

PERIODIC HAZARD STUDIES IN ORICA

SAFEX Congress XVI

May 2008

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Process Safety Incidents

- There have been many significant incidents in process industries . . .

Toulouse

Longford

Texas City

Longford 1998



- 10t of flashing hydrocarbon released
- Blast killed two, injured 8, one immobilised
- Crater 1.5m dia by 1m deep

Toulouse 2001

30 killed, 4000 injured, 3500
houses seriously damaged



Texas City 2005



Fifteen people killed,
180 injured, financial
losses exceeding \$2bn

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And our industry as well . . .





Zambia '05



Austria '08



Lorena 2004

Process Safety Failures

- There are many similar system failures noticed after major incidents -

Longford Inadequate risk assessments, using wrong metrics, confusing alarms, operator lack of understanding . . .

Texas City Process safety inadequate, wrong metrics, deficiencies systemic (not isolated) . .

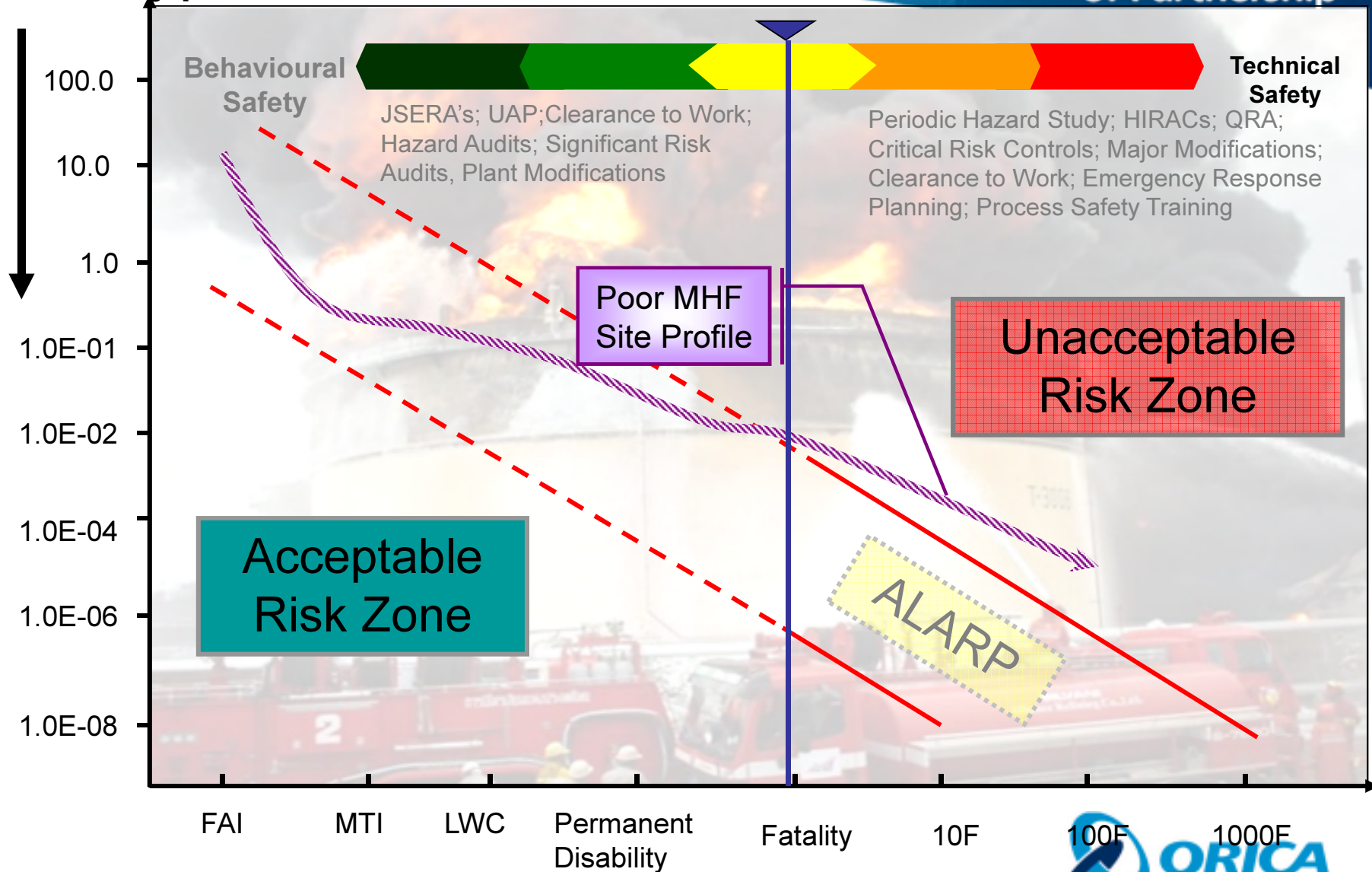
AND

Inappropriate focus on lagging indicators eg LTI rates

Event Frequency / Probability p.a.

Increasing Severity Impact →

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How can a site/business manage occupational safety well but drop the ball on operational safety?

