Onshore Pipeline Engineering 2016

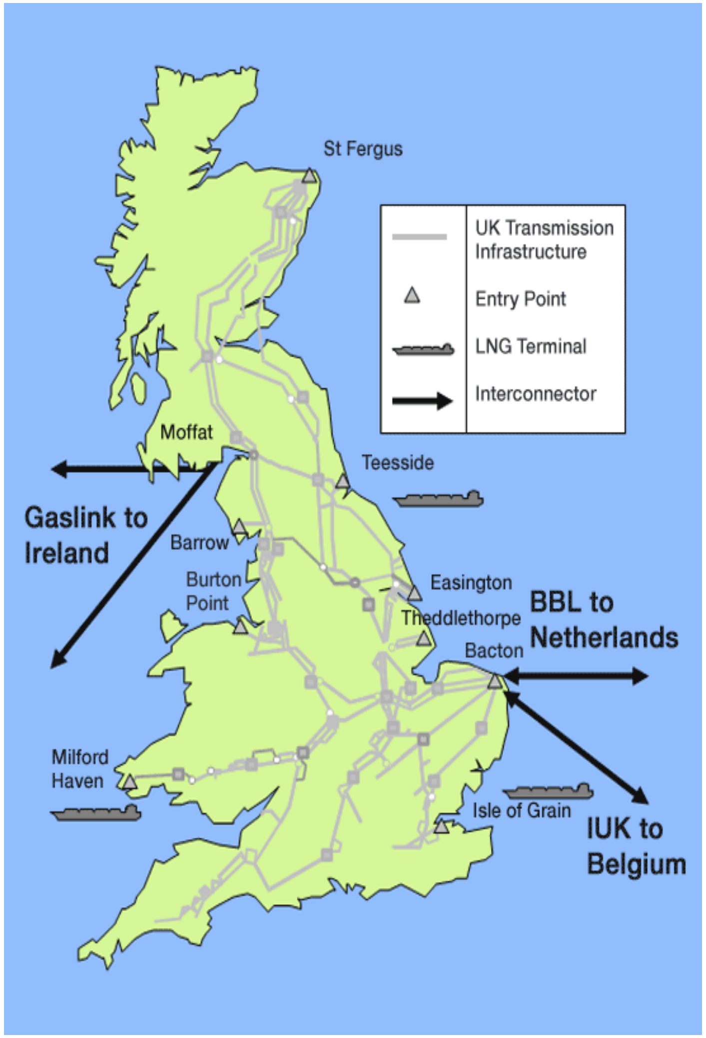
Overview of Hazard Analysis and Risk Assessment

Thursday 2nd June 2016

Tim Wilson

National Grid

- Multinational Utility
  - Gas/Electric
  - Transmission / Distribution
- National Transmission System
  - 7500km
  - Up to 94 bar
  - Up to 48” diameter pipes



Presentation Overview

- Definitions for Risk Assessment
- What is Risk Assessment
- Types of Risk Assessment
- National Grid Formal Process Safety Assessment
- Hazard Identification Studies (HAZIDs)
- Pros / Cons for HAZIDs
- Why Risk Assessment is Important

Definitions

- Hazard – A physical situation with a potential for human injury, damage to property, damage to the environment or some combination of these.
- Hazardous Event – An event that results in Harm or Loss (e.g. Fire, Explosion, Exposure to toxic material).
- Harm – Physical injury, pain, death.
- Loss – Financial loss, cost, loss of production.
- Frequency / Likelihood – How often the harm or loss occurs.
- Consequences – Effects of the Hazardous event on people (№ fatalities) or the financial loss (£££)

Definitions

- Risk – The likelihood of a specified undesired event occurring within a specified period or in specified circumstances. It may be either the frequency (the number of specified event occurring in unit time) or probability (the probability of a specified event following a prior event) depending on the circumstances.

Risk and Tolerable Risk

- Risk – a measure of harm per unit of time (e.g. Injuries per year, Fatalities per year)
- Two types of Risk Measure:
  - Individual Risk – *"The frequency with which an individual may be expected to sustain a given level of harm from the realisation of a specific hazard"*

$$\text{Individual Risk } (R_I) = f \times P_C \times P_E$$

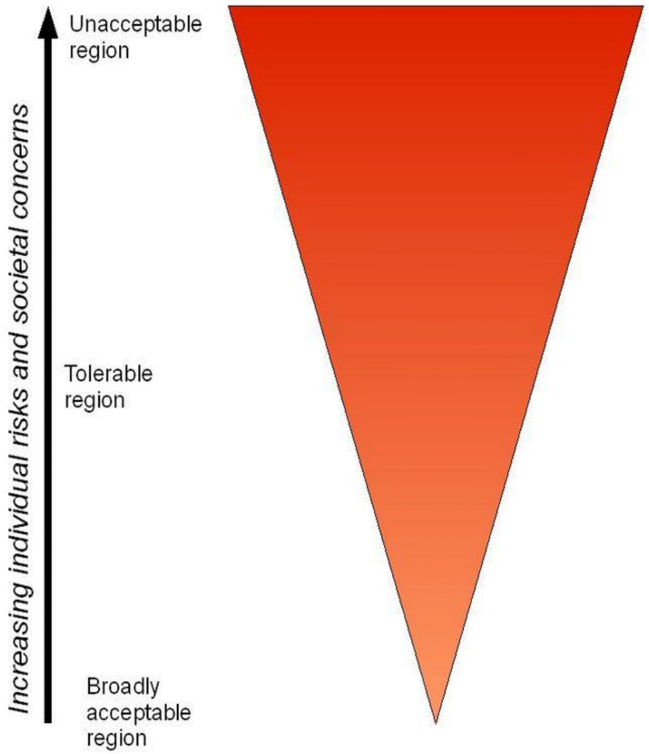
Where f	=	frequency of incident
P_C	=	probability of being a casualty/fatality
P_E	=	probability of exposure

  - Societal Risk: *"The chance of a large accident causing a defined number of deaths or injuries"*

nationalgrid

Risk and Tolerable Risk

- Risk Acceptability
  - Acceptable (Low)
  - Unacceptable (High)
  - ‘As Low As Reasonably Practicable’
- HSE / Legal guidance

