



# Lessons from Texas City

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# Texas City Refinery

- Texas City refinery is located 40 miles from Houston in Texas, USA
- 1600 people work at the refinery plus contractors
- It is one of the largest refineries in the USA, processing 460,000 barrels of crude oil/day, around 3% of gasoline US supplies

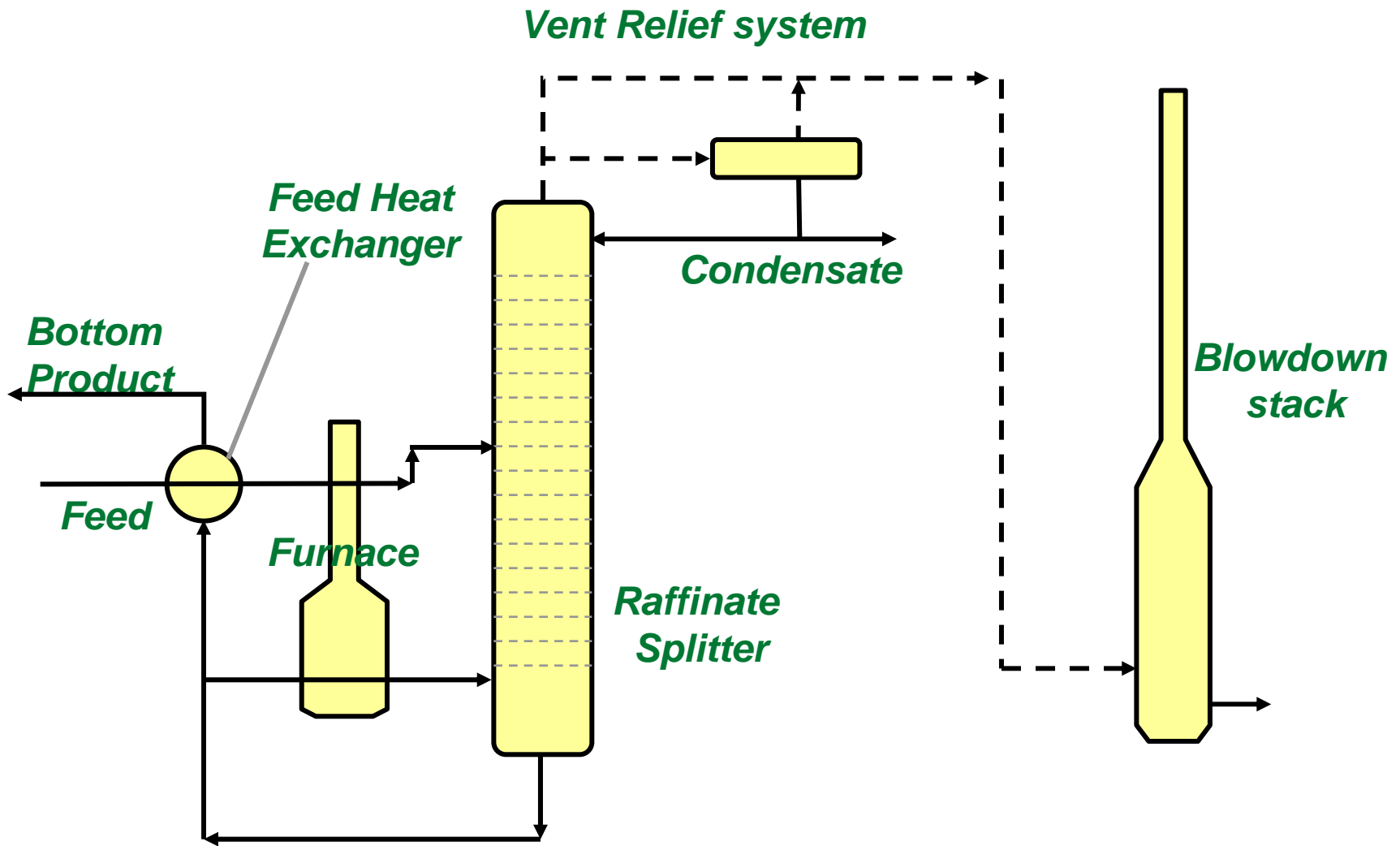


## The accident

- An explosion and fire occurred at the refinery's isomerization unit
- The explosion happened at 13:20 (Houston time) on March 23, 2005
- 15 people died and many more were injured
- Note: The isomerization unit boosts the octane of gasoline blendstocks.



