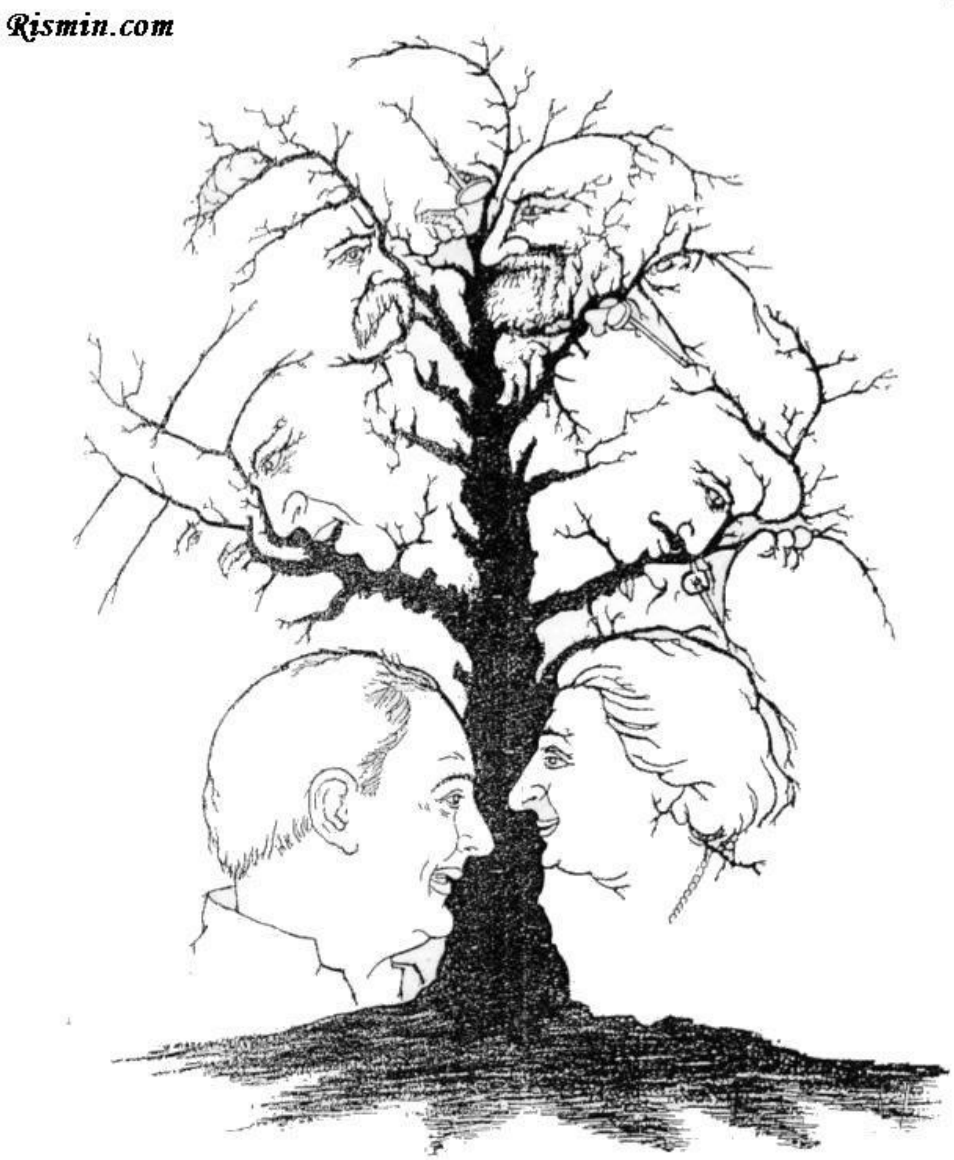
Incident Investigations

Learning from Incidents

- Recall the primary message from the safety triangle:
- Causes of all incidents, including near misses, fall into categories
- Causes of incidents within these categories are similar regardless of the consequence levels
- Therefore: Learn from the more numerous events at low consequence levels to help prevent the more costly incidents.