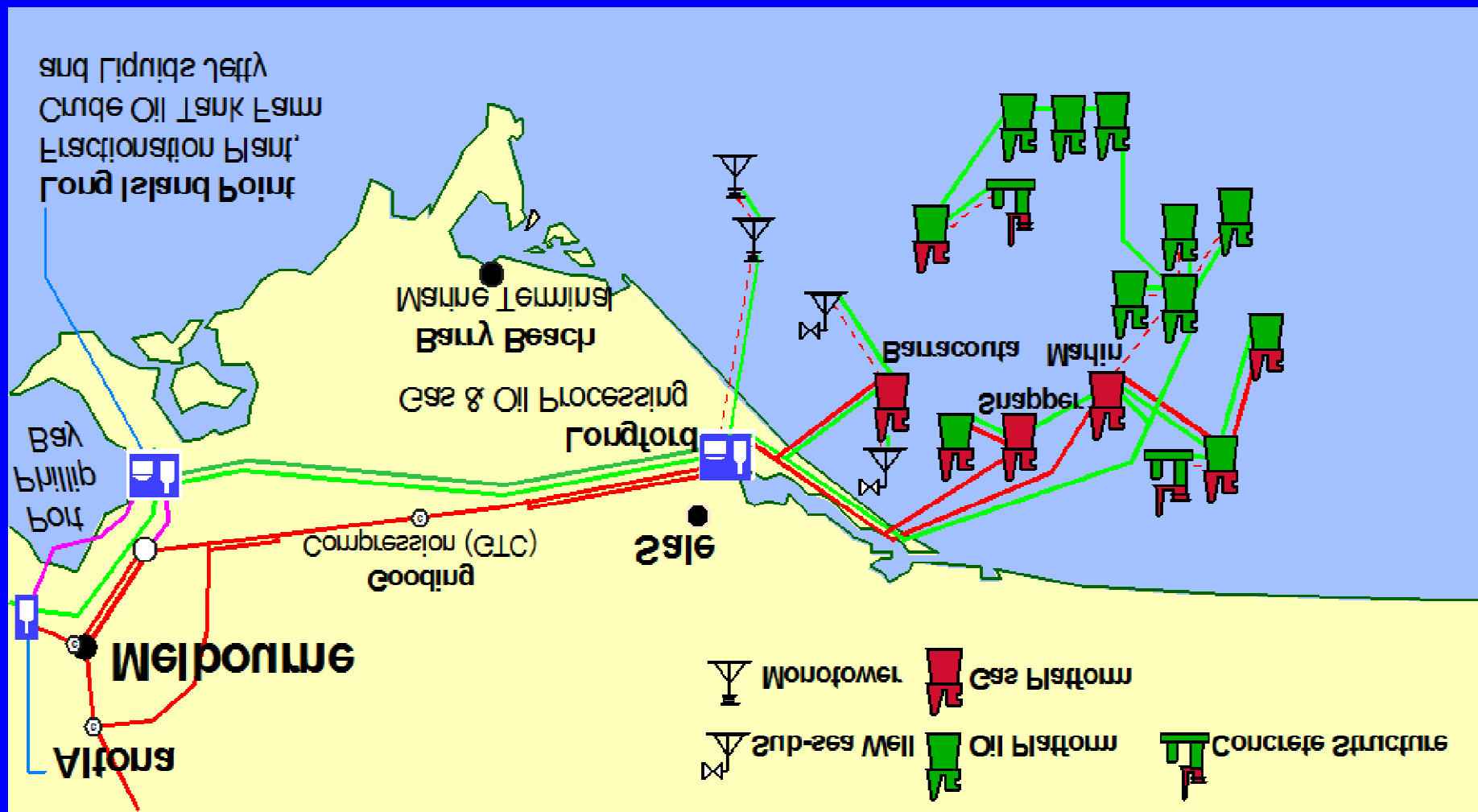


What Happened at Longford?

- And what relevance did Longford have to the Periodic Hazard Study process developed in Orica?

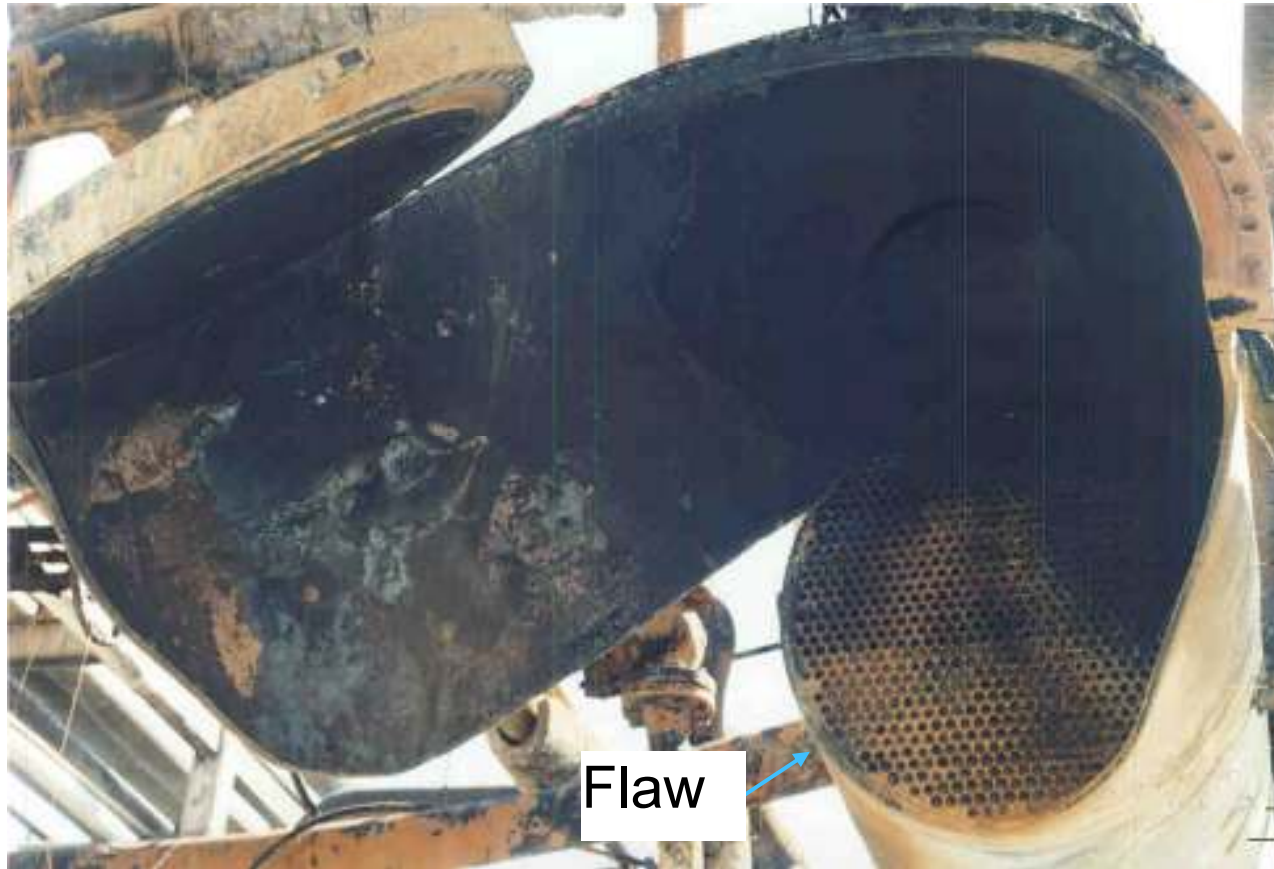
Connections to Longford

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Why Did GP 905 Fail?

