PETROCHEM DAY 2018

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PROCESS HAZARD ANALYSIS - PHA

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Management Force

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MANAGEMENT FORCE GROUP

With EHSS projects and project contacts already in TWENTY EIGHT (28) countries, most around the Mediterranean Sea and in Balkans, MFG is an EHSS Consultant of Choice and the leader in Safety Management in construction in Southeastern Europe.

IN CONSTRUCTION ALONE

MFG has been involved in projects totaling 50+billion Euros.
MFG clients have been responsible for over of the two thirds of that.

MFG works for (list in order of value of MFG contracts/services):

- Contractors
- Owners/Investors & PMCMs
- Designers
- Subcontractors

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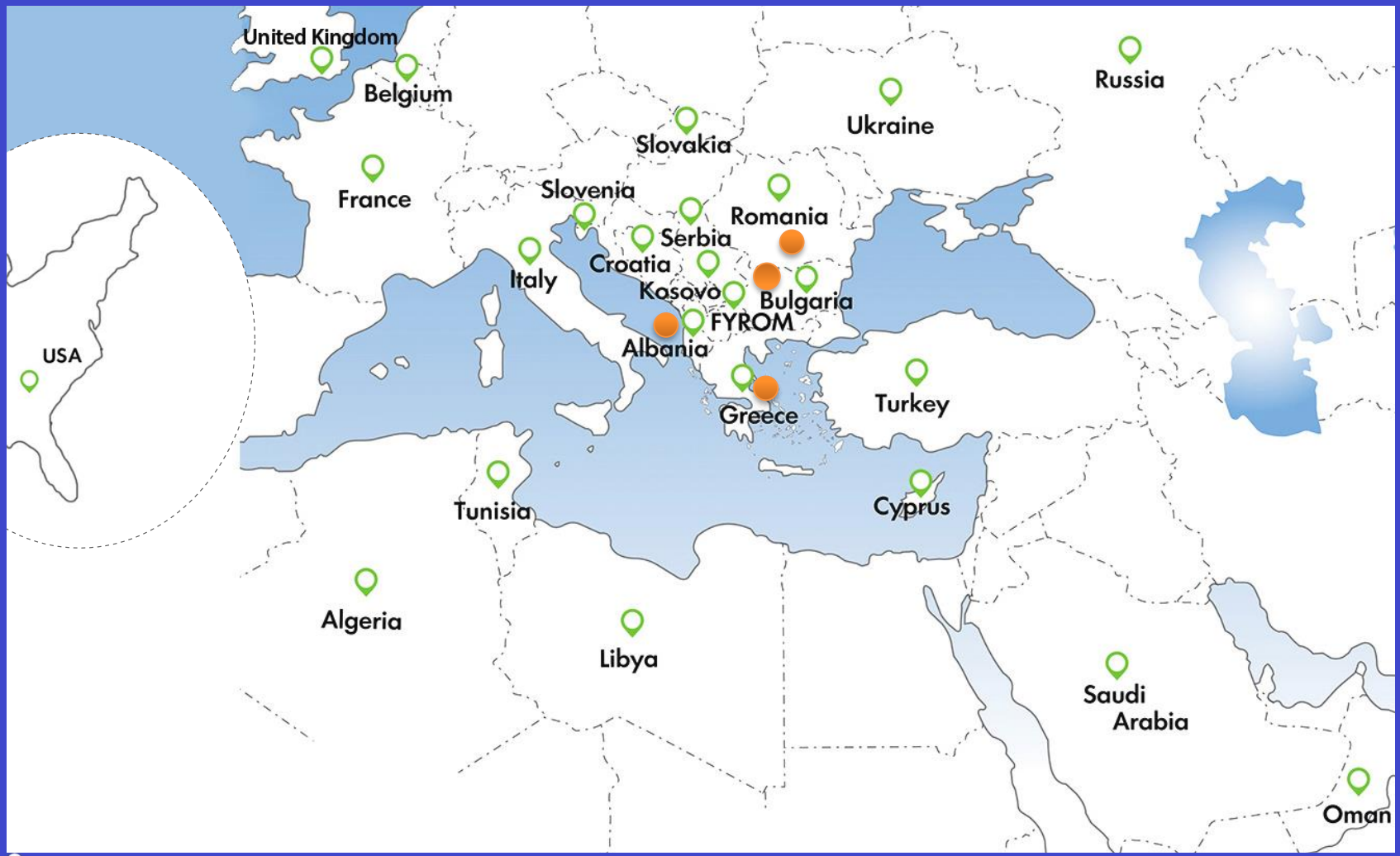
GEOGRAPHICAL EXPANSION