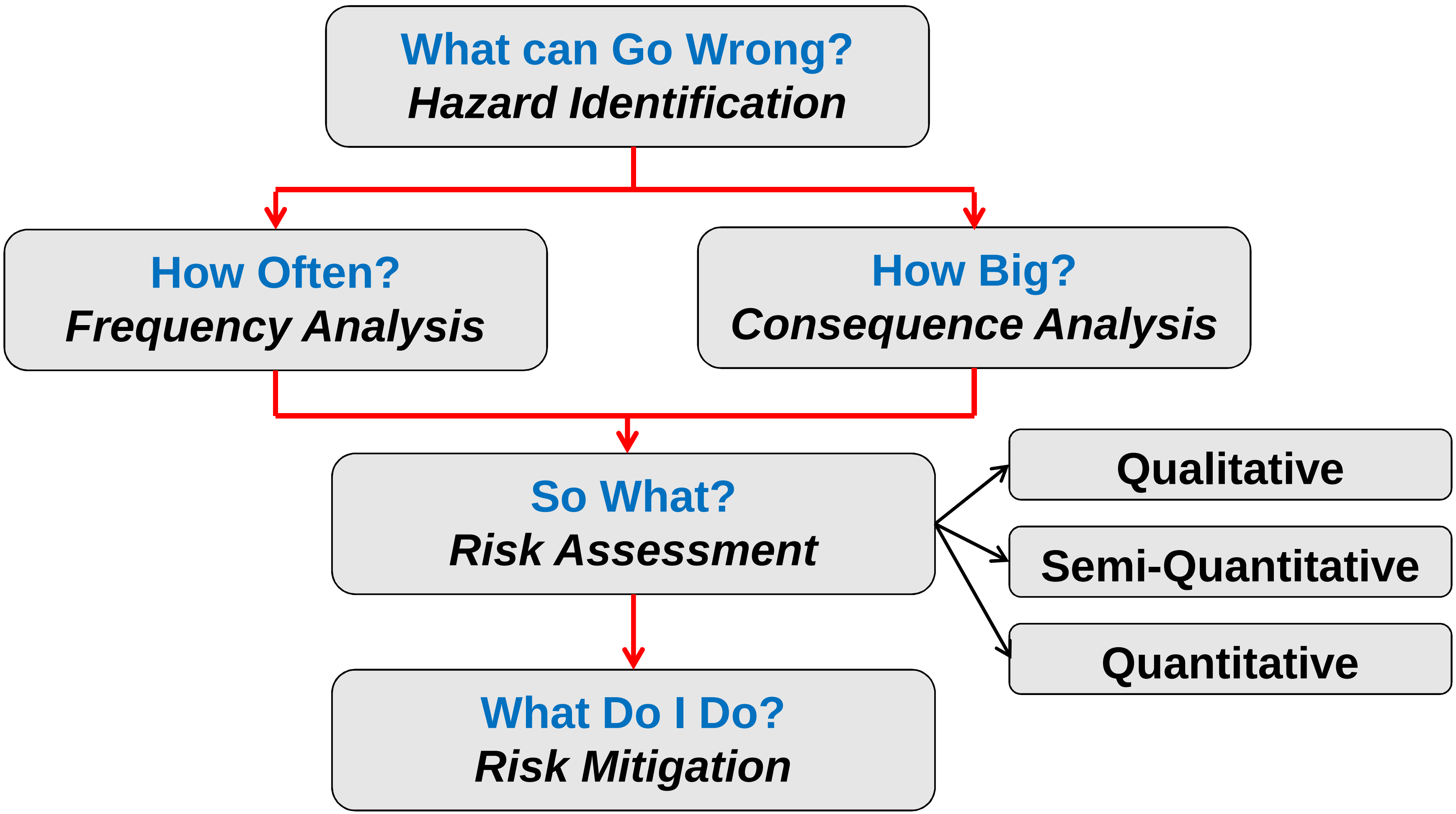


Risk - Modes of Travel Risk Assessment

- On your tables rank the following modes of travel from highest risk to lowest risk

- Car
- Bicycle
- Rail
- Motorcycle
- Air
- Foot
- Bus
- Water
- Van

Risk Assessment



Risk Mitigation

- Elimination
- Substitution
- Engineering Controls
- Administrative Controls
- PPE

Decreasing Effectiveness

Qualitative Risk Assessment

- Non-numerical
- Identify Hazards
- Assess Risk
- Identify Safeguards
- Based on judgement, experience and perception
- Subjective acceptance criteria – Ok / Not Ok

- Easy, can be done by non-experts, Imprecise

Qualitative Risk Assessment - Example

Activity/ Process/ Operation	What are the Hazards to Health and Safety	What Risks do they pose and to whom?	What precautions have been taken to reduce the risk?	What further action is needed to reduce the risk
Walking to Racecourse and return journey	Young persons becoming separated from rest of party.	Loss of young person(s).	• The group is supervised by an adult who has been assessed by the LA or EVC to be competent to lead the activity. • At least the minimum number of adult to young person ratios are met as specified in the OSA document.	• Parents/carers to be provided with information on the nature of the activity and any risks. • All medical information to be obtained for every person on the walk.
	Interface with public	Theft/assault	• Party members carry a minimum amount of valuable possessions. Mobile phones are not to be used or held where they can be seen by members of the public. • Non-confrontational approach is taken by all party members.	• Group or party leader to alert authorities, e.g. police if any person is acting in a way that endangers themselves or others

Semi-Quantitative Risk Assessment

- Semi Numerical
- As before but uses a Risk Matrix
- Needs someone to set up Risk Matrix, but still quite easy

		Consequence				
		1	2	3	4	5
Likelihood	1	1	2	3	4	5
	2	2	4	6	8	10
	3	3	6	9	12	15
	4	4	8	12	16	20
	5	5	10	15	20	25

Score	Consequences	Likelihood
1	Minor Injury	Extremely Infrequent (< 10^{-4} per year)
2	Lost Time Injury	Very Infrequent (10^{-3} to 10^{-4} per year)
3	Major Injury	Infrequent (10^{-2} to 10^{-3} per year)
4	Fatality	Occasional (10^{-1} to 10^{-2} per year)
5	Multiple Fatalities	Frequent (>10^{-1} per year)

nationalgrid

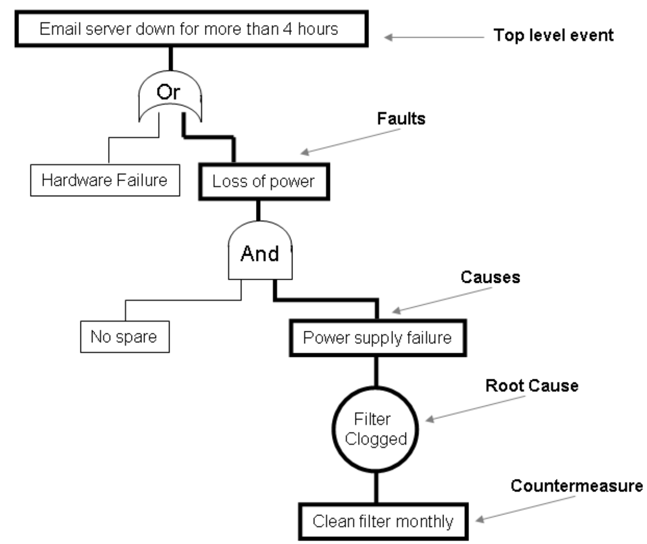
Semi-Quantitative Risk Assessment – Example