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Std carbon steel channel rated to -29 C nominal, brittle at -48 C but still took static stress. Hot oil entering shell resulted in thermal stress causing crack to propagate from welding flaw



Royal Commission

A Royal Commission was set up to investigate the incident

Found that the accident was caused by:

- failure to isolate cold flow when the pumps could not be restarted because...
- the dangers were not recognised because...
- they were not trained in these hazards, and
- no relevant procedures existed

Contributing Factors

- The Royal Commission found the following contributing factors:

Failure to carry out a HAZOP of GP1

Inappropriate supervision of operating practices




Inappropriate design of absorber temperature
overrides

Ineffective isolations

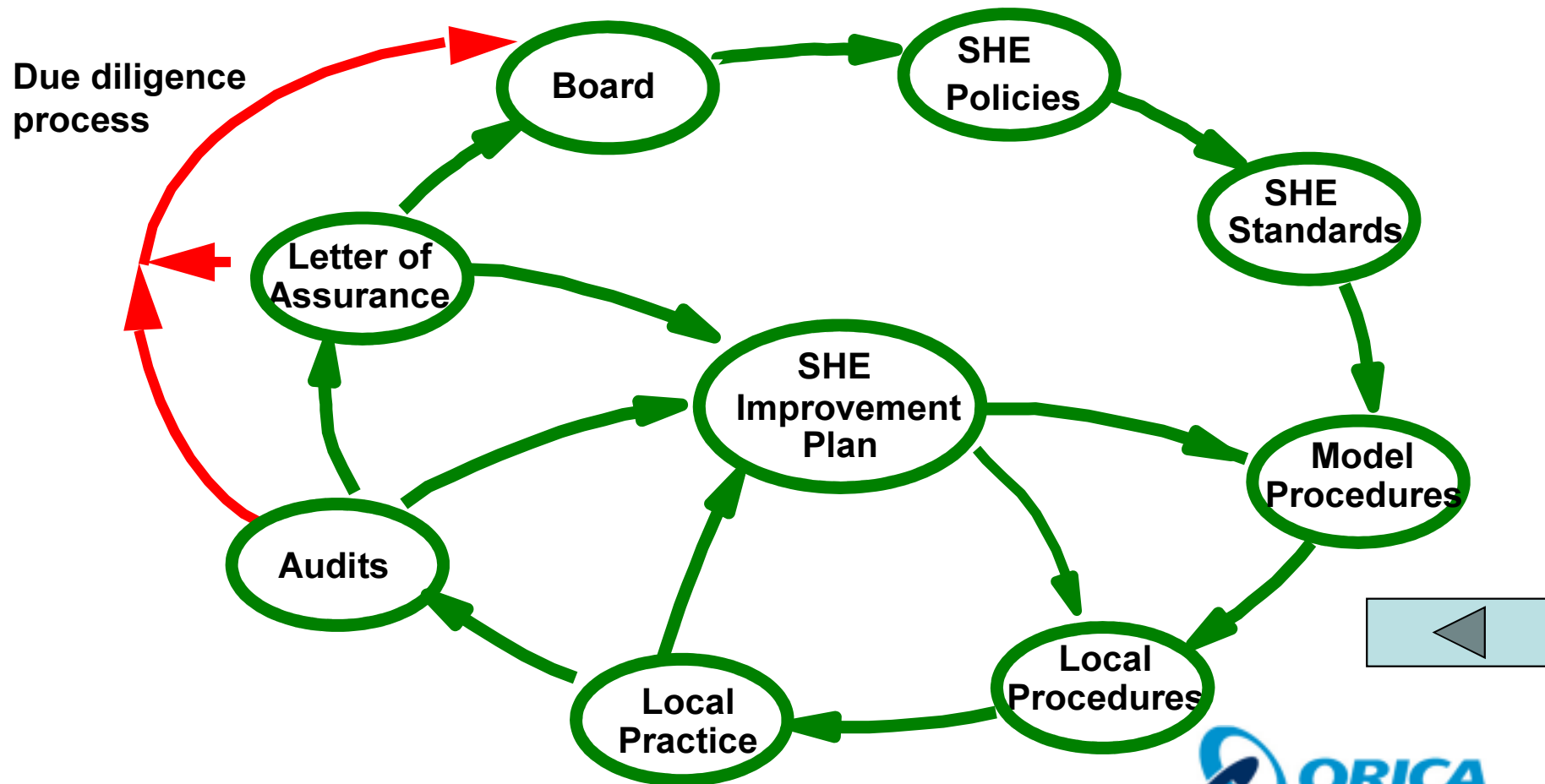
Introduction of MHF Legislation

- Post Longford, the state of Victoria introduced MHF (Major Hazard Facilities) Regulations
- MHF not unlike PSM, Seveso II (COMAH in UK)
- Intended to regulate safety at plants that contain major chemical hazards.
- Posed "non-prescriptive" regime on sites, operators, requiring them to demonstrate control of major chemical hazards via the use of a **Safety Management System** and a **Safety Case**.
- Part of Safety Case was 5 year review of hazard studies

The Periodic Hazard Study Process in Orica

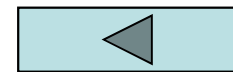
- Orica follows a defined SHE Management Process, with Policy, Standards and Procedures supported up by a structured audit process. 
- Identified improvement actions make up the annual Letter of Assurance, which is reviewed by the Board and changes to policy made as required.
- The key requirements of the periodic hazard study procedure are stated in one of Orica's 117 Model Procedures. PHS is considered a core procedure. 
- The PHS procedure applies to all Orica sites 

Orica's SHE Mgt System



Core Critical Procedures in Orica

- Permits to Work
- Change Notices
- Emergency Planning
- Vehicles on Site- including Forklifts
- Job Safety & Environment Risk Analysis (JSERA)
- Hazard Studies for New Projects
- Periodic Hazard Studies for Existing Plants
- Incident Management