Projects

Established offices

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SERVICES PORTFOLIO

Management systems
- H&S Management Systems (OHSAS18001)
- Environment Management Systems (ISO14001)
- Integrated (Quality &) EHSS Management Systems
- Project EHSS Management Systems
- Contractor's Management

In Situ Resources and Consultancy
- H&S Coordination during design phase
- H&S Coordination during construction
- Safety Practitioner & physician
- Project EHSS Management
- Operations EHSS Management
- EHSS Supervision
- PtW & LOTTO Management
- Measurements & monitoring of agents

EHS & Risk Studies
- ATEX
- Hazop – Hazid
- Risk Assessment & QRAs
- Seveso Safety Case
- Gap Analysis
- Benchmarnking for re-engineering and Business Optimisation (BRBO)
- Environmental studies & ESIA
- Health and Safety Plan
- Health and Safety File

Other services & products
- EHSS Software solutions
- Safe pass
- EHSS Audits
- Incident investigation & analysis
- EHSS Coaching (ICSI)

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MAJOR EVENTS IN THE LAST 25 YEARS

Piper Alpha
1988

Pipeline explosion
Nigeria 1998

Mumbai High
North platform
fire 2005

Buncefield fire UK
2005

Helicopter crash
North Sea 2009

Kolskaya oil rig
sunk 2011

Exxon Valdez
1989

Petrobras P36
2001

Texas City
refinery
explosion 2005

S. Korea tanker
spill 2007

Deep Water
Horizon 2010

Rayong Oil
Spill 2013

REQUIREMENTS

- Legal compliance:
  - SEVESO; N.G. transport system;
  - ATEX 137;
  - The Pressure Systems Regulations 1999
  - Offshore Directive
  - OSHA's Process Safety Management standard
  - HS at Work Regulations: Prevent incidents;
- Business optimization:
  - Less interruption, no loss of production, increased productivity, higher turnover/profit.

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REQUIREMENTS

- Costs saving:
  - Insurance premiums;
  - Cheaper/sometimes only possible to intervene during design than later.
- Corporate image:
  - Less problems with authorities, no incidents;
  - Easier permitting;
  - Easier investment, market more accessible to good performers.

PROCESS RISK MANAGEMENT OBJECTIVE

- Identify hazards as early as possible, in order to determine the most appropriate “solution” for managing their risk;
- Modifications made early in the design stage of project have minimal effect on cost and schedule;
- PHA methodology shall be appropriate to the complexity of the process.

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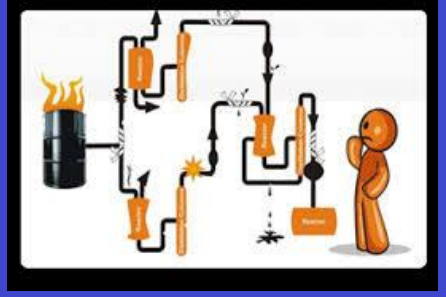
WHAT IS PHA?



- Proactive and systematic identification and evaluation of “incidents” that could occur as a result of failures in process, procedures or equipment;
- It provides the structure upon which an effective Process Safety Management program is designed and built;
- It is applied during the detailed design of a Project and before applying a “design change” during normal operation.