# Simplified block diagram of Raffinate Splitter



# Raffinate Splitter and Blowdown Drum Stack



*Raffinate Splitter Tower*



*Blowdown Drum Stack*

# Aerial Photograph of Isomerization Unit



## What happened ?

- Prior to Feb. 15
  - Temporary trailers placed 150 feet from the Isomerization unit. They were being used by personnel preparing for a turnaround at another part of the refinery
- Feb. 21
  - Shut down part of the Isomerization unit to refresh the catalyst in the feed unit
- March 22
  - On the night shift, the raffinate splitter was being restarted after the shutdown. The raffinate splitter is part of the Isomerization unit that distils chemicals for the Isomerization process
- March 23
  - Splitter was over-filled and over-heated
  - When liquid subsequently filled the overhead line the relief valves opened
  - This caused excessive liquid and vapour to flow to blowdown drum and vent at top of the stack
  - An explosion occurred which killed 15 people and injured many others



*Texas City Refinery March 23, 2005  
15 People Killed  
Many more injured  
A community devastated*

# Isomerization Unit



# Satellite Control Room



# Trailer



## Double-Wide Trailer



## Key Issues

- Operator Inattention
- Following Procedures
- Supervisor Absence
- Communication – shift handover
- Trailers Too Close to Hazards
- Some Instrumentation Did Not Work
- Abnormal Start-ups
- Investigation of Previous Incidents
- Blowdown Drum Vented Hydrocarbons to Atmosphere
- Opportunities to Replace Blowdown Drum

# Underlying Cultural Issues

- **Business Context**
  - Motivation
  - Morale
- **(Process) Safety as a Priority**
  - Emphasis on Environment and Occupational Safety
- **Organizational Complexity & Capability**
  - Investment in People
  - Layers and Span of Control
  - Communication
- **Inability to See Risk**
  - Hazard Identification Skills
  - Understanding of Process Safety
  - Facility Siting
  - Vehicles
- **Lack of Early Warning**
  - Depth of Audit
  - KPI's for Process Safety
  - Sharing of Learning / Ideas

# Technical Lessons Learned

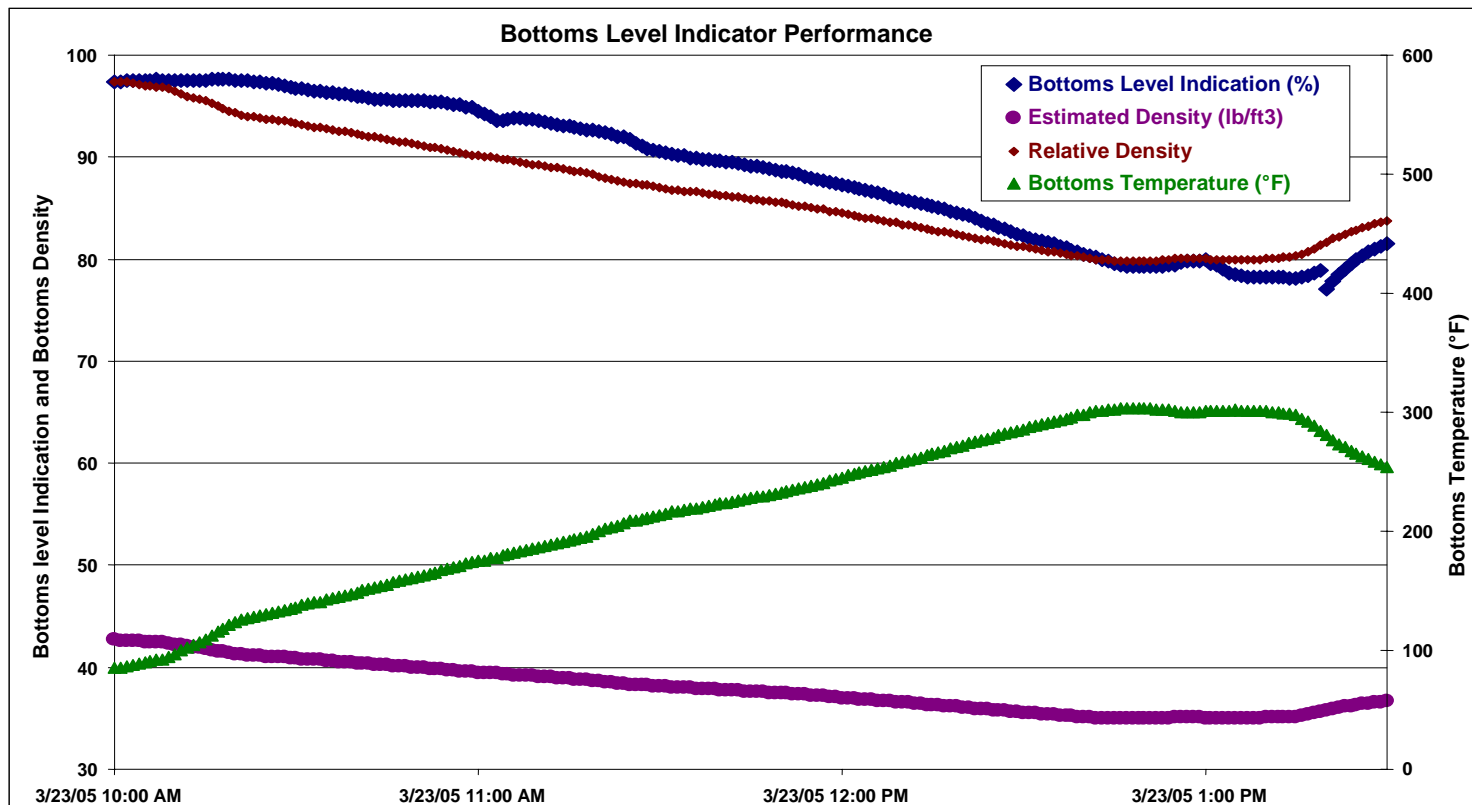
- Many Lessons from Texas City
  - Level Indication
  - Blowdown Systems
  - Facility Siting