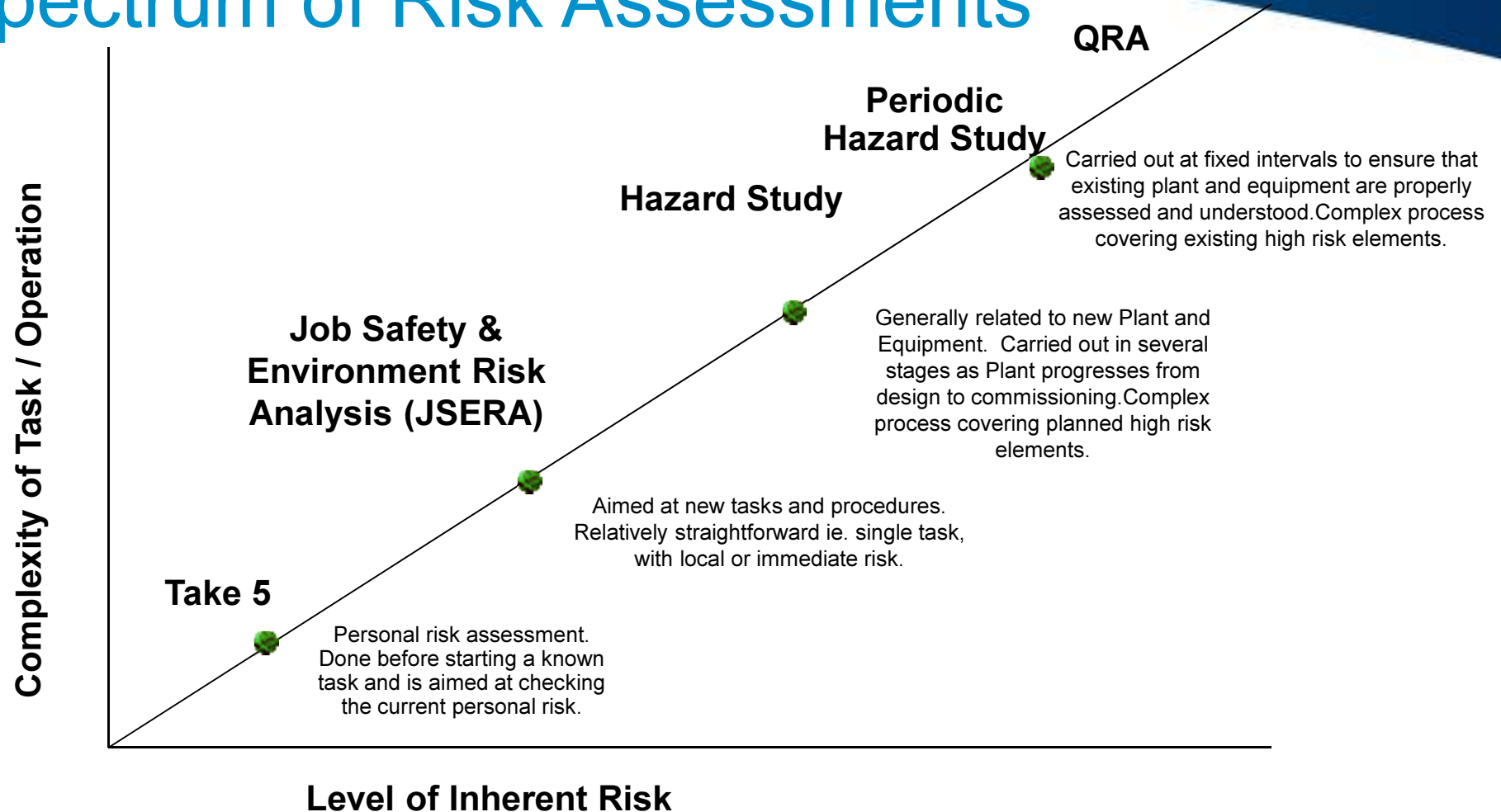
What are Periodic Hazard Studies?

- Orica and predecessor ICI have long history with hazard studies
- Follow a 6 stage process that evolved in the late 1960's.
- A systematic questioning of design basis to discover if deviations from design can give rise to hazardous excursions
- Process now well entrenched for new projects, supported by cadre of trained hazard study leaders

What are Periodic Hazard Studies?

- The periodic hazard study process is similar but different
- It's the application of a structured hazard identification and risk assessment technique for existing plants and processes.
- Outcomes are
 - an understanding of the areas of deficiency related to the plant's risk related systems,
 - the generation of associated projects to close such gaps and,
 - a set of key risk related scenarios and their associated critical controls.

Spectrum of Risk Assessments



What are PHS's?

- Risk profile of the site, captured within the key scenarios, is progressively monitored until an acceptable level of risk reduction is achieved.
- Intended to review the cumulative effects of facility mods, changes to legislation, statutory requirements and organisation, and the learnings from incidents.
- For established facilities which have not previously undergone a structured hazard study process, more extensive Periodic Hazard Studies need to be undertaken.
- This is particularly relevant to new acquisitions, ones that have not normally been through the full Orica 6 stage hazard study process.

What are PHS's?

- They are required to be conducted within a 5 year cycle on potentially hazardous manufacturing, warehouse or storage facilities.
- They may recommend additional specific Hazard Studies or other actions to ensure that the facility can continue to meet SH&E requirements.
- And finally . . . output from Periodic Hazard Studies will generate a register of major hazards which can be used to assist with the Safety Report/Case for a Major Hazard Facility.