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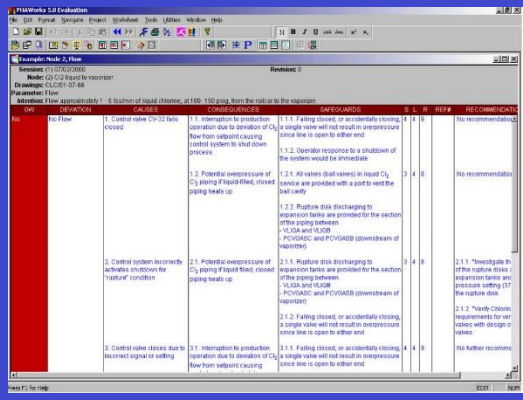
THE PHA MUST ADDRESS



- Facilities description/sitting.
- Components/Equipment in the process;
- Hazards of the process;
- Consequences of deviations or failures;
- Engineering and administrative controls;
- Human factors;
- Evaluation of consequences and effects; Qualitative/Semi-Quantitative;
- Steps required to correct or avoid failures/deviations.

RISK STUDIES PER PROJECT PHASES

Concept Design	Basic Design	Detail Design	Construction	Start up & Commissioning	Operation & Maintenance	Decommissiong
• HAZID (high Level) • Coarse Risk Assessment	• HAZID • HAZOP • QRA • Basis of Safety • Layout review	• HAZID • HAZOP • SIL • QRA • HAC/ATEX • SCEs Performance Standards • Fire Risk Assessment • HSP/HSF	• HSP/HSF • Construction HAZID & Risk Assessment • Risk Studies revision according to design changes	• OHRA • HS MS Documents • Risk Studies revision according to as build • Pre-Startup Safety review	• OHRA • HS MS Documents	• HAZID • HSP/HSF

Preliminary HSE Report → Design HSE Case (or COMAH or HSEIA or SEVESO) → Operation HSE Case → Decommissiong HSE Case

Hazards & Effects Register

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PHA METHODOLOGIES

- Hazard and Operability – HAZOP;
- Hazard Identification – HAZID;
- Bow Tie Analysis;
- What-If analysis;
- Checklists;
- Failure Mode and Effects Analysis –FMEA;
- Fault Tree Analysis;
- Combination of the above.

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HAZOP

- **Hazard and Operability study (HAZOP):** A systematic approach to identify hazards and operability problems occurring a result of deviations from the intended range of process conditions;
  - Qualitative technique based on use of guide words which question how the design intention or operating conditions might not be achieved at each step in the design, process, procedure or system
  - Identification of potential deviations from the design intent, examination of their possible causes and assessment of their consequences

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HAZOP OBJECTIVES

- Identify Hazards
  - Fire/Explosion
  - Toxicity
- Identify Exposures
  - Local,
  - Entire Facility
  - Surrounding Community
- Review Design
  - Safeguards
  - Errors/Omissions
  - Procedural Problems
  - Compliance With Code/Standards

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HAZOP FEATURES

- Modes of operation;
- Trigger events/Causes;
- Hazardous conditions;
- Corrective actions;
- How would hazardous conditions detected ;
- Contingency actions;

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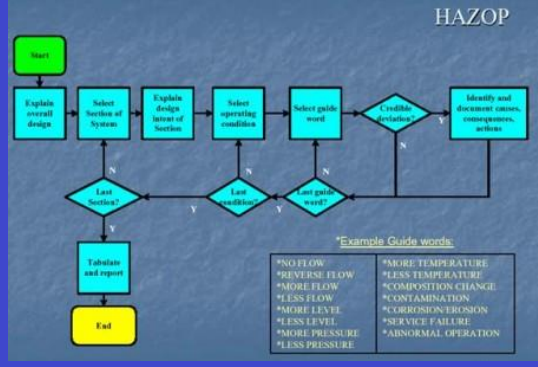
HAZOP



