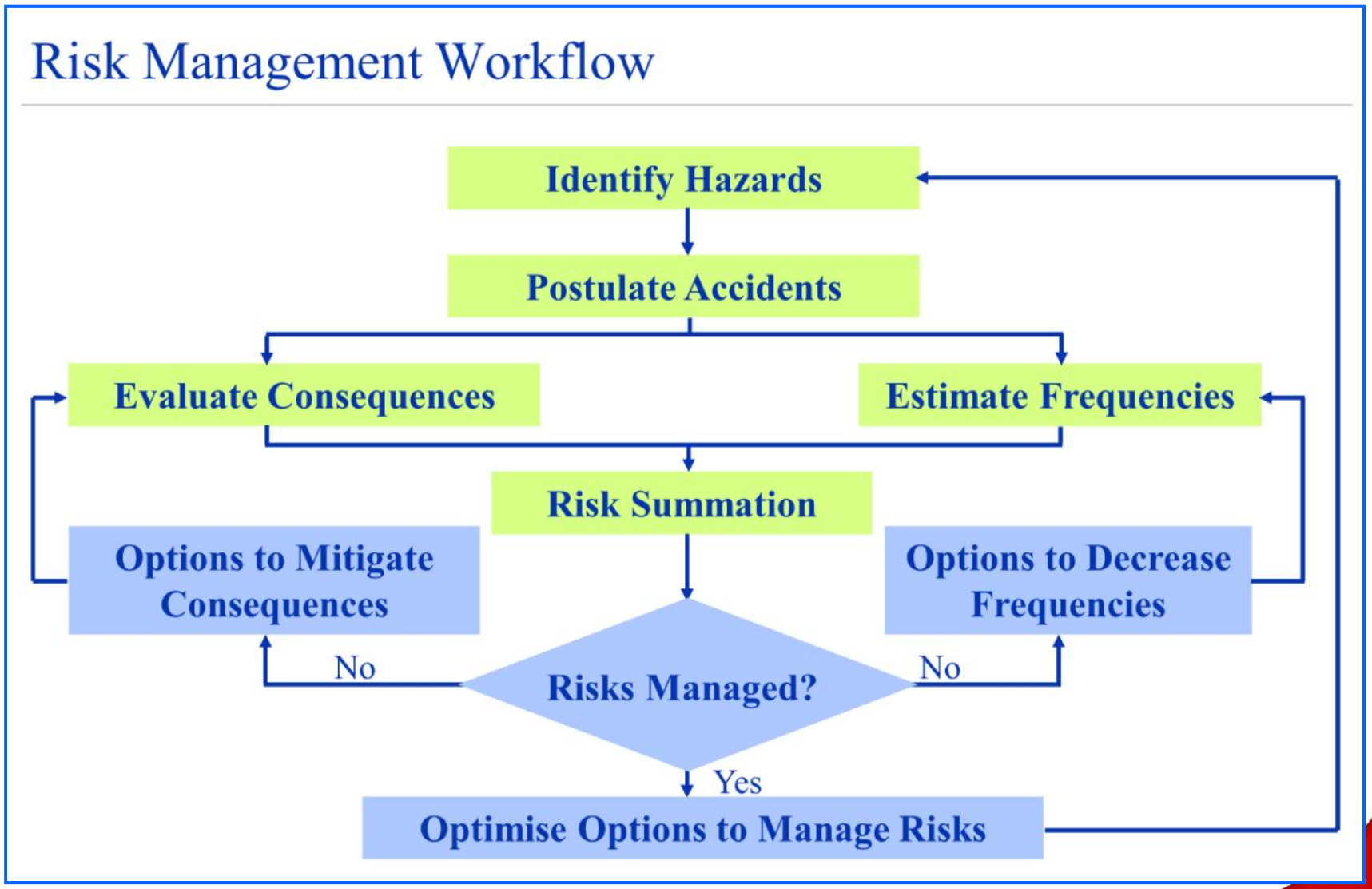
QRA	HAZOP
Risk is calculated considering Operating condition, wind speed & direction.	Hazard are analysed using deviation in parameter line by line or by Equipment.
Risk is calculated based on number of people present in the facility and surrounding areas.	Consequence and risk are analysed qualitatively based on risk ranking.
Abnormal case are not considered in QRA study.	Abnormal case are considered in HAZOP study.