# Level Transmitter

- Design typical of many in the industry
- Displacer type instrument
- Not faulty – worked as designed before, during and after the incident
- Trending downwards (but other data available)
- **Lessons Learned**
  - Functionality changed when top tap flooded

# Raffinate Splitter Bottoms Level

- Level instrument submerged early with cold raffinate
- Instrument output changed from reading liquid level to indication of buoyancy
- As raffinate temperature went up (green), density decreased (purple)
- “Level” output on the DCS screen decreased (blue)



# Blowdown Systems

- Commitment to replacing blowdown drums on light hydrocarbon duty
- Survey all sites

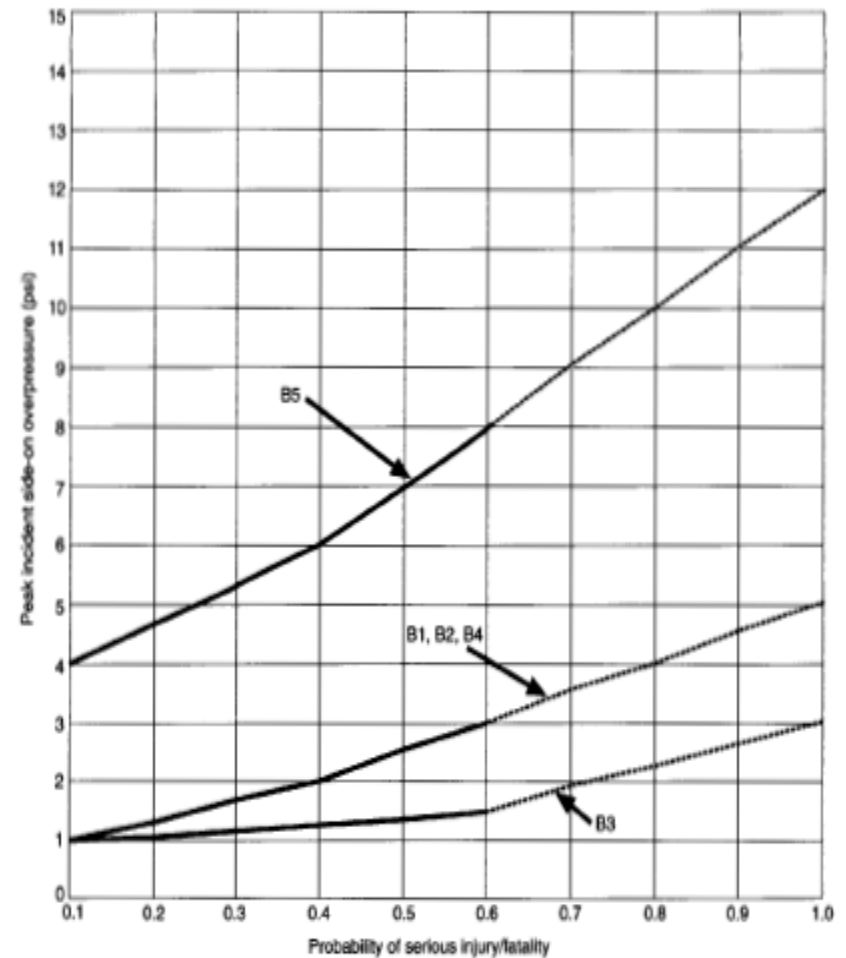
## Lessons Learned

- Design basis sometimes unclear – mods. over time
- Some have flammable liquids (flash < 100°F)
- Limited understanding of vapor dispersion