Implementation of PHS

- The implementation followed a series of steps :
 1. Sites requiring a Safety Case in Australia were identified and initiated the PHS progress
 2. Other sites that met the criteria globally (ie potentially hazardous facilities including plants, warehouses and storage facilities) were prioritised and put on the program.
- Prioritisation based on several criteria eg
 - Inventory size, siting and layout
 - Complexity of site operations
 - Need for a customized Basis of Safety
 - Level of site personnel expertise and experience
 - Strengthening requirement of hazard studies

PSM activity (audits/hazard studies); PHA Revalidation (I Lake); SRA - F Barker; Insurance Audit (AIG); Vulnerability Audit (R Ferro); PSM Compliance Audits (3rd Party); PHS1 and PHS2 completed as part of PHA Revalidation; SHE Risk Register set up (I Lake); Siting remote from main township at Seneca, farm house within 1 mile of site; Site has co-occupancy (a non-Orica facility)							
Orica Explosives		Gap Analysis Scoring Elements				Legend: H=3; M=2; L =1; & use 0 if further action required. Max score	
Explosives Sites Ranking	Risk	Inventory Size Layout and Siting (HML 0)	Complexity of Site Operations (HML 0)	Need for Customised BOS (HML 0)	Need for Experience & Expertise (HML 0)	Strengthening Requirement of Hazard Studies (HML 0)	Code
Explosives Sites	Inventory	Complexity	BOS	Expertise	PHS / SRA	Max 15	Allowance for Following A
1 United States							
Seneca	M	M	H	H	M	12	PSM activity (audits/hazard studies); PHA Revalidation (I Lake); SRA - F Barker; Insurance Audit (AIG); Vulnerability Audit (R Ferro); PSM Compliance Audits (3rd Party); PHS1 and PHS2 completed as part of PHA Revalidation; SHE Risk Register set up (I Lake); Siting remote from main township at Seneca, farm house within 1 mile of site; Site has co-occupancy (a non-Orica facility)
Geneva (50% JV)	N/A	N/A	N/A	N/A	N/A	N/A	PSM Activity, Insurance Audit (AON)
2 Canada							
Carseland	M	M	M	M	L	9	Hazard Studies (Vision 2000); Significant Risk Audit (F Barker); Insurance Audit (AON); Basis of Safety developed adjacent to industrial facility, but remote from site (Note*: BOS material needs to be reviewed)
Brownsburg	M	M	L	L	L	7	Hazard Studies well developed and executed; Insurance Audit (AON); Hazard Studies organised by Site HS Manager; Risk Register yet to be established
Tappen	L	M	L	M	L	7	Significant Risk Audit (F Barker); Virtual Facility Inspection (VFI); Insurance Audit (AON); SHE Systems Review; Significant hazard studied.
3 Latin America							
Brasil - Lorena	M	M	L	M	M	9	Significant Risk Audit (F Barker); SHE Systems Review (F Barker)



PHS Implementation

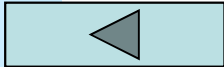
- In parallel the electronic SH&E Risk Register was developed as an enabler 
- Established as a hazard focused register of process technology related risks
- Serves as a risk assessment tool for generating the risk profiles required
- Also functions as a Study Authorisation and Action Management System to ensure that the outcomes are properly tracked and managed. 

Hazard Studies



SHE RISK REGISTER
Version 4.00

Study Summaries	All Reports
Hazard Studies	Fire Scenarios
Risk Assessments	Emergency Scenarios
Plant Dossier	Critical Controls
Meetings	

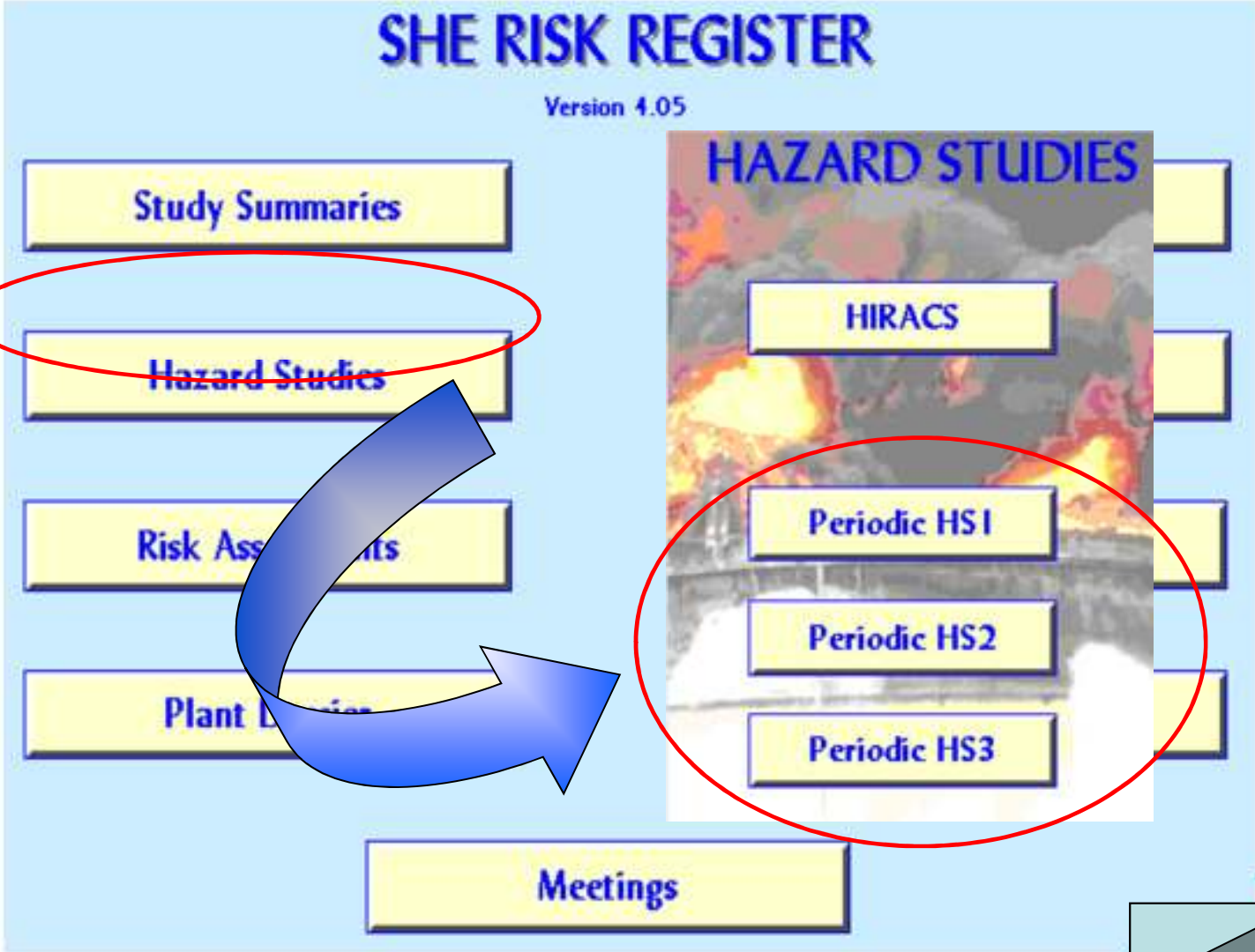
[Exit Database](#) [Risk Register Help](#) [Other SHE Risk Registers](#)
[Administration](#)