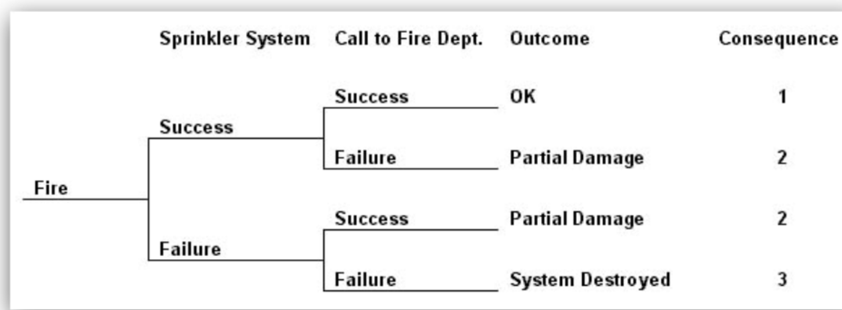
Hazard	Consequences	Safeguards	Consequence Score	Likelihood Score	Risk	Action
Pipeline damaged by farmer	Pipeline rupture leading to multiple fatalities	Depth of Cover Slabbing	5	3	15	Intolerable: Carry out landowner liaison to ensure awareness of pipe
Discharge Temperature of product too hot from compressor	Accelerated corrosion, could lead to a pin – hole leak	High temperature alarm	3	3	9	ALARP: Consider automating alarm into a trip
Incorrect product quality in pipe	Could cause blockage and lost production	Quality Control	1	4	4	No further action required apart from recognised good practice.

nationalgrid

Quantitative Risk Assessment (QRA)

- Full Numerical Analysis
- Fault and Event Trees (Boolean algebra & Probability theory)
- Computer models
- Complex, easy to get wrong, for experts only
- Only use for special cases
  - Infringements to pipeline codes
  - Uprating of pipelines
  - Pipeline routing
  - Land use planning



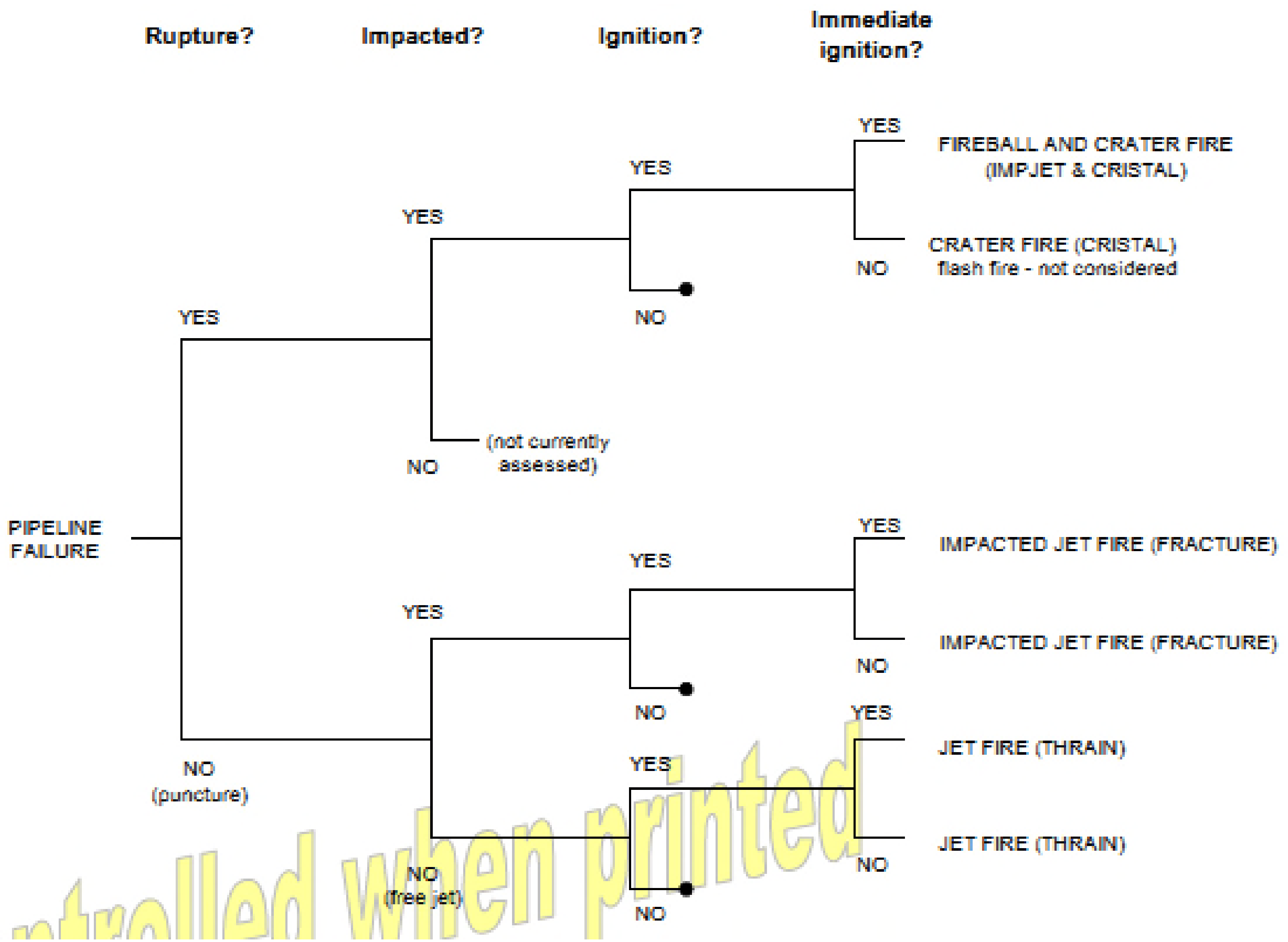


Event Tree Analysis

- Used to identify and quantify the outcomes of an initiating event
- Graphical representation of the logic providing a time sequence of event propagation
- Used for pre and post incident application
- Mostly uses binary branches e.g. yes/no
- Need to identify the safety factors and hazard promoting factors
- Usually multiple outcomes