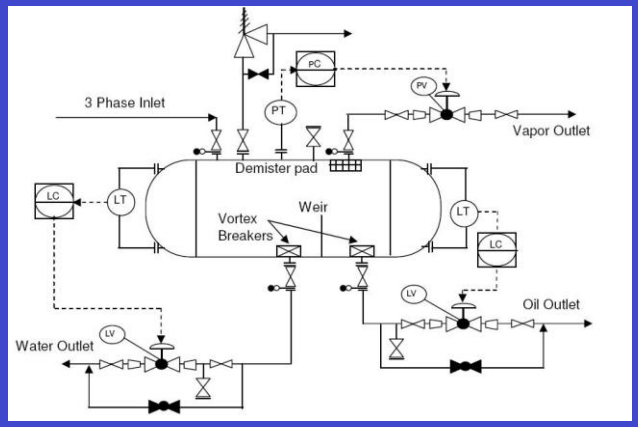
- Team Work:
  - Chairman, Process, Safety, Operation, Maintenance, Instrument, Other.
- Systems/processes are divided into nodes;
- Each node systems/components is systematically questioning in order to establish how deviations from the design intent can arise;
- Appropriate guidewords and deviations are used to focus the attention of the team upon deviations and their possible causes.

NODE SELECTION

- System, process or procedure is divided into smaller elements (Nodes) to make the review tangible
- Each process line/vessel usually consist one node. Factors to be considered :
  - Each Node should contain active components, which gives rise to deviations, e.g. piping which contains control valves can give rise to flow deviations, heat exchangers can cause T deviations.
  - Materials handled
  - Process and states of materials. Only 1 process operation per 1 node.

HAZOP GUIDE WORDS

- Appropriate guidewords and deviations are used to focus the attention of the team upon deviations and their possible causes.
  - Flow: Low/No/High/ Reverse
  - Pressure: Low/High
  - Level: Low/High
  - Temperature: Low/High
  - Different Composition / Contamination
  - Corrosion/Erosion/Deposition
  - Loss of power / utilities / instrumentation
  - Isolation / Drain / Vent
  - Start-up / Shut down
  - Other



GUIDE WORDS/PARAMETERS/DEVIATIONS

- Standard set of deviations per item

ID No.	Deviation	Column	Vessel	Line	Exchanger	Pump	Compressor
1	High Flow			X			
2	High Level	X	X				
3	High Interface		X				
4	High Pressure	X	X	X			X
5	High Temperature	X	X	X			X
6	High Concentration	X	X	X			
7	Low / No Flow			X			X
8	Low Level	X	X				
9	Low Interface		X				
10	Low Pressure	X	X	X			X
11	Low Temperature	X	X	X			X
12	Low Concentration	X	X	X			
13	Reverse / Misdirected Flow			X			X
14	Tube Leak				X		
15	Tube Rupture				X		
16	Leak	X	X	X	X	X	X
17	Rupture	X	X	X	X	X	X

DEVIATIONS, CAUSES AND CONSEQUENCES

- Once a deviation is considered valid, the causes are analyzed and consequences are defined.
- Risk evaluation process:
  - Barriers are recorded
  - Assessment and evaluation of risk
  - Recommendations if risk is high
- Process is repeated for all guide words
- Typical assumptions:
  - No catastrophic loss, No double jeopardy, Good faith

ASSESSMENT OF RISK

- The Risk Assessment approach for the PHA includes the assessment of:
  - Raw Risk;
  - Residual Risk;
  - Final Risk.