- Drums may be too small
  - inadequate liquid holdup
  - vapor/liquid disengagement
- Discharge to sewers sometimes not well understood
- Quench designs may be ineffective
  - Lack of contacting internals
  - Inadequate or non-existent controls
  - Potential for steam explosions
- Potential for stack fire/explosion due to inadequate purge



# Facility Siting

- Trailers used as temporary buildings
- Local practice based on API RP 752 used for siting
  - Adopted own occupant vulnerability correlation as allowed by API RP 752
  - Predicts lower vulnerability than CCPS

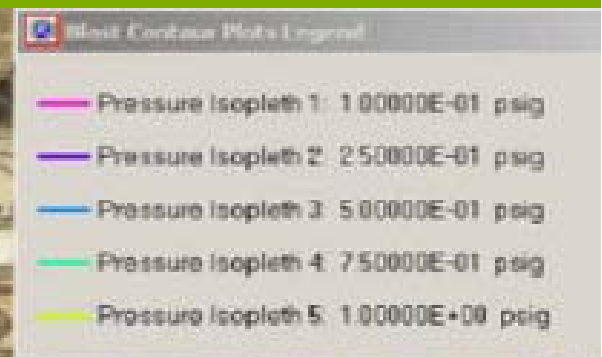


Note: Figure taken from CCPS, *Guidelines for Evaluating Process-Plant Buildings for External Explosions and Fires* (work in progress).

Figure C-1—Sample Overpressure Versus Vulnerability

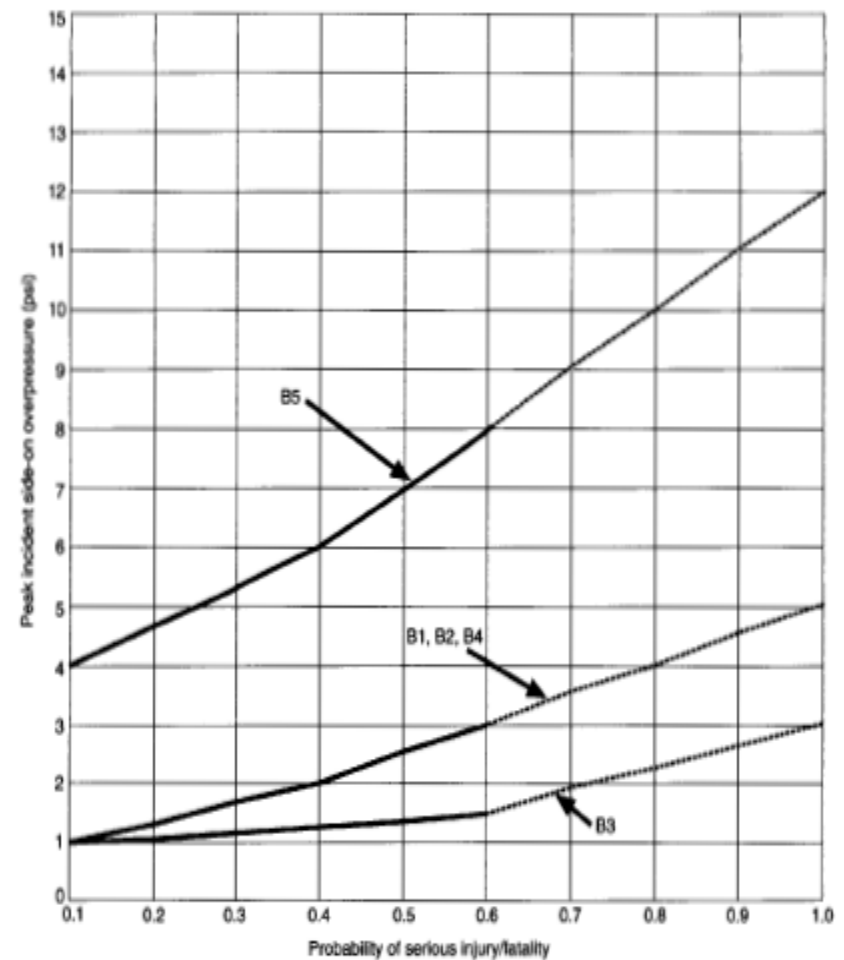
# Predicted Side-On Pressure Contours (in psi)