Table 1.1 The differences between Hazop and Hazan

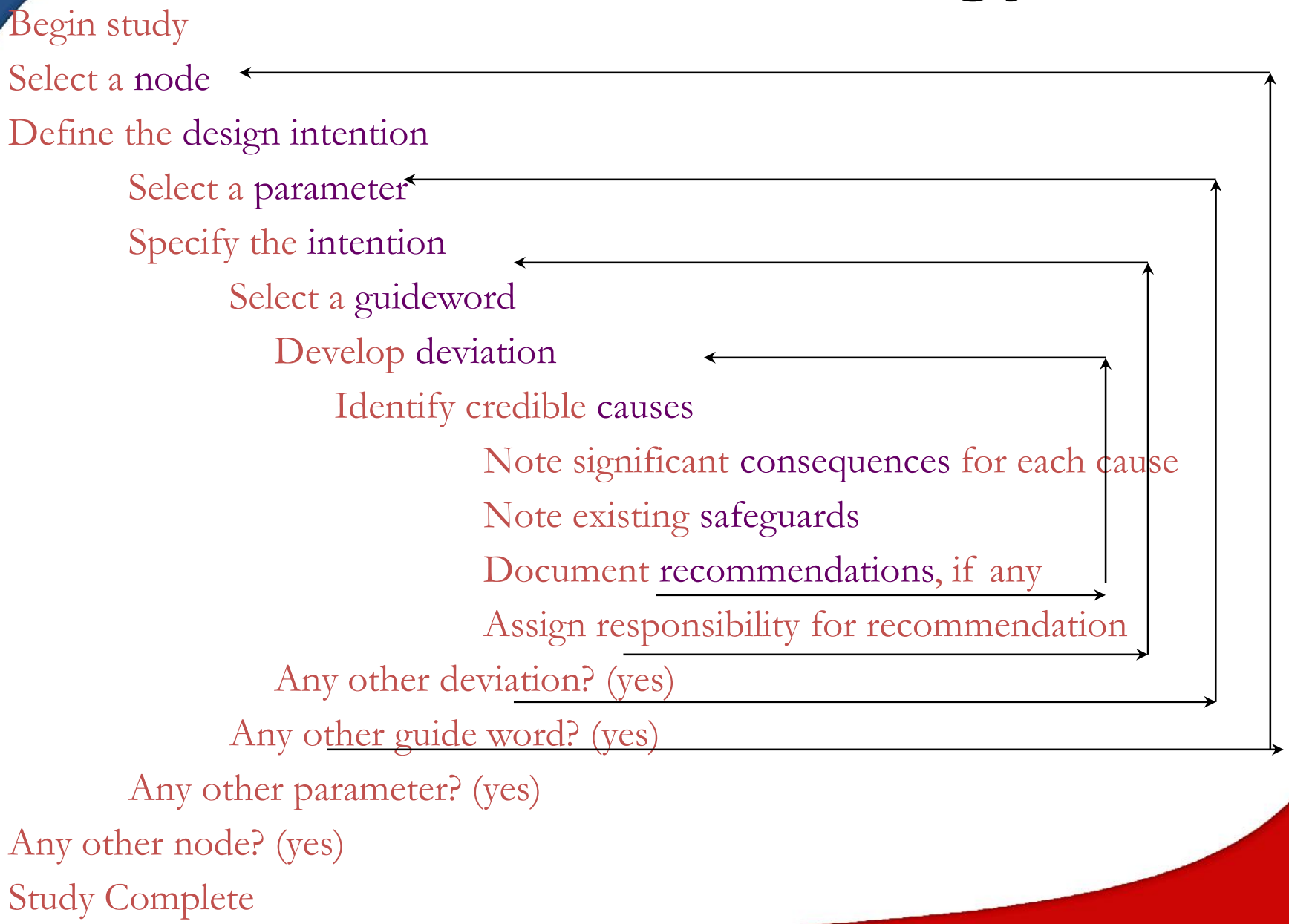
Hazop	Hazan
Identifies hazards	Assesses hazards
Preferred technique: use on every project	Selective technique: use when others fail
Qualitative	Quantitative
Done by a team	Done by one or two people
Also called: 'What if?'	Also called: Risk analysis Risk assessment Probabilistic risk assessment (PRA) Quantitative risk assessment (QRA)


Hazard Identification
Consequence Modelling
Frequency Estimation
Risk Summation/Presentation
Risk Analysis
Assessment of Acceptability
Selection of Reduction Measures
Risk Assessment
Risk Management