RISK RANKING

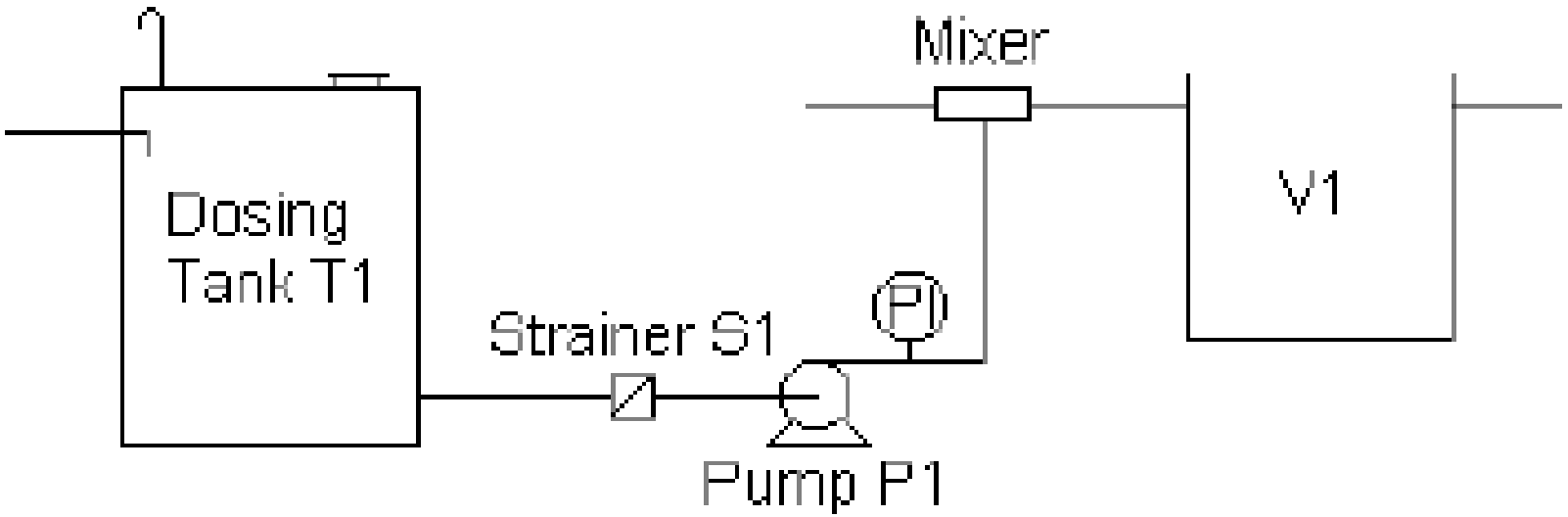
Severity		Likelihood				
		1-Very Unlikely ($<10^{-6}$)	2- Unlikely (10^{-6} to 10^{-4})	3- Likely (10^{-4} to 10^{-2})	4- Very likely (10^{-2} to 10^{-1})	5- Certain (10^{-1} to 1)
5-Catastrophic	Internal: many fatalities External: irreversible effects, multiple fatalities	5	10	15	20	25
4-Very Extensive	Internal: Fatality. External: irreversible effects, fatality, public evacuation	4	8	12	16	20
3-Critical	Internal: major injuries. External: irreversible effects, public shelter in place	3	6	9	12	15
2-Marginal	Internal: small injury. External: reversible effects	2	4	6	8	10
1-Negligible	Internal: First aid, keep working. External: no effects	1	2	3	4	5