nationalgrid

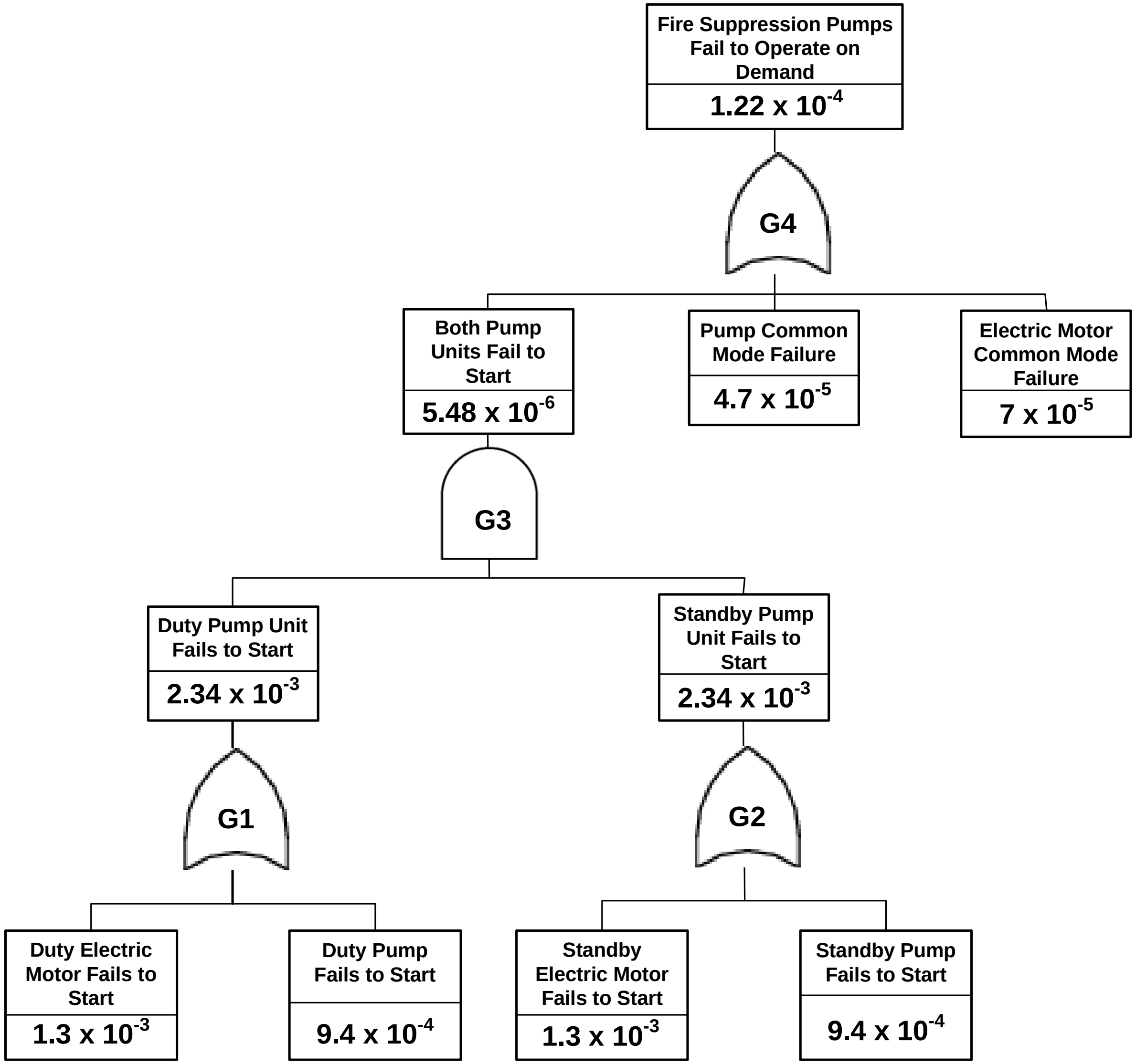
Example Event Tree



Fault Tree Analysis

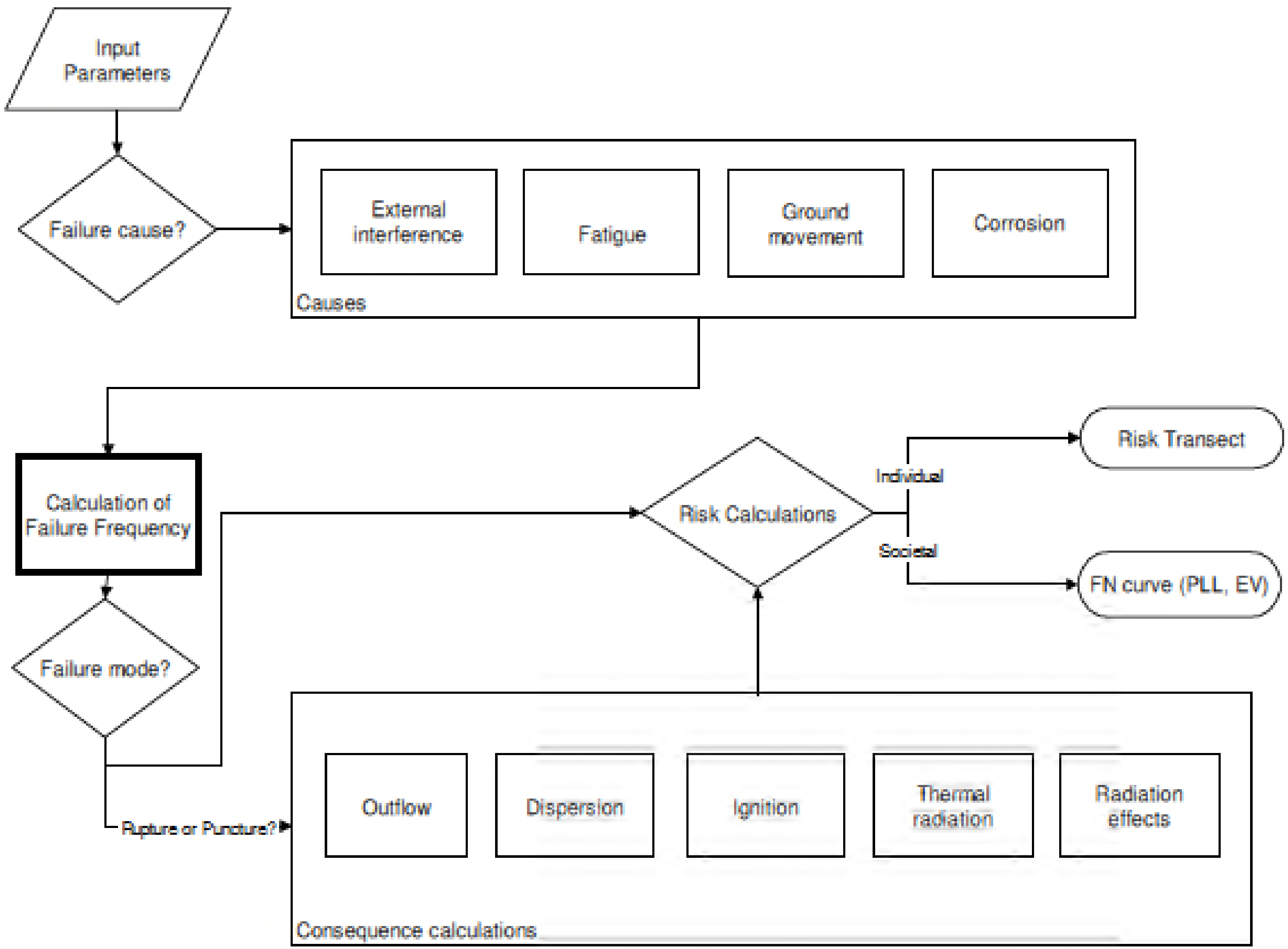
- Used to identify causes of an assumed failure (Top event)
- Logical structure including equipment failures and human errors
- Uses:
  - ‘Events’ – Top, intermediate and basic
  - ‘Logic’ gates – ‘And’, ‘Or’
- Can be used to:
  - Predict reliability, availability, failure frequency
  - Identify system improvements
  - Understand the system
  - Predict the effects of changes in design and operation