QRA Methodology



HAZOP Methodology



QRA Goals

- **To screen or bracket the range of risks for further study:** It is often consequence analysis without frequency part.
- **To Evaluate a range of risk reduction measures:** Identify major risk contributors & suggest risk recommendations.
- **To estimate employee risk –** individual risk
- **To estimate public risk –** Societal risk
- **To meet legal or regulatory authorities**
- **To assist emergency planning:** effect zones to be marked for use in emergency planning

HAZOP Goals

- A systematic review of the design & operation of a system to identify the potential for accidental releases of hazardous material, or operability problems.
- HAZOP study is carried out by application of guidewords to identify all possible deviations from design intent, which can lead to undesirable effects on safety and operability, with the aim of identifying potential hazards.
- Based on the premises that :
  - ✓ A hazard is not realized if the process is always operated within its design intent
  - ✓ Creative input of a team is better than of an individual
  - ✓ Item can be applied, independent of process technologies

Risk Criteria

- As per Annex E, IS 15656 : 2006, Hazard Identification and Risk Analysis, Code of Practice, Risk Criteria for QRA study is

Authority and Application	Maximum Tolerable Risk (Per Year)	Negligible Risk (Per Year)
VROM, The Netherlands (New)	1.0E - 6	1.0E - 8
VROM, The Netherlands (existing)	1.0E - 5	1.0E - 8
HSE, UK (existing hazardous industry)	1.0E - 4	1.0E - 6
HSE, UK (New nuclear power station)	1.0E - 5	1.0E - 6
HSE, UK (Substance transport)	1.0E – 4	1.0E - 6
HSE, UK (New housing near plants)	3 x 1.0E - 6	3 x 1.0E - 7
Hong Kong Government (New plants)	1.0E - 5	Not used

Plant workers will work in the Industry on 10 times higher Risk than Social people