Investigation Components

- Develop a detailed description of the incident
- Accumulate relevant information employing a fact-finding and not a fault-finding style – No blame policy
- Construct possible causes, immediate and underlying, of the incident
- Develop the most likely causes based on an analysis of the system and operating method
- Construct recommendations to prevent or reduce repetition of this type of incident or cause



NATIONAL LEADERS TREE

Investigation Principles

- Investigations are opportunities to improve safety and management systems rather than opportunities to assign blame
- The majority of incidents are related to or the direct result of defects in management systems.
- Therefore, “failure to follow established procedures” is usually not a fundamental or root cause.

What Incidents to Investigate?

- Catastrophic incidents for which there is much concern and energy to investigate
- Near-miss incidents, which have the potential for a catastrophic incident
- Subjectivity is an element in such decision.
- There are various criteria for selection of incidents for detailed investigations.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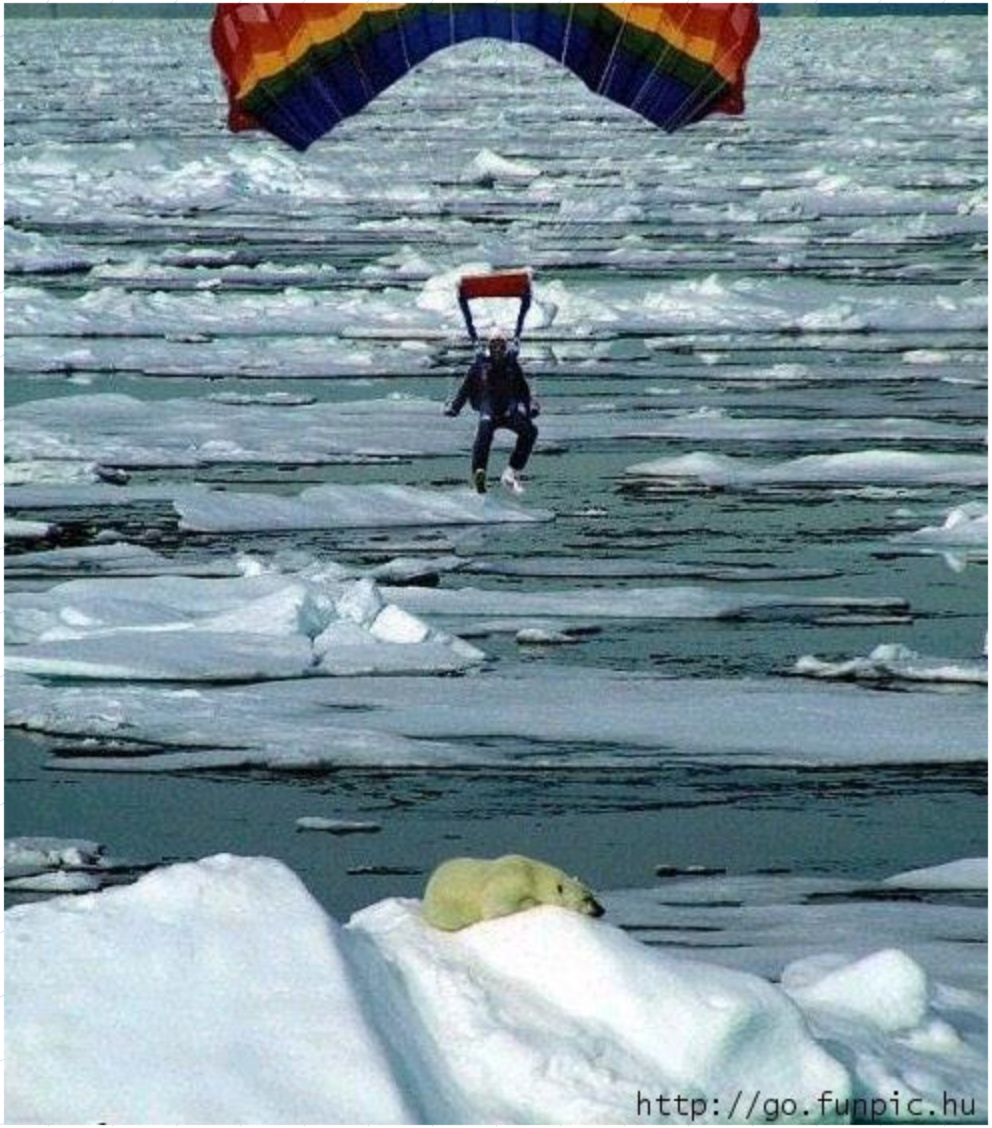
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American Chemical Council (ACC) Guidelines