Example Fault Tree



nationalgrid

PIPESAFE Methodology

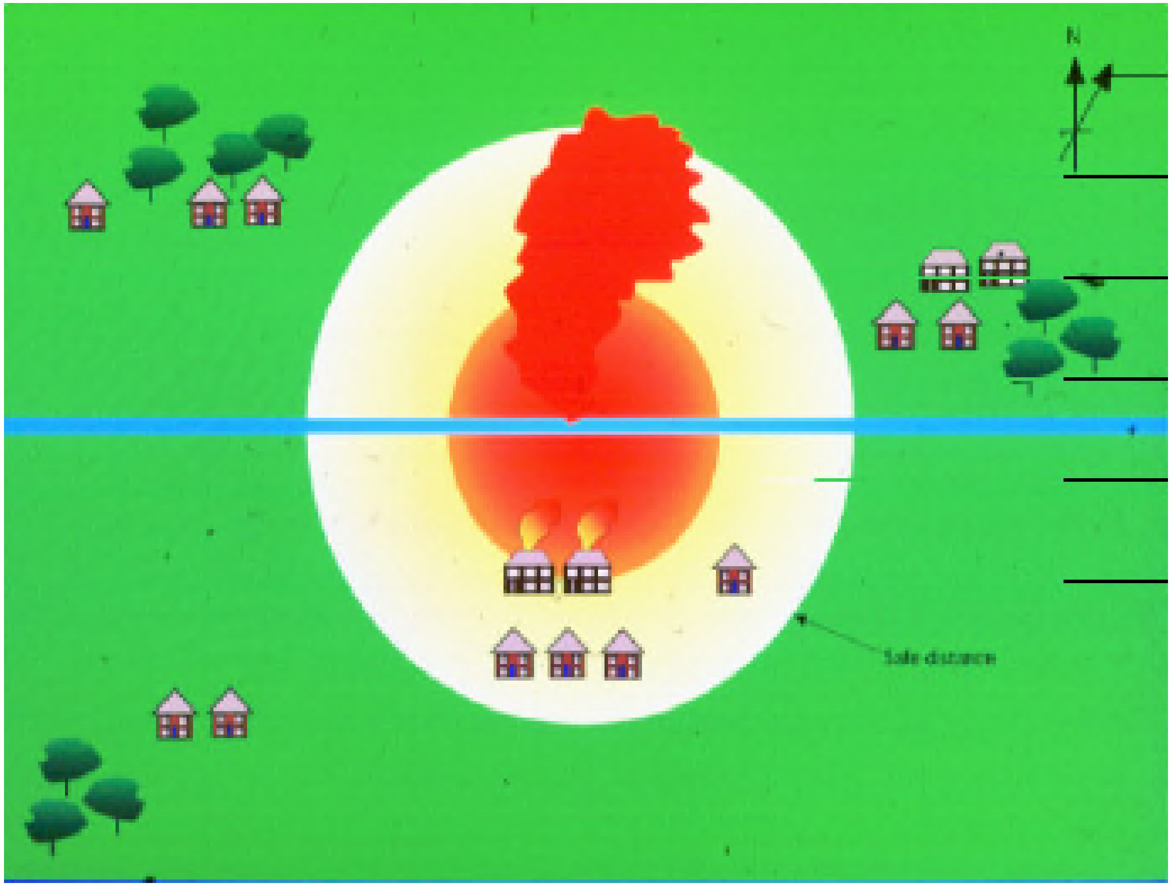


nationalgrid

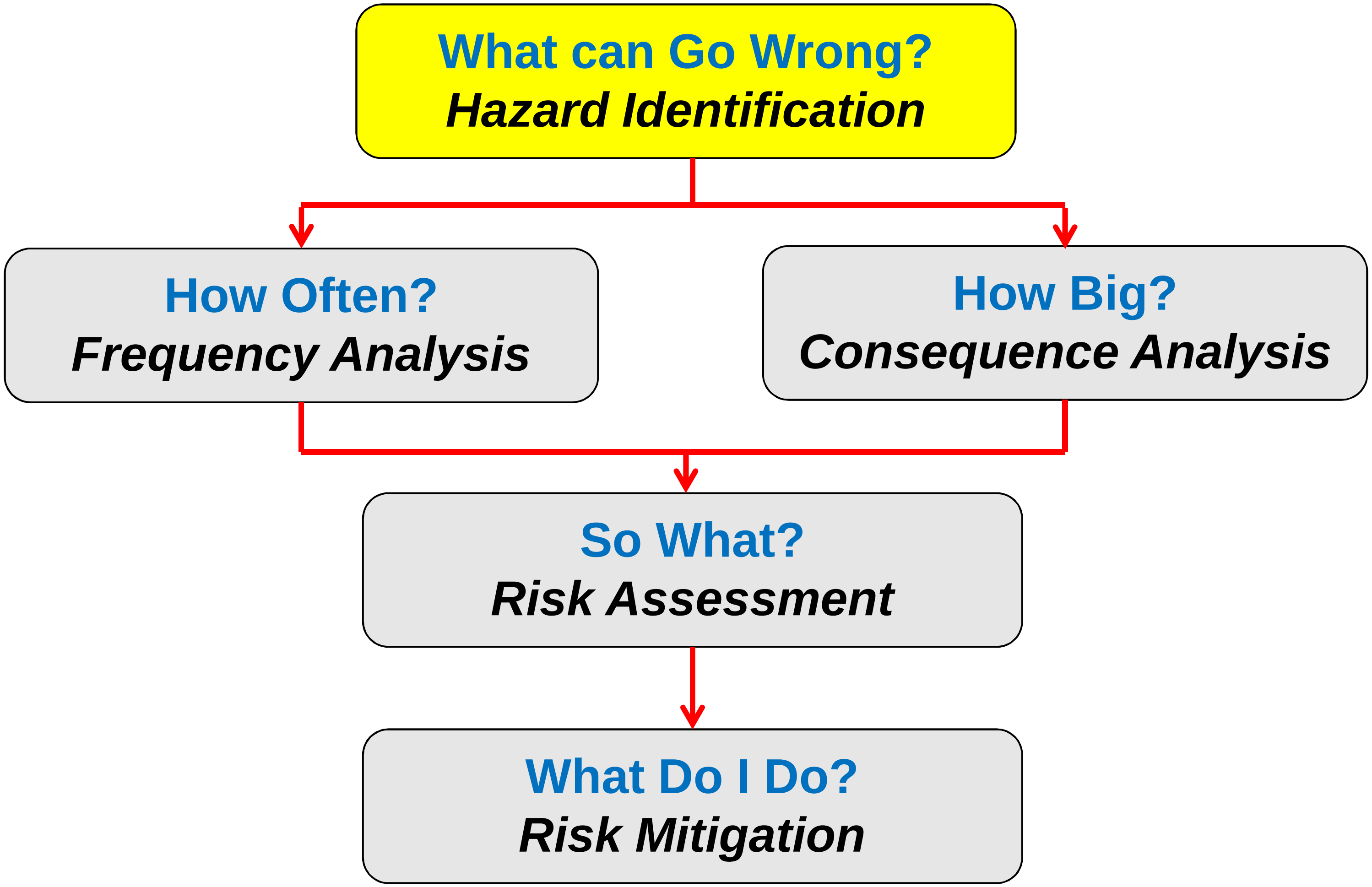
Input Parameters

- Pipeline diameter, pressure, wall thickness, material grade
- Gas composition
- Locations of compressors and valves, and mode of operation
- Burial depth and soil type
- Proposed protective measures
- Locations of buildings within hazard range
- Location of major roads, railways, rivers
- Location of sensitive developments (schools, hospitals)
- Occupancy of buildings and traffic density
- Prevailing weather conditions