UNACCEPTABLE

ALARP

ACCEPTABLE

ANALYSIS EXAMPLE

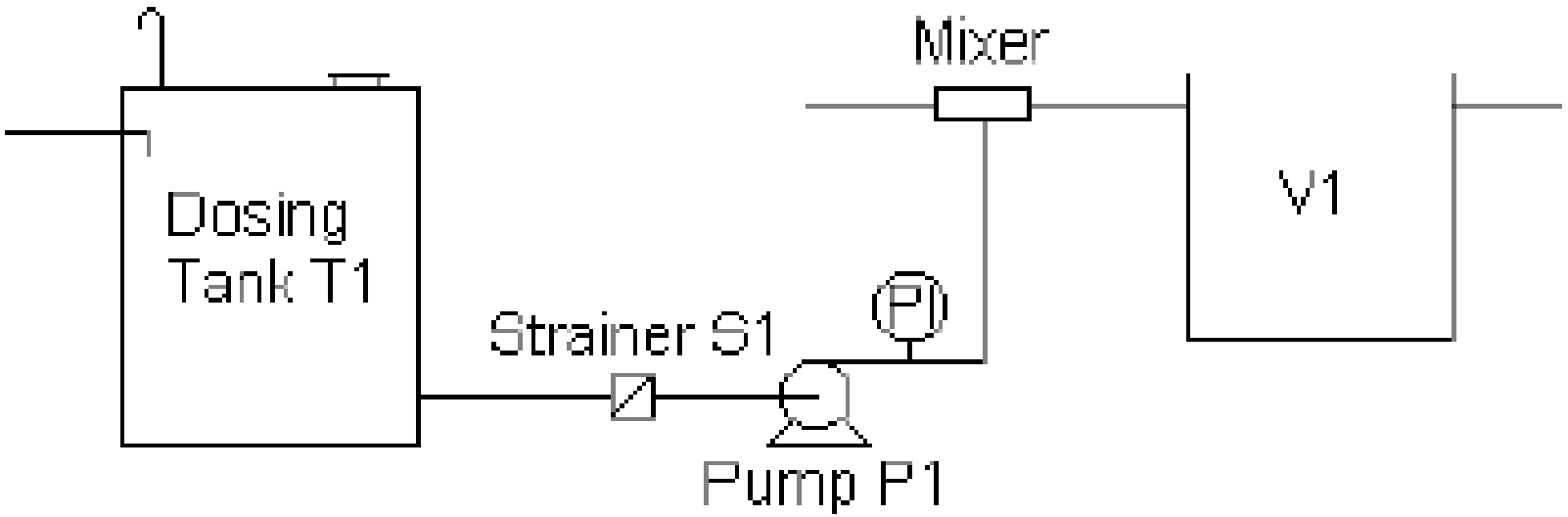


Deviation	Cause	Consequences
No Flow	Strainer S1 blockage due to impurities in Dosing Tank T1	Tank T1 High level, overflow, hazardous atmosphere Cavitation in Pump P1, loss of process

BARRIERS

- Team is looking for barriers which will prevent top event/consequences:
  - Basic process control system;
  - Alarm system;
  - Safety interlock system;
  - Relief system;

ANALYSIS EXAMPLE



Deviation	Cause	Barriers
No Flow	Strainer S1 blockage due to impurities in Dosing Tank T1	Tank T1 High level alarm Pump P1, overheating protection Flow monitoring and no flow alarm

HAZOP DOCUMENTATION

- Worksheets
  - Deviation/causes/safeguards & barriers/risk assessment/recommendations/responsible/due date/etc
- Action Sheets
- Marked up P&IDs
- Actions acceptance sheet
- Team Members list
- List of drawings, specifications, etc considered

HAZOP FOLLOW UP

- Project Manager responsibility
  - Progress/Implementation of agreed actions monitoring
  - HAZOP review if significant changes are introduced

HAZOP ADVANTAGES

- Systematic, reasonably comprehensive and flexible.
- Suitable mainly for team use whereby it is possible to incorporate the general experience available.
- Provides good identification of cause and excellent identification of critical deviations.
- Group work.
- Excellent well-proven method for studying large plant in a specific manner.
- Identifies virtually all significant deviations on the plant, all major accidents should be identified but not necessarily their causes.