- Threshold
- Chemical /Process
- Location

Threshold

- Fire or explosion with damage > $25,000
- Release of a quantity of chemical that qualifies under the Superfund Amendments and Reauthorization Act (SARA1986)
- Release of > 5,000 lb of a flammable material
- Fire or explosion resulting in one or more fatalities or serious injuries

Chemical/Process

- A chemical or chemical process was directly involved in the incident
- Employee injuries that were not involved in the process are not included

Location

- The incident occurs inside a PSM-covered facility
- Transportation incidents may be investigated if the threshold and chemical/process criteria are satisfied

Incident Reporting

- If it is not reported, it cannot be investigated.
- If it is not investigated, it cannot be changed.
- If it is not changed, it cannot be improved.

Investigation Team

- Team leader
- Team members
- Development of a specific plan

Approaches to Investigations

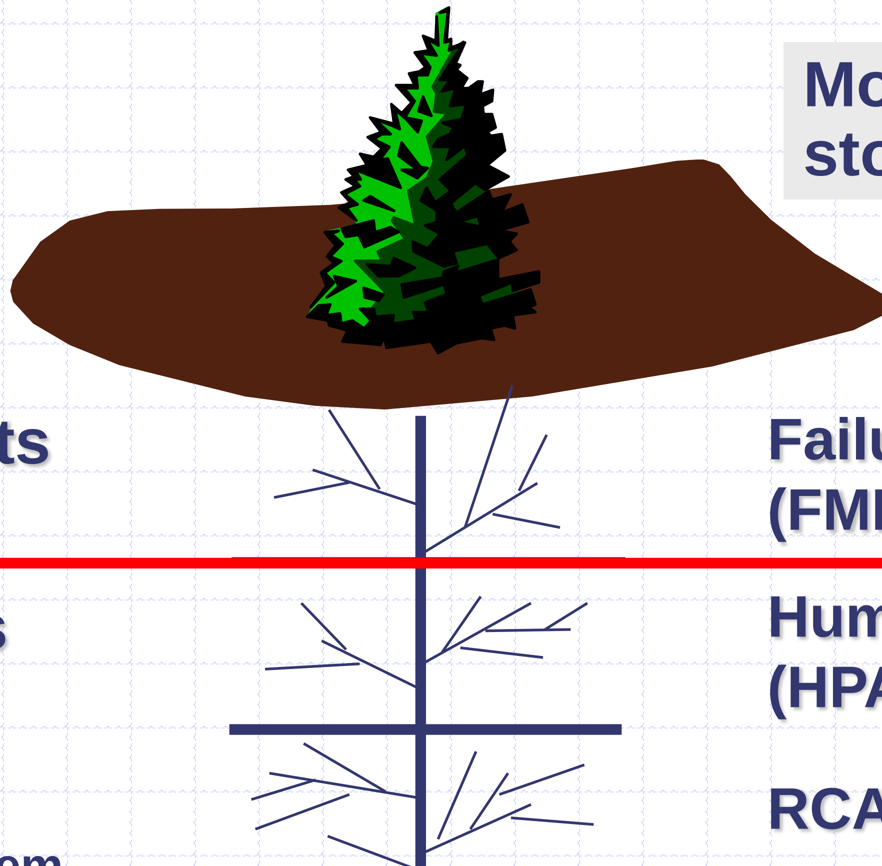
- Informal: to find quick remedy, conducted by immediate supervisor
- More formal: find single cause and solution, performed by expert committee
- Systems oriented committee to focus on multiple causes and determination of root cause and strategies that affect the process safety management program

Root Cause

A root cause is an *underlying primary cause* of an incident. Often root causes are associated with deficiencies in management systems.