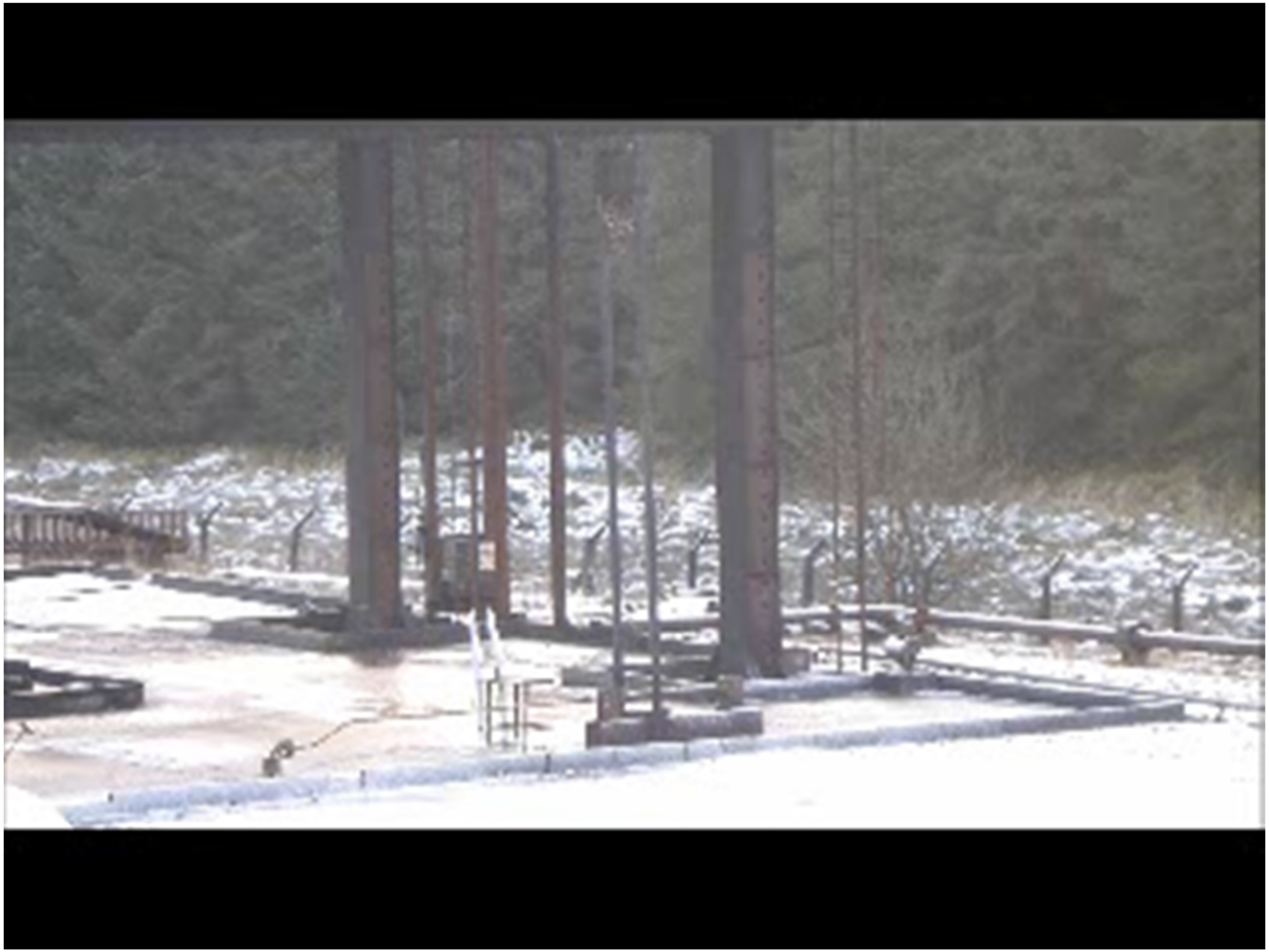
Hazard Ranges



HAZID – Hazard Identification



The Need for Hazard Identification….



HAZID

- Hazard identification is critical to risk assessment quality
- If a hazard is overlooked it will result in an underestimate of the risk

"Are we sure that we have identified all the major hazards and all the ways in which they can occur…?

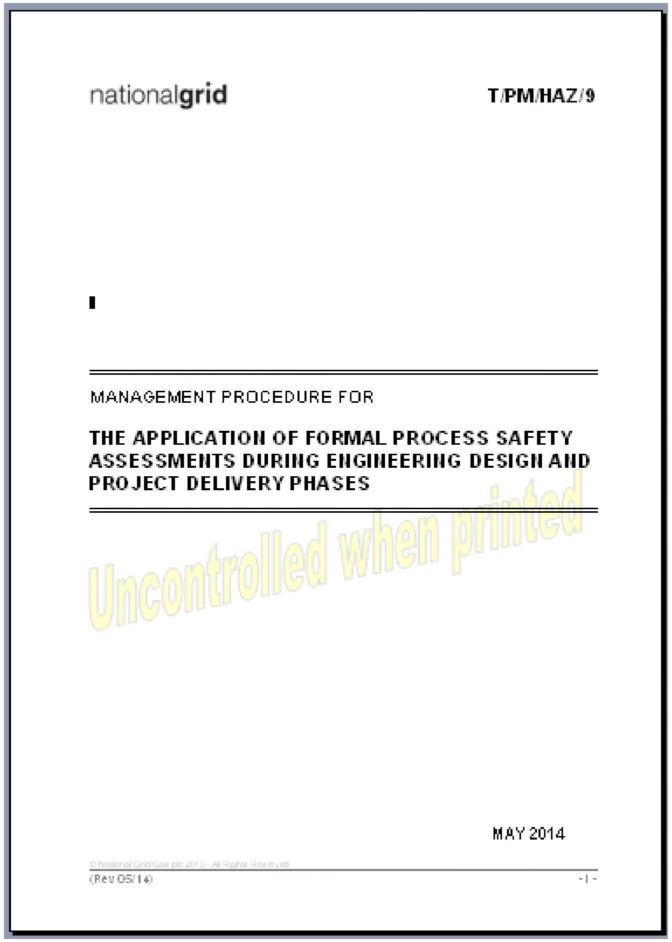
What has not been identified can neither be assessed nor mitigated…"