Implementation of PHS

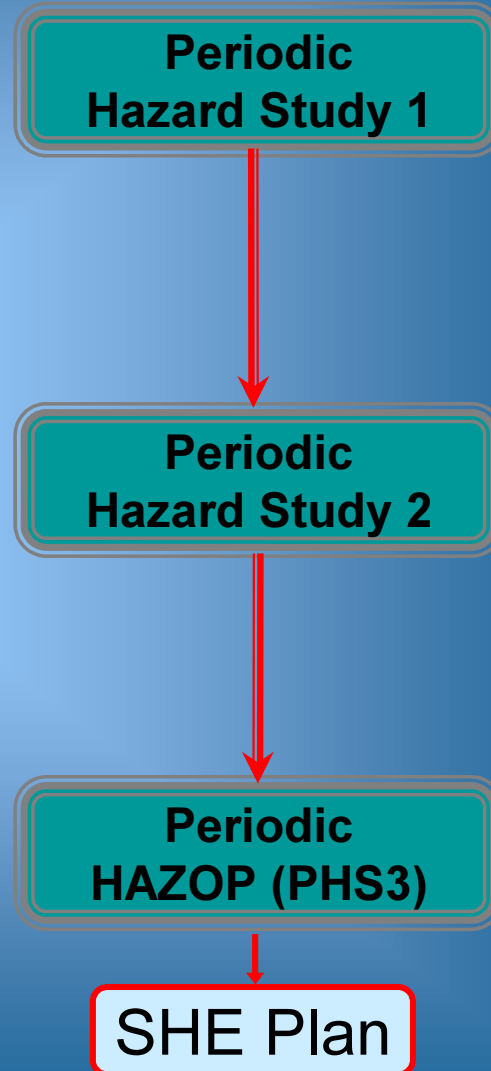
- PHS's are carried out every five years on hazardous facilities including plants, warehouses & storage facilities.
- They are led by an Orica-accredited Hazard Study Leader.
- PHS's are performed by a team of suitably qualified and experienced people
- The facility manager/delegate updates the facility's hazard scenario database. This is known as the SH&E Risk Register within Orica Mining Services and is fully transparent within the organisation. It is a Lotus Notes application. 
- Actions from PHS reviews are prioritised by the facility manager, included in the site SH&E Improvement Plan and for MHF sites in the Orica SHERMIS dB. 

Periodic Hazard Studies



3 Stages of PHS

- PHS1
 - A Gap Analysis of hazard related systems
- PHS2
 - A scenario based risk assessment (HIRAC)
- PHS3
 - A HAZOP of existing operations
 - “Focused” on area of concern



Periodic Hazard Study 1

- PHS 1 consists of a series of steps.

Set the team



Collect information

Populate the Risk Register



Complete the Gap Analysis

Agree the Key Gaps

Prepare/review the draft PHS1 report

Develop/agree actions arising.

Develop a further PHS strategy &
Resource Plan, including potential costs.



Selecting the Team

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HSCHCK/002 - Revision : C - Lotus Notes

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1 Quit 2 Trash 3 Save as Draft 4 File Completed Document

Hazard Study Participant	Hazard Study SH&E Basis (PHS1)	HAZID & Risk Matrix Review (PHS2)	Knowledge Based HAZOPs (PHS3)	Overview PHS Audit Assessment
HS Leader	✓	✓	✓	✓
Facility Manager	✓			✓
Operations Manager or Representative(s)	2	✓	✓	✓
Technical Manager or Representative	✓	✓	✓	✓ (Process Eng)
Maintenance Manager or Representative(s)	✓	✓	✓	✓
Plant Operating &	✓	✓	✓	✓

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Collecting Information

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Help Document : PHS1 Proforma - English Version - Lotus Notes

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PROFORMA No 1. PHS ASSESSMENT OF PLANT SYSTEMS

Facility/Plant		PLANT, SITE		Date: XX / XX / 0X	
Item	Examine	Comment/Action Required		Action By	
1.1	Plant Drawings (P&IDs) <ul style="list-style-type: none">How well have the plant P&ID drawings been maintained & updated? What mechanism is in place to ensure that P&ID revisions are being tracked? What quality are the P&IDs as representing the current detail of the operation?				
1.2	Plant Modifications <ul style="list-style-type: none">Has there been significant number of modifications (Plant Mods, Change Notices, Alteration Authorities) since				

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Agreeing Gaps

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Help Document : PHA & Revalidation Approach - OSHA PSM - Lotus Notes

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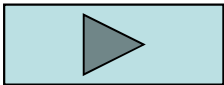

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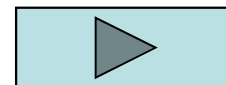
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PHA Revalidation Management Action Plan

No.	Action Required	by whom	by when	Link to detailed Notes PHA action
#1	• Summarise action required	eg JXM0	Day/Mth/XX	{doc link}
#2	•			
#3	•			
#4	•			
#5	•			
#6	•			
#7	•			
#8	•			
#9	•			
#10	•			

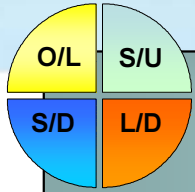
Periodic Hazard Study 2

- PHS 2 follows a different process
- Team much the same
- Need strength on the team around developing “what if?” questions
- First step is to develop a platform of scenarios 
- Can use Guide Words 
- Can also use previous HAZANs, QRAs, SRAs, instrumented system hazard studies, HAZOP’s, incident investigations and incident reports.