- A root cause determined for a given incident applies to a broad range of possible incidents.
- A root cause is therefore a cause that can lead to recurrence of this and similar incidents, which is consistent with the safety triangle principle.
- Categories of root causes: system *design* and system *implementation* deficiencies.

Root Cause



Most investigation stops here

Physical Roots
Facility

Failure Analysis (FMEA)

Human Roots
Human interrupt

Human Error Analysis (HPA)

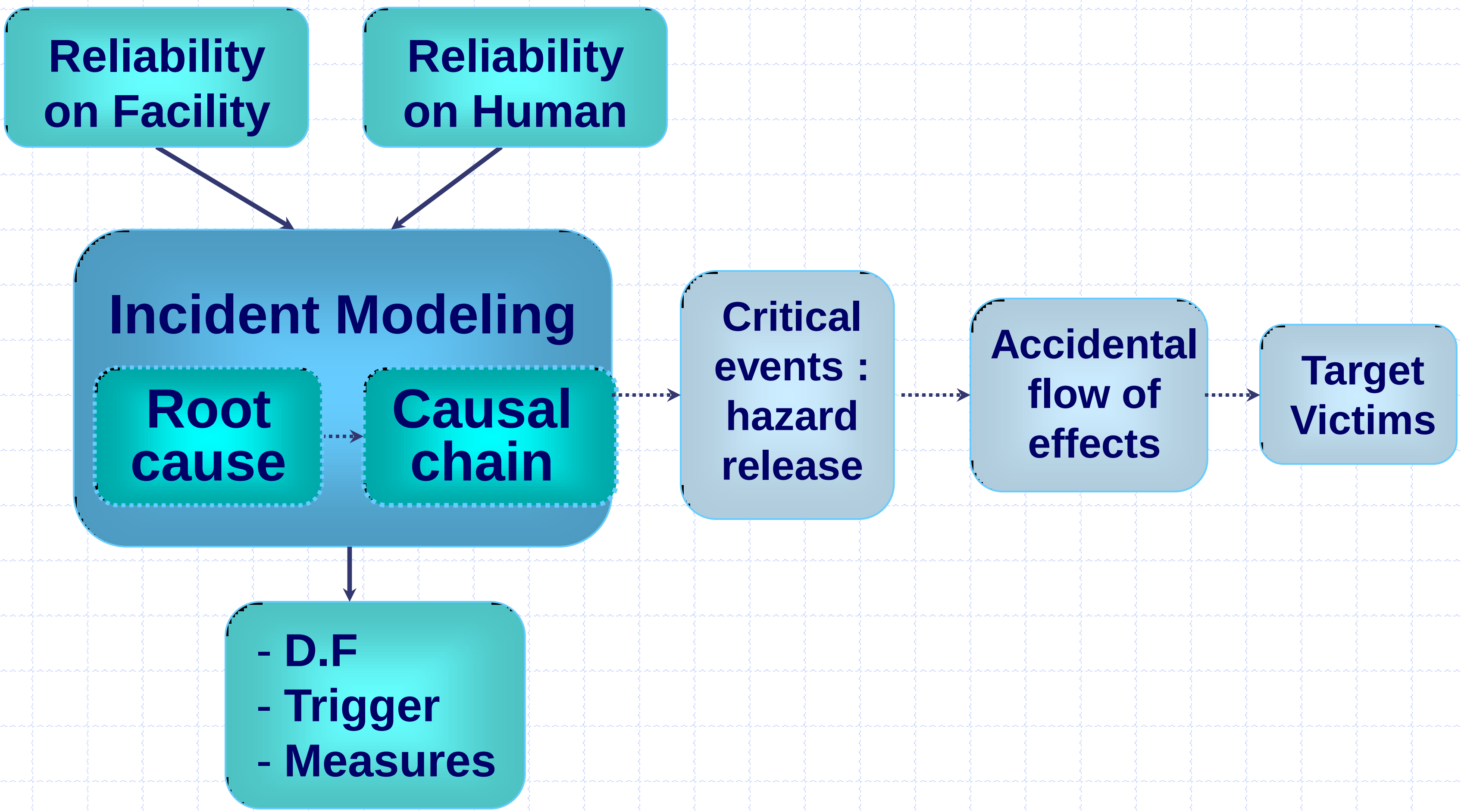
Latent Roots
Management system

RCA

Layered Investigations

- Three levels of recommendations for preventing and mitigating incidents:
  - First layer: immediate technical recommendations to reduce or avoid the hazards
  - Second layer: recommendations to break the chain of events leading to the incident
  - Third layer: recommendations to improve the management system

ACCIDENT MODELLING



Investigation Categories

- Deductive
- Inductive
- Morphological

Deductive

- Reason from general to specific
- Postulate failure event, then determine modes of system or component, or operator behavior that contributed to the failure
- Looks backward in time, e.g, fault tree
- Suitable for a root cause analysis

Inductive

- Reason from an individual case to a general conclusion that can lead to this case and similar cases
- Postulate initiating event, then determine expected effects or consequences
- Looks forward in time, e.g, HAZOP

Morphological

- Broad scope, based on structure of the system
- Identify factors that have the most significant influence on the system
- Uses insights from past experience in this identification process
- Usually less detailed and rigorous than a formal hazard analysis

Sources of Evidence, 1

- P&IDs, instrument & electrical drawings
- Operating procedures, training manuals
- Design calculation bases
- Scenarios for sizing relief & emergency systems
- Alarms and set points, control software logic
- MSDS, descriptions of chemical reactions
- Past incident reports and records
- Site maps, plot plans