- Trevor Kletz

- There are a number of HAZID techniques available to identify all the hazards e.g.
    - Checklists
    - Hazard and Operability Study (HAZOP)
    - Failure Modes and Effects Analysis (FMEA)
    - Task Analysis

Formal Process Safety Assessment

- National Grid operate a Formal Process Safety Assessment (FPSA) system.
- This system is used to ensure that all potential major accidents are identified at design stage for new projects or modifications to enable appropriate control and mitigation measures to be put in place.


nationalgrid T/PM/HAZ/9

MANAGEMENT PROCEDURE FOR

THE APPLICATION OF FORMAL PROCESS SAFETY ASSESSMENTS DURING ENGINEERING DESIGN AND PROJECT DELIVERY PHASES

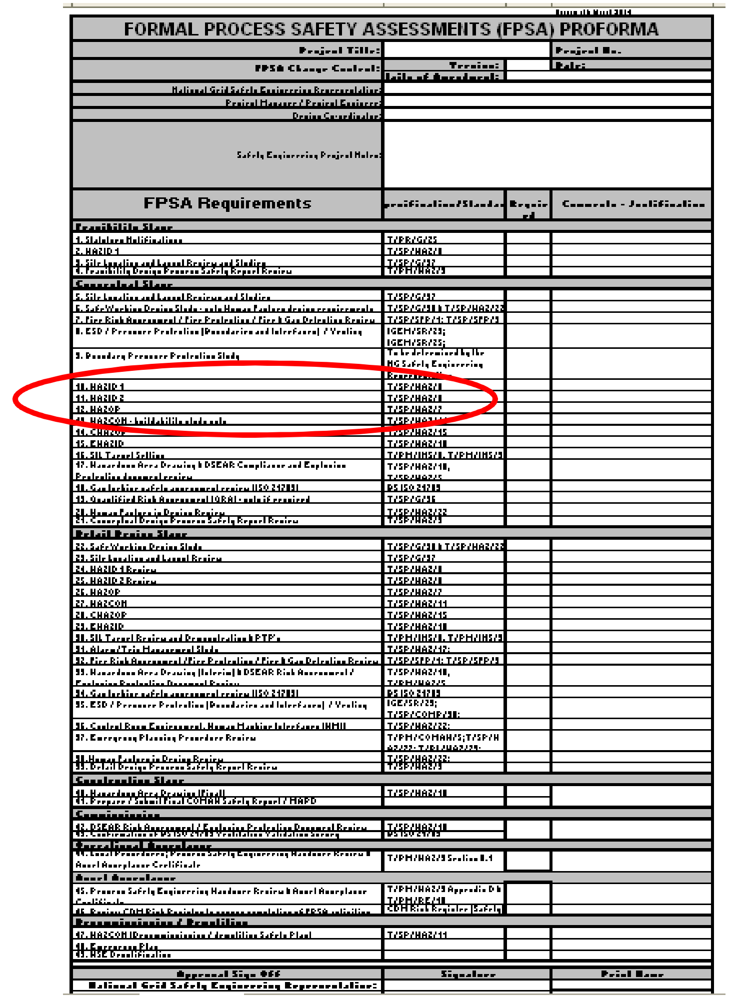
Uncontrolled when printed

MAY 2014

(Rev 05/14) - I -

Formal Process Safety Assessment

- One technique that is used as part of an FPSA is a HAZID Study
- A HAZID is a safety assessment tool that can be used during the course of an engineering project or to review the safety of a particular piece of plant or equipment.



HAZID – What it is and isn't

- What it is
  - Structured Brainstorming Technique
  - Systematic approach - ERIC
  - Team exercise – uses risk assessment
  - Identify Hazards Only
- What it isn't
  - Not to resolve issues – only identify them.
  - Fun

HAZID – Pre-requisites

- Team exercise
  - Chairman – impartial, leads the study team through the process
  - Scribe – to record workshop – report in full.
  - Team members: Design / Project / Operations / Maintenance / Mechanical / Electrical / Instruments
  - 6 to 8 people is right number
- Documentation
  - Drawings
  - Design information

HAZID Guidewords

Primary Guideword	Secondary Guideword
Loss of containment	Rupture Puncture Gas cloud Liquid pool Asphyxiation Toxicity Pollution
Fire	Jet fire Pool fire Flash fire Fireball Smoke Flame impingement Thermal radiation
Explosion	Confined Unconfined Congested Detonation BLEVE (Boiling Liquid Expanding Vapour Explosion) VCE (Vapour Cloud Explosion) RPT (Rapid Phase Transition)
Missile Generation	
Ignition Sources	Electrical Electrostatic Hot surfaces Hot working Vehicles

HAZID – Step-By-Step

HAZID Process	Pipeline Example
1. Select Hazard Guideword	Corrosion
2. Is it applicable?	Yes
3. Identify Causes	Oxidation of metal
4. Identify Consequence	Metal loss – pipeline failure
5. Identify Safeguards	Cathodic / Pipeline Coating
6. Are Safeguards Adequate?	Yes / No / Maybe?
7. If not raise an action.	

HAZID - Example

- In your groups identify some pipeline failure modes
- For each failure mode, identify some causes
- In your groups identify some safeguards for each failure mode

nationalgrid

HAZID – Follow up meeting

- Actions must be completed and reviewed
- Action review meeting
  - 3 or 4 people from original study
  - Can accept, reject or modify actions
  - May require further follow-up meetings

- Actions are signed and approved by HAZID Chair

HAZID – Pitfalls

- Too many cooks / Not enough
- Independent chair / experience
- Reporting in full
- Not completing actions
- Trying to solve problems at the workshop

nationalgrid

HAZOP

- Structured technique using guidewords to identify potential deviations from normal conditions