List of Scenarios

HAZARD IDENTIFICATION SUMMARY SHEET					
No	Activity Details	No. of Persons Exposed	HAZID Outline– What can happen and how?	Potential Consequence	Indicative Likelihood
Hazard Category Guide Words Apply to Each Hazardous Activity					
1.0	External Fire or Explosion				
1.1	grass fire		transformer arc, lightning, smoking, sparks from passing railcar, vehicle incidents creates grass fire and impacts on magazine, production area, mainenance area fuel and oxidiser storage mobile site transport of anfo.		
1.2	truck based fire e.g. tire		flaming truck ladened with explosives on enters site leading to detonation.		
1.3	burning ground		leads to grass fire; spontaneous combustion leading to un supervised burn; detonation during what should have been a trash burn leads to fatality; embers from previous burns detonates explosive contaminated trash leads to fatality.		



EXTERNAL FIRE / EXPLOSION

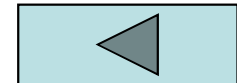
(flammables, combustibles, wastes, pyrophorics, dusts, unstable compounds)

Release Mechanism (LOC)

- corrosion/erosion
- fatigue, thermal cycling, vibration incorrect maintenance procedure*
- operated outside design
- puncture, mechanical failure*
- maloperation of openings*
- burst containment, missiles

Ignition / Initiation

- friction, static, sparks
- impact
- flares, furnaces, welding
- heat, hot spots
- autoignition
- lightning
- contamination



** vents, stacks, drains, reliefs, maintenance, construction material, gasket, pump seals, weld failure, sampling points, purging, blowdown, spillages, operator error*

Scenarios Reviewed in Depth

- Initial steps are to
 - Develop the causal contributors
 - Develop the potential consequences. (Potential consequences can be SHE related, property damage, business losses, external impacts or regulatory action.).
 - Develop the control measures, both preventative and mitigating
 - Placed in a *HIRAC*



HIRAC

Types of HIRAC's

Process HIRAC

Equipment HIRAC

PHS2 (MHF)

Job Risk Analysis

Environment Risk

- Process HIRAC
 - Typical process HAZID & risk assessment with Controls
- Equipment HIRAC
 - Equipment based human interaction risk assessment
- PHS2
 - A comprehensive Regulatory risk assessment (e.g. MHF)
- JRA (JSA/JSERA)
 - Activity & sequence based risk assessments
- ERA
 - Environment pathways & impacts (potentially offsite)

Risk Level Significance

- Next step in the scenario-driven process is to determine the significance of the risk level, given the controls in place.
- Each scenario has a number of potential outcomes which are related to the impact, and how close the person or persons are to the event.
- Both Consequence and Likelihood need to be considered in order to assess the actual Risk from the impact.

Risk Level Significance

- "Likelihood" is estimated from multiplying the initiating frequency by the probability of the consequences being realised,

$$\begin{array}{|c|} \hline \text{Likelihood} \\ \hline \text{P.A.} \\ \hline \end{array} = \begin{array}{|c|} \hline \text{Initiation} \\ \text{Frequency} \\ \hline \text{P.A.} \\ \hline \end{array} \times \begin{array}{|c|} \hline \text{Probability of} \\ \text{Consequence} \\ \text{being Realised} \\ \hline \end{array}$$

And : Probability of Consequence being realised = {Failure of Prevention and Mitigation Probability} X {Occupancy}

Assessing Risk

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HIRAC Minute : 00001 - Lotus Notes Desktop

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Human Factors (list items)	adequate to ensure no knock-on event Key Factors: HF1 : Operator training; HF2 : Authorised pump operators (formally certified); HF3 : Fatigued conditions outside normal hours	Supporting SMS Components (list items)	Key Elements: SMS1 : Audits of the safety equipment; SMS2 : Pump protection and housekeeping; SMS3 : Fire SMS4 : Cor (including v
Action	Review the audits undertaken for management of contractors vehicles to ensure that they are not more susceptible to the failure modes identified in the HIRAC analysis	Action By	Paul Harris
		Due Date:	30/06/2002

Risk Ranking

Case	Risk Type	Consequence Help -> ?	Likelihood Help -> ?	Risk -> ?
1	S - Safety & Health	Category 3.1	Unlikely	Level III
2	S - Safety & Health	Category 2	Very Unlikely	Level IV
3	S - Safety & Health	Category 1	Unlikely	Level IV
4	B - Business Liability	Category 3.1	Very Unlikely	Level IV

Click here to see / hide Risk Evaluation Basis

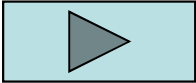
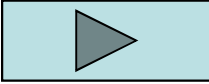

Notes:

1. Category 3.1 is based on operator attempting to intervene and being affected by heat radiation. If operator response was to evacuate then the consequence would have been restricted to Category 1.
2. Neighbouring operator assumed to be present in the harmful range or unshielded only 10% of the time.
3. Offsite damage is limited to projectiles. Public roadway is close to the boundary (less than 70 metres) and shrapnel could

Start HIRAC Minute : 00... Microsoft PowerPoint... Island 7:02

Risk Assessment using MP-SG-030

Establishing Critical Controls

- An important outcome of the HIRAC process & the key to effective process safety is the determination of critical controls. 
- The "bottom line" is how well we nurture and test these controls to ensure they will be effective if they are ever called upon. 
- If they are not in place, their criticality understood, their effectiveness ensured, their failures reported and acted upon, we can never say with assurance that the system of '*practicable preventability*' is well embedded in our process safety management program. 

Help Document : 01. Prevention Controls (Doc link) - Lotus Notes

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Engineering Prevention Controls {associated with Internal Events & L.O.C. mechanisms}	Procedural Prevention Controls {applicable to all events & loss mechanisms}
<p>SEGREGATION</p> <ul style="list-style-type: none"><input type="checkbox"/> Separation distances<input type="checkbox"/> Grading area around storage <p>BURST</p> <ul style="list-style-type: none"><input type="checkbox"/> Control system with backup ESD<input type="checkbox"/> Pressure relief devices<input type="checkbox"/> Vents<input type="checkbox"/> Alarms<input type="checkbox"/> Trip systems<input type="checkbox"/> Interlocks<input type="checkbox"/> Explosion suppression<input type="checkbox"/> Procedure for checking vents	<p>GENERAL</p> <ul style="list-style-type: none"><input type="checkbox"/> Signage: Warning signs or labels<input type="checkbox"/> Preventive maintenance system<input type="checkbox"/> Regular monitoring of equipment or plant condition<input type="checkbox"/> Job procedures or work instructions<input type="checkbox"/> Regular review of job procedure or work instruction<input type="checkbox"/> Rotation of jobs to reduce exposure <p>SPECIFIC PROCEDURES</p> <ul style="list-style-type: none"><input type="checkbox"/> Control of ignition sources<input type="checkbox"/> Clearances procedure<input type="checkbox"/> Modifications procedure