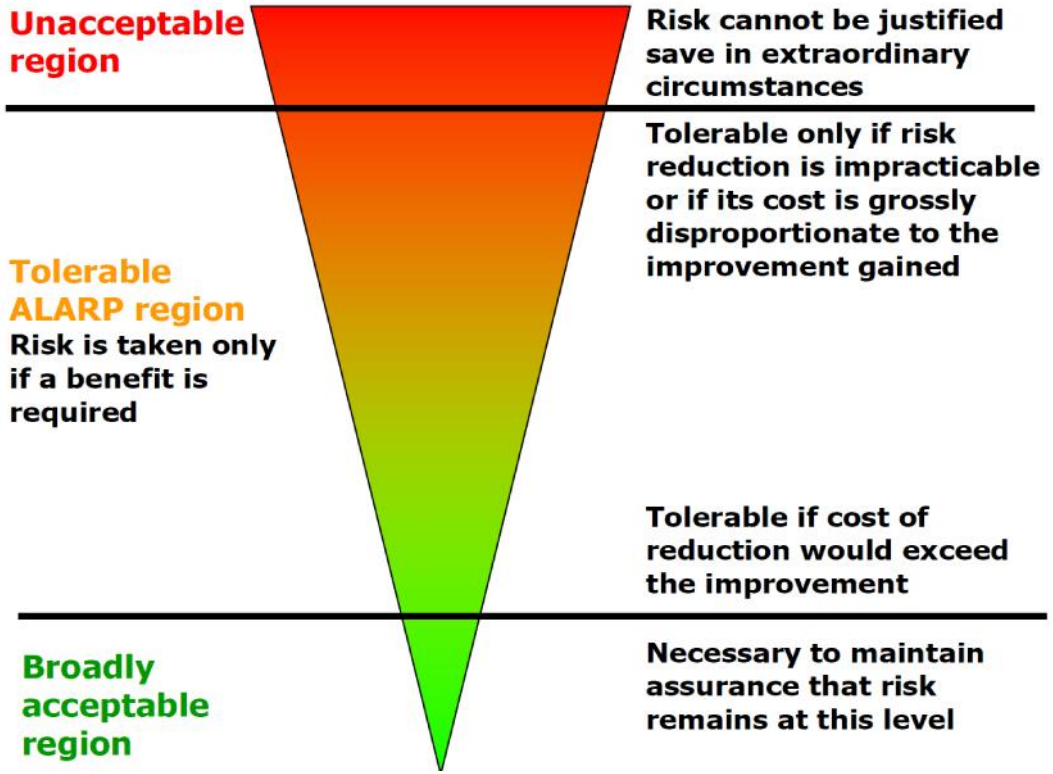
Risk Criteria

- HAZOP Risk Matrix

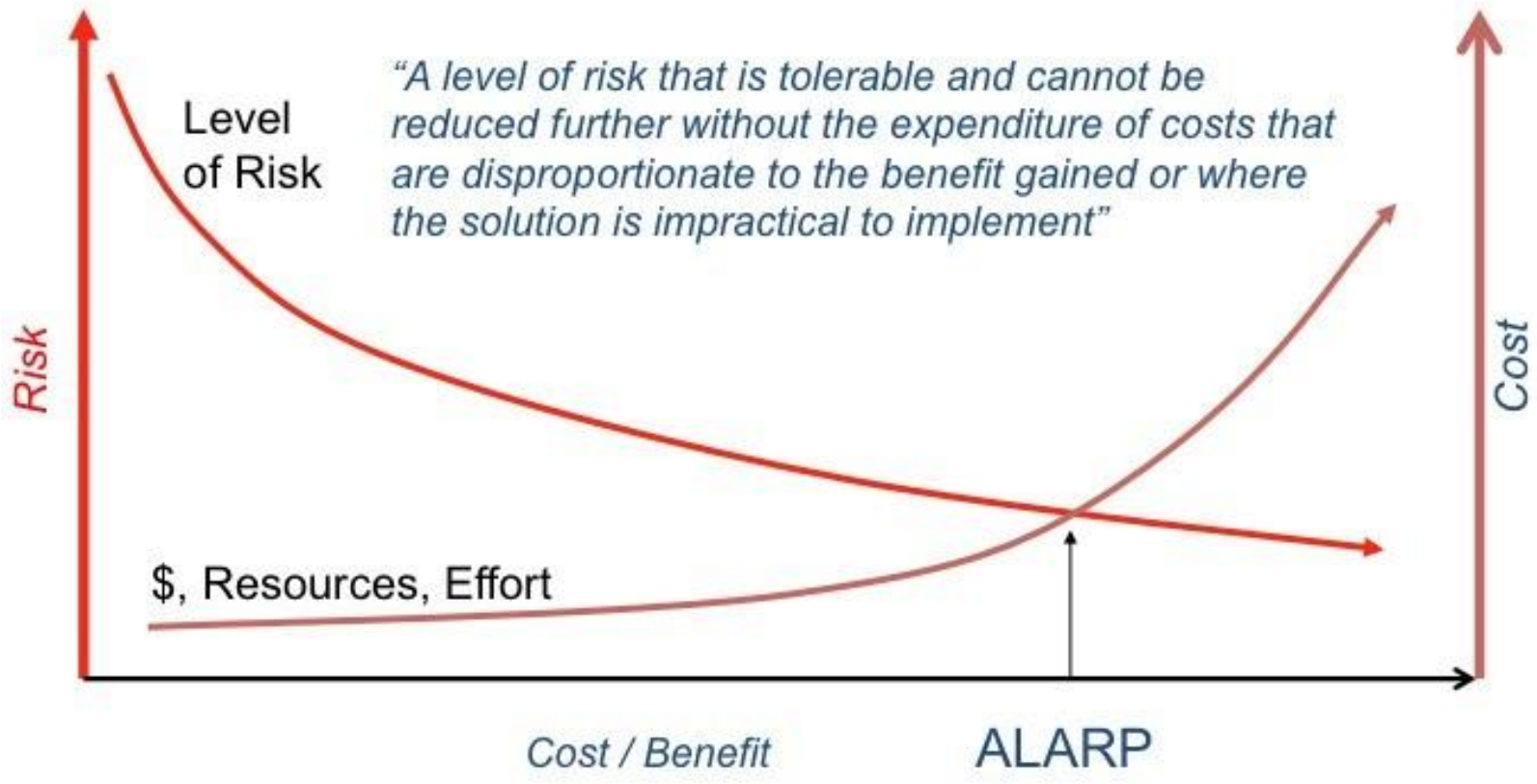
Likelihood	Consequences				
	Insignificant	Minor	Moderate	Major	Severe
Almost certain	M	H	H	E	E
Likely	M	M	H	H	E
Possible	L	M	M	H	E
Unlikely	L	M	M	M	H
Rare	L	L	M	M	H

As low as reasonably practicable (ALARP)

- The residual risks are not unduly high and kept as low as reasonably practicable.