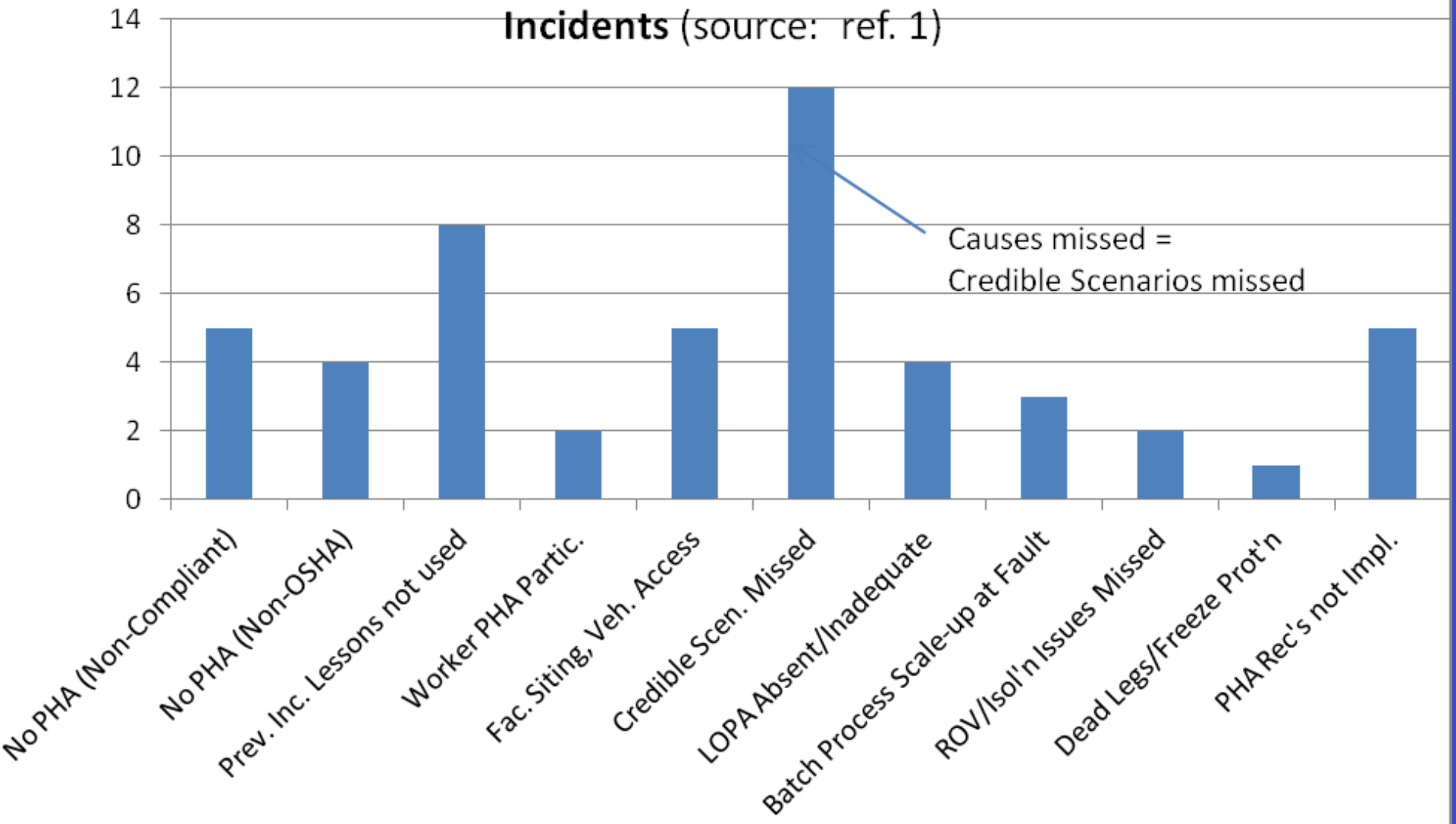
HAZOP DISADVANTAGES

- Time consuming.
- Tends to be hardware-oriented and process-oriented, although the technique should be amenable to human error application.
- Generate many failure events with insignificance consequences and generate many failure events which have the same consequences.
- It takes little account of the probabilities of events or consequences, although quantitative assessment can be added.
- The group generally let their collective experiences decide whether deviations are meaningful.

ALWAYS BE ALERT

- PHA may not identify all incidents that could occur in a process if:
  - A scenario may be excluded from the scope of the analysis;
  - The team may be unaware of a scenario;
  - The team consider the scenario but judge it not credible or significant;
  - The team may overlook the scenario.
- No shortcuts; systematic consideration;
- PHA team experience and expertise.

Figure 1. Pareto Analysis: Contributing Factors to Serious Incidents (source: ref. 1)



Mark Kaszniak, —Oversights and Omissions in Process Hazard Analyses: Lessons Learned from CSB Investigations‖, presented at the AIChE 2009 Spring National Meeting, 5th Global Congress on Process Safety, 43rd Annual Loss Prevention Symposium, Tampa, Florida (April 26–30, 2009)

SUMMARY

- The Process Hazard Analysis is the backbone of the Process Safety Management program;
- PHA is the tool to achieve:
  - Risk reduction;
  - Business optimization.

- Questions?

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