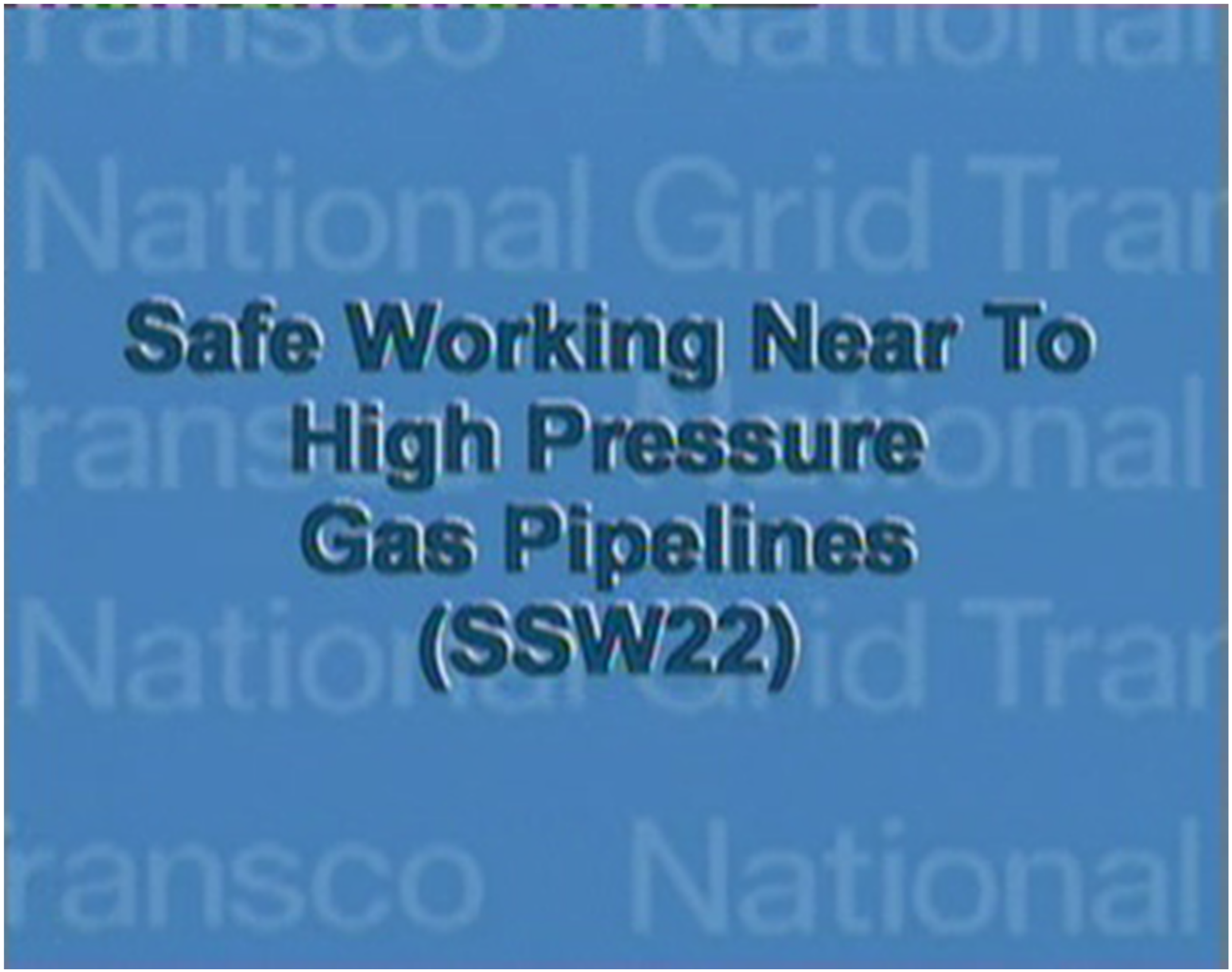
PARAMETER	GUIDEWORD	POSSIBLE CAUSE
Flow	NO	Wrong routing, blockage, blind flange left in, faulty non-return valve, burst pipe, control valve, isolation valve, pump or vessel failure.
	MORE	More than 1 pump operating reduced delivery head increased suction pressure, other routes, exchanger tube leaks, greater density.
	LESS	Partial blockage, vessel or valves failing, leaks, loss of pump efficiency.
	REVERSE	As for NO FLOW, plus emergency venting, 2-way flow.
Pressure	MORE	Surge, relief, leakage from an HP connection (lines and flanges), thermal, rate of pressurising lines.
	LESS	Generation of vacuum by pump drain out of vessels, condensation from vapour or gas dissolving in a liquid. Blocked pump or compressor suction lines.
Temperature	MORE	Fouled cooler tubes, cooling water failure, failed exchanger tubes.
	LESS	Freezing, loss of pressure, loss of heating, failed exchanger tubes.
Level	MORE	Outlet blockage, control valve, pump, instrumentation failure
	LESS	Control valve, instrumentation failure. By-pass/drain valve open
Viscosity	MORE	Change of material, specification or temperature.
	LESS	Change of material, specification, or pressure.

Why Risk Assessment is Important

- Gas Pipeline Explosion - North Texas 06-07-2010

- A natural gas pipeline explosion in North Texas killed three people.
- Eight workers from Brazos Electric were digging a hole near the pipe when the blast occurred.
- They were drilling holes to put up power lines when they struck the gas line
- Enterprise Products owns the 36-inch pipeline, which is part of its Texas Intrastate system.
- The Texas intrastate pipeline system transports natural gas within the borders of the state of Texas.
- One energy analyst said the gas pipeline blast could add to jitters about energy supply from across the Gulf Coast.

Safe Working in the Vicinity of the NTS



Questions?

Workshop 1 - Modes of Travel Risk Assessment

FATALITY RATES PER MILLION PASSENGERS BY TRAVEL MODE, GREAT BRITAIN, 1992			
	Fatalities per Km	Fatalities per trip	Fatalities per hour of travel
Motorcycle	9.7 (1)	100 (1)	300 (1)
Foot	5.3 (2)	5.1 (5)	20 (3)
Bicycle	4.3 (3)	12 (4)	60 (2)
Water	0.6 (4)	25 (3)	12 (6)
Car	0.4 (5)	4.5 (6)	15 (4)
Van	0.2 (6)	2.7 (7)	6.6 (7)
Rail	0.1 (7)	2.7 (7)	4.8 (8)
Bus	0.04 (8)	0.3 (9)	0.1 (9)
Air	0.03 (9)	55 (2)	15 (4)

RSPCA (Royal Society of the Prevention of Accidents). Cited in "Fasten Your Safety Belts." *The Economist*, 11 January 1997, p. 57.

Workshop 2 - HAZID Example

Hazard Guideword	Potential Hazard	Failure Mode / Cause	Direct / Indirect Consequence	Safeguards / Safety Systems	Comments	Action	Person
Loss of Conta-inment	Rupture	Loss of support / structural failure due to landslip	Fire / Explosion	Pipeline routed in area not susceptible to landslip		Consider methods of monitoring movement over lifetime of pipeline	James
Corrosion	Pin hole leak	Parallel HV overhead cables inducing voltages	Reduced effectiveness of Cathodic Protection	Avoid parallel HV routes	Cross HV routes at 90^0	AC mitigation study required for CP design	Jane
Loss of Conta-inment	Gas release	Opening pig trap door under pressure	Fire / Explosion	Procedures		Consider interlocking mechanism that prevents this	Matthew

nationalgrid

Threats to Pipelines

- External interference/impact
- Internal and external corrosion
- Material and construction defects
- Natural hazards
- Over-pressurisation
- Fatigue
- Sabotage and pilferage

nationalgrid

Example Safeguards

- Pipeline design
- Burial depth
- Surveillance
- Pipeline markers
- Physical protection
- Landowner liaison
- Pipeline design
- Pipeline coating
- Corrosion management
- In-line inspection
- Cathodic protection
- High quality steel, quality control, hydrostatic testing