Sources of Evidence, 2

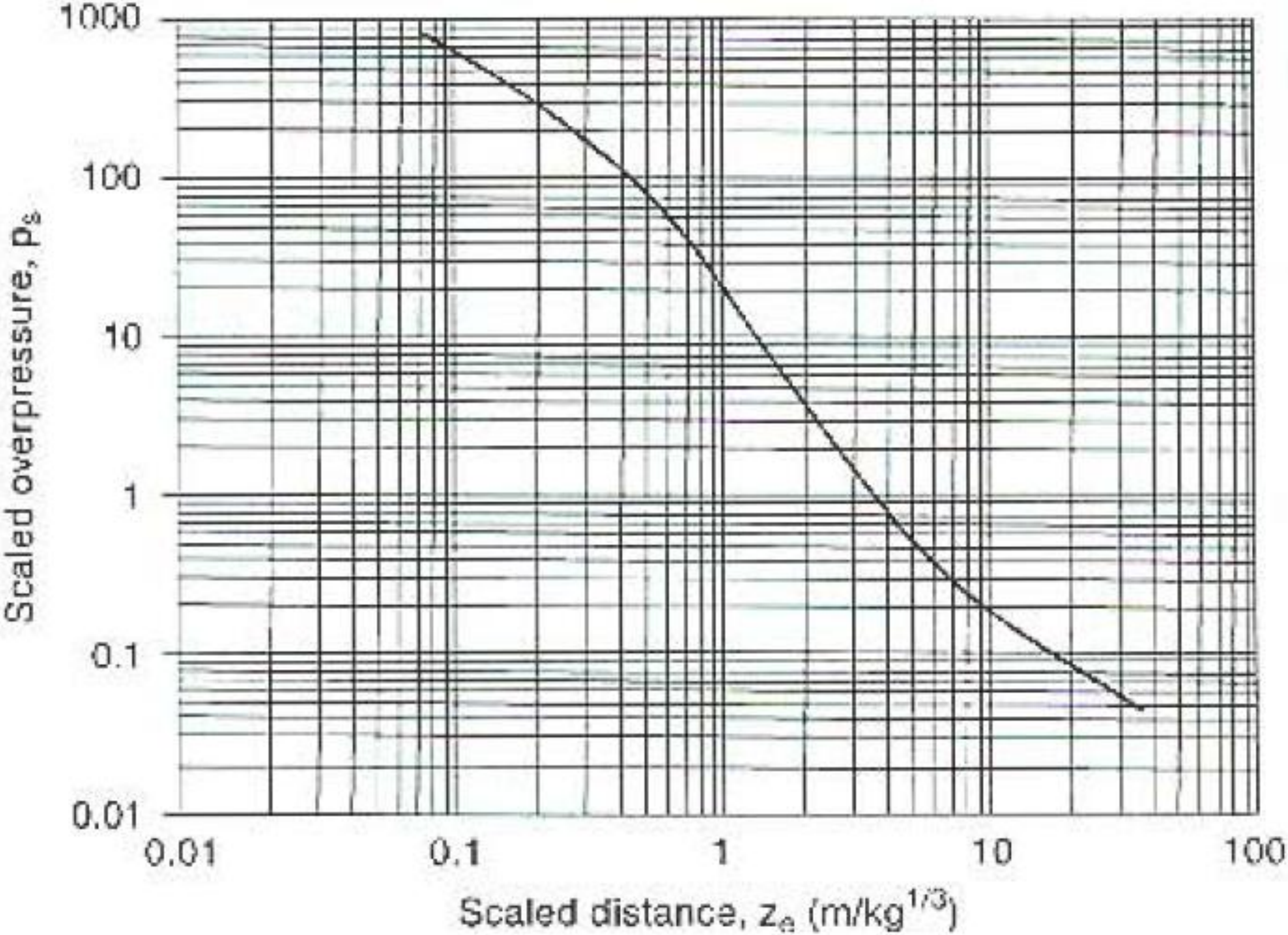
- Control instrument records, shift logs
- Maintenance records
- Run histories, batch sheets
- Raw material quality control records
- Retainer samples
- Emergency response logs and recordings
- Field instrumentation devices
- “As found” position of valves, switches, indicators

Sources of Evidence, 3

- Rupture disk integrity
- Residual liquid inventories and samples
- Blast and damage patterns
- Meteorological records
- Dispersion calculations
- Consequence analysis, PHA studies
- News media video
- Contacts with other manufacturers with similar processes; practices for this industry

Sleuthing Tools

- Information available for analysis includes condition and final states of components and materials.
- Damage to vessels: yielding and failure
- Explosion energy from position of fragments: Fig. 6-26, p. 279.
- Explosion overpressure estimated fro m overall damage: Tab 267, p. 267



1000
100
10
1
0.1
0.01
Scaled overpressure, p_s
0.01
0.1
1
10
100
Scaled distance, z_e (m/kg$^{1/3}$)

Pressure Effects

Cylindrical vessels, $p < 0.385 \cdot S_M$:

$$p = \frac{S_M t_v}{r + 0.6 t_v}$$

Spherical vessels, $p < 0.665 \cdot S_M$:

$$p = \frac{2 S_M t_v}{r + 0.2 t_v}$$

p, gauge pressure to cause deformation
S_M, yield strength
p, gauge pressure to cause failure
S_M, tensile strength
t_v, wall thickness
r, inside radius

Root Cause Analysis

Why did the fire occur?	**Gas released from heater.**
Why did the heater tube rupture?	**Stagnant liquid overheated.**
Why was the liquid not flowing?	**Heater blocked from pump.**
Why was heater blocked in?	**Operator, undetected error.**
Why was operator not alerted?	**Flow and *T* alarms out.**
Why did the flow & *T* alarms fail?	**No systematic inspections.**
Why the safeguards not tested ?	**Inadequate PSM mechanical integrity program (MIP).**

(Approach from Apollo Assoc. Services, *Root Cause Analysis*, Friendswood, TX, 1996)