As low as reasonably practicable (ALARP)



Residual Risk

- It is not possible to bring down the Risk to ZERO.
- A risk that remains after all efforts have been made to mitigate or eliminate risk associated with a process.
- After a risk assessment, a residual risk may be known but not completely controllable, or, it may not be known. In either case, the residual risk is assumed by whoever owns the investment or the business process.

Mitigation Measures

- A suggested course of action intended to prevent the occurrence (or recurrence) of an accident event sequence, or to mitigate its consequences.
- Risk Mitigation measure are helpful to reduce the consequence hazard and/or reduce likelihood of occurrence and/or minimizing exposure of people/property.
- Consider Facility having Octane Storage and Fuel gas piping.

  Flash Fire hazard due to release of Fuel gas from piping are tabulated as below (With & Without ESD activation)

Flash Fire level	Half LFL	LFL
Hazard distance in meter	8	5

Mitigation Measures

- Gas Oil release from 120m3 Storage tank without provision of bund and subsequent Pool fire hazards tabulated as below

Thermal Radiation level	4 KW/m2	12.5 KW/m2	37.5 KW/m2
Hazard distance in meter	202	84	NR

- Gas Oil release from 120m3 Storage tank with provision of bund and subsequent Pool fire hazards tabulated as below

Thermal Radiation level	4 KW/m2	12.5 KW/m2	37.5 KW/m2
Hazard distance in meter	21.7	42.2	NR

Mitigation Measures

- Individual and Societal risk calculated using PHAST RISK Software is as below

	Individual Risk	Social Risk
Without Mitigation Measures	1.47 E-03	1.40 E-03
With Mitigation Measures	2.33 E-04	2.31E-04

- **Conclusion**

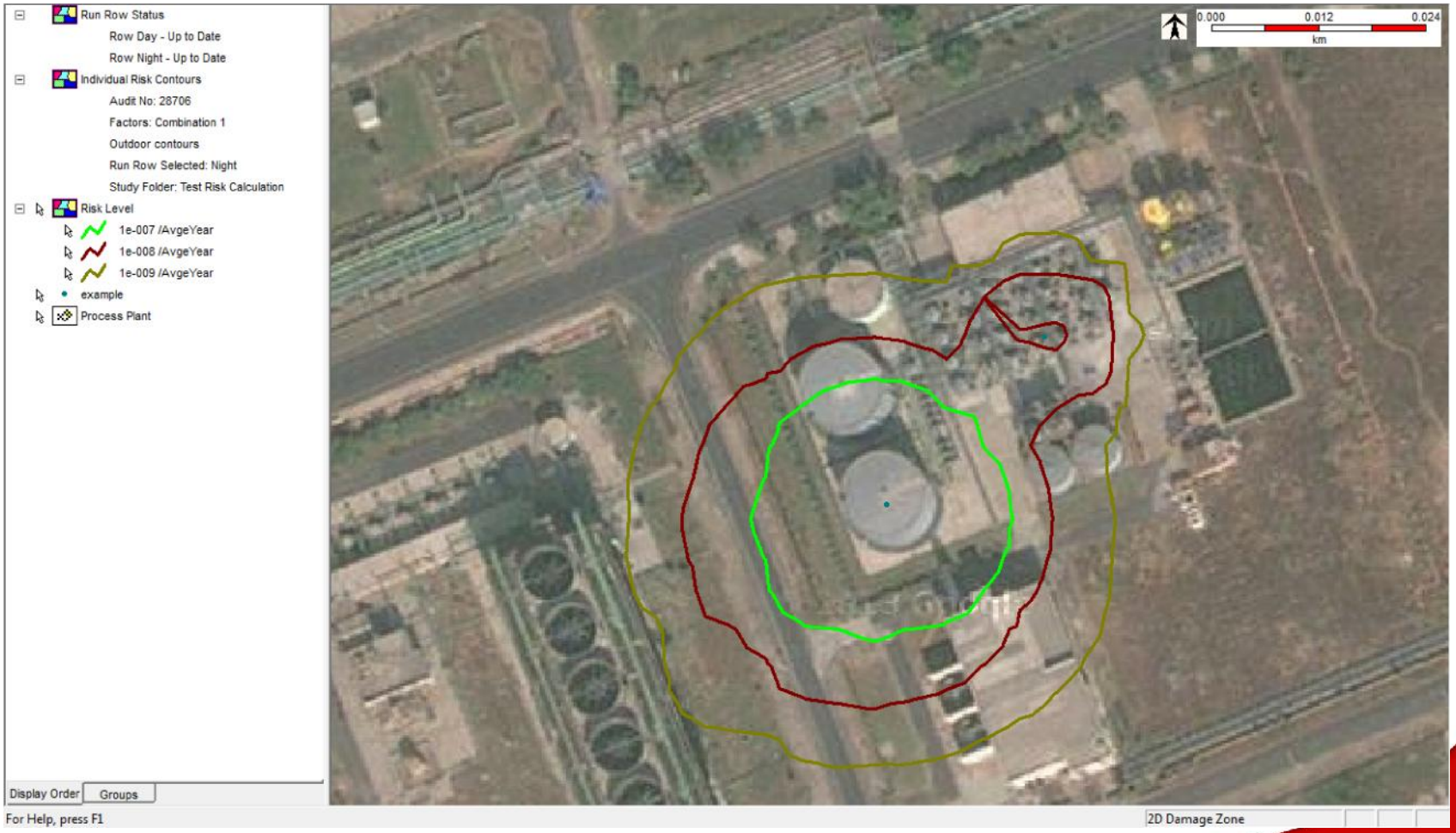
Before mitigation Risk was in Unacceptable region, After considering the Risk mitigation measures Risk bring down to tolerable region.