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Critical Control : Fire protection system -High Speed/High Volume Deluge System* - Lotus Notes


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1 New Audit Checklist 2 Edit Report 3 Print

CRITICAL CONTROL DATA SHEET

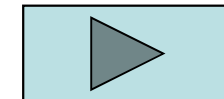
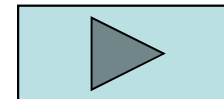
Critical Control Identifier:	Fire protection system -High Speed/High Volume Deluge System*
Owner/Responsible:	Tracey L Ackerman/US/EXP/ORICA
Custodian's Role:	Charlestown IN
Relevant Scenarios: (Removal of control substantially increases risk)	
Critical Feature Details: 	2 Infared Dectectors in Primary filter and 1 Infared Dectectors in Primary Reciever. 7 UV Dectectors throughout Giante Room.
Functionality:	Sprinkler located directly over operator position to protect the operator from the effects from a flash fire. 2 Sprinkler heads in primary filter and 1 Sprinkler heads in primary reciever. The response time of the system is ???
Availability:	The system needs to be available during room operations.
Reliability:	The system needs to have a failure on demand of less than 1×10^{-4}
Survivability:	The system needs to survive instantanious flash fire.



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Periodic Hazard Study 3

- PHS 3 is essentially a HAZOP Study that has been determined as being required by the PHS 1 and PHS 2 processes.
- A very focused HAZOP Study.
- Done on areas that have been identified by PHS2 as requiring immediate attention.
- Guide Words and knowledge based Checklists can be used



Help Document : 03. Guidewords (Doclink) - Lotus Notes

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Document	Rev	File
Knowledge Based HAZOP Checklists		
KBHC/001	A	Process Safety
KBHC/002	A	Personnel Safety
KBHC/003	A	Fire Safety
KBHC/004	A	Process Piping
KBHC/005	A	Electrical Safety
KBHC/006	A	Boiler & Machinery
KBHC/007	A	Heat Exchangers
KBHC/008	A	Pumps
KBHC/009	A	Centrifugal Compressors
KBHC/010	A	Positive Displacement Compressors
KBHC/011	A	Control Valves
KBHC/012	A	Process Towers & Drums
KBHC/013	A	Reactors

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Capture the Actions and Manage Them

SH&E Action Management - 5. Risk Register Actions - Lotus Notes Desktop

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SH&E Action Management

- 00. ASSIGNED TO ME
- 1. Actions
- 2. Actions by Status
- 3. Housekeeping
- 4. SHERMIS Issues
- 5. Risk Register Actions
- LOA RockleaActions
- ZExport
- Administration
- Support
- KPI completed
- KPI outstanding not ov
- KPI overdue
- SaveOptions
- Agents

Site	Op Unit	Srcce	Assigned To	Due Date	Resolved Date	Priority	Action to be Taken
▼ DEER PARK							
▼ A&R DEER PARK							
▼ Major Hazard Facility							
			Lisa M Wild	20/09/2002	27/09/2002		Set up emergency plan testing schedule in acc with MHF Reg 305 (5) i.e. maximum 3 yearly in between tests
			Angus N Kay	30/04/2003			Establish a job cycle check program to audit c with work instructions/operating instructions. Co also if this program fulfils the requirements of er operators retain the knowledge of operating the formal refresher training program
			Lisa M Wild	30/08/2003			Develop a list of persons responsible for each f Procedure (critical & non-critical)
			Lisa M Wild	15/02/2003	09/08/2002		Populate the A&R training matrix with informat to training needs vs positions. Include MHF trai module in the matrix
			Lisa M Wild	30/03/2003	22/10/2002		Include in the SHE Improvement Plan a KPI wh considers review of performance of critical contr measures & critical SMS elements
			Simon A Farrar	31/05/2002	25/05/2002		Formally document the definition of criticality u A&R i.e. what criteria is used to select a contr as critical
			Simon A Farrar	31/05/2002	31/05/2002		Develop an auditing program for MHF critical c measures & critical SMS elements
			Simon A Farrar	22/11/2002	20/11/2002		Upgrade modifications system with the followir improvements: 1. Implement modification comp checklist 2. Risk Register review required 3. La versions of various forms to be included e.g. prc mods, manufacturing review form (3F2) from NF 4. Train necessary people in importance of moc system and revised forms
			Simon A Farrar	29/11/2002	20/11/2002		Complete refresher training for all relevant pers on the MHF HAZID/Safety Assessments. The t should include: 1. HAZID/Safety Assessment r

Office

How Are We Doing?

- It's a journey . . .
- If you think Safety is expensive . . .
- Some good results from the AN side . .

“What we've learnt is that process safety risk management is never done, it's an ongoing commitment from all people on site and has become a part of what we do every day.”

Site Comments . . .

- “A big step forward made in the past 18 months has been integrating risk assessments into our day-to-day activities eg
 - When a modification to the start-up procedure was proposed, the relevant scenario was reviewed and updated to ensure that the risk remained acceptable.
 - When the control room is moved, we will use data from the scenarios to ensure the location and design of the building provides the best protection.
 - We have changed the trip testing on some AN pumps to better protect them.
 - The need to install a de-superheater on steam to the AN Plant has been confirmed.”

Further Site Comments . . .

- “During an incident investigation to a compressor failure, a risk assessment was developed to see what controls were required to prevent this type of incident resulting in serious consequences, such as multiple medical treatment cases.
- This year’s team training will focus specifically on operating procedures that are critical controls.
- An audit program has been introduced to ensure critical controls are in place and effective.

The Journey . . .

- “We have a long way to go yet though – in fact we will never be “finished”.
- The risk assessments are an evergreen tool.
- As we learn more about our plant through technology, research, and our own and others’ incidents, we constantly refine our scenarios and critical controls.
- Everyone on site realizes the benefit of minimizing the risk of disastrous high consequence events.”

Notable Quotes . . .

- Kletz – if you think safety . . .
- Buchan . . .