Mitigation Measures

- Individual Risk Contour – Without Risk Mitigation Measures

Mitigation Measures

- Individual Risk Contour – With Risk Mitigation Measures



Mitigation Measures

- Demonstration of Individual Risk Contours
  - ✓ After providing ESD and automatic blocking system to Fuel gas release scenario, consequence are the same but release inventory reduced and subsequently time reduces from 30min to 2min.

  Note: Consequence distance are not reduced as fuel gas is very light and having high dispersion coefficient. In case of Heavy gas dispersion as inventory reduce, Consequence also reduced.

  - ✓ In case of Storage scenario, provision of bund will help to reduce the hazard consequence.
  - ✓ Considering above points risk reduced and accordingly Risk Contour changes.

Mitigation Measures

- Some Risk Mitigation Measures are as below
  - ✓ F&G Detection System and Automatic/ Semi Automatic Blocking System
  - ✓ Containment
  - ✓ Regular Maintenance Procedures
  - ✓ Deluge System
  - ✓ Use of PPEs
  - ✓ Blast-proof Walls
  - ✓ Emergency Evacuation planning
  - ✓ Water Hydrant and Water curtain, Sprinkler System etc.

Limitations

QRA Study

Cause of limitation	Implication to CPQRA	Remedies
Incomplete or inadequate enumeration of incidents	Underestimate risk for a representative set or expansive list of incidents	Require proper documentation. Involve experienced CPQRA practitioners. Apply alternative enumeration techniques Peer review/quality control. Review by facility design and operations personnel.
Improper selection of incidents	Underestimate risk for all incident groupings	Involve experienced CPQRA practitioners. Apply alternative enumeration techniques Peer review/quality control. Review by facility design and operations personnel.

Limitations

Cause of limitation	Implication to CPQRA	Remedies
Unavailability of required data	Possibility of systematic bias Uncertainty in consequences, frequencies, or risk estimates Incorrect prioritization of major risk contributors	Secure additional resources for data acquisition. Expert review/judgment. Ensure that knowledgeable people are involved in assessing available data. Check results against other models or historical incident records; evaluate sensitivities.

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Cause of limitation	Implication to CPQRA	Remedies
Skills unavailable	Incorrect preparation and analysis Improper interpretation of Results	Amend scope of work Acquire expertise through training programs, new personnel, or consultants

Limitations

Cause of limitation	Implication to CPQRA	Remedies
Consequence or frequency model assumptions/validity	Similar in effect to data limitations	Ensure appropriate peer review Check results against other models or historical incident records Ensure that models are applied within the range intended by model developers Ensure that mathematical or numerical approximations that may be used for convenience do not compromise results Use, if feasible, different models (e.g., a more conservative and a more optimistic model) to establish the impact of this type of uncertainty

Limitations

- HAZOP Limitations
  - ✓ No means to assess hazards involving interactions between different parts of a system or process
  - ✓ No risk ranking or prioritization capability
  - ✓ Teams may optionally build-in such capability as required
  - ✓ No means to assess effectiveness of existing or proposed controls (safeguards)
  - ✓ May need to interface HAZOP with other risk management tools for this purpose

THANK YOU