SS3G V1.04.0033 DLL: 27-Feb-2005 03:16 PM



# Facility Siting

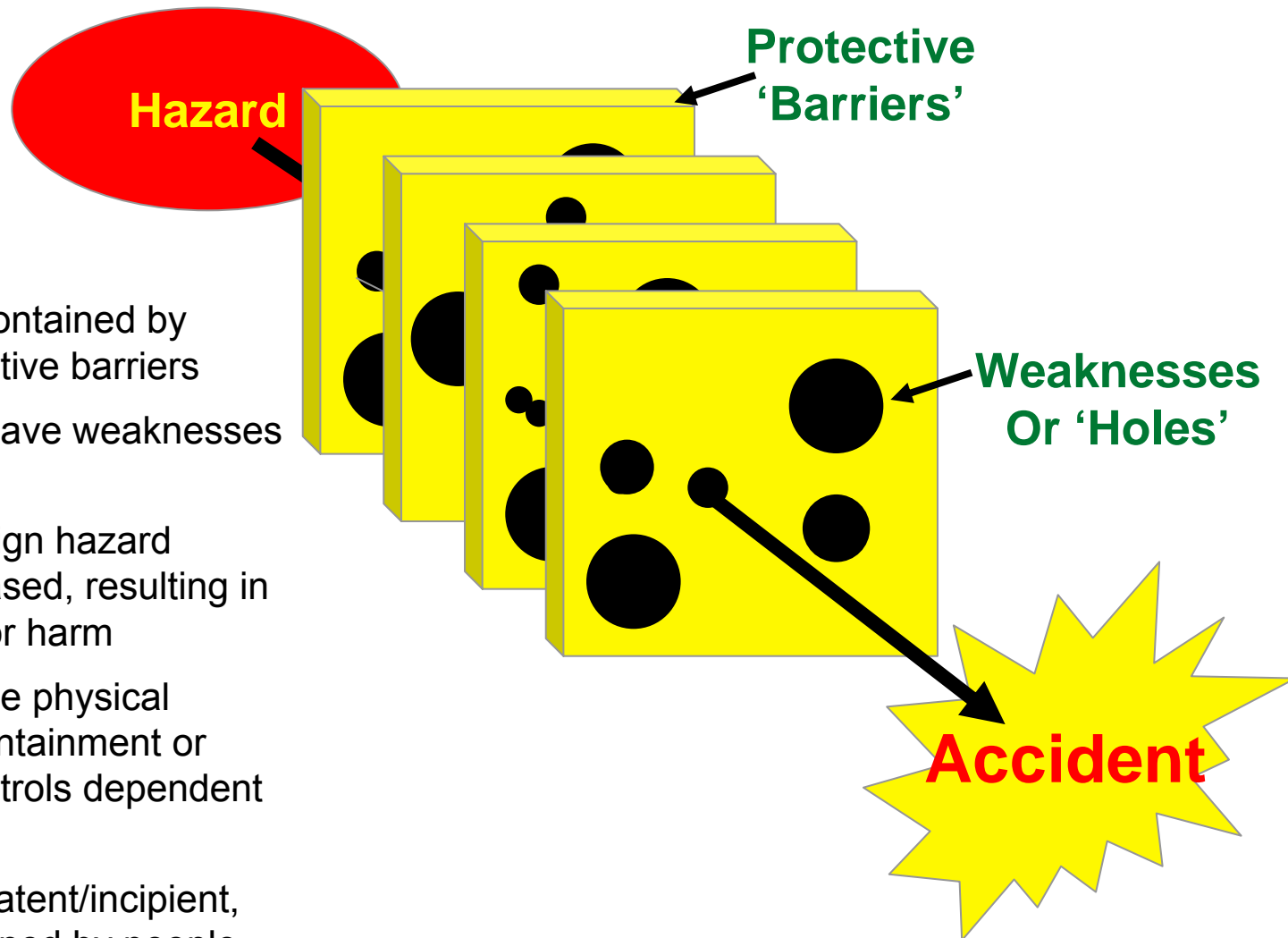
- Trailers used as temporary buildings
- Local practice based on API RP 752 used for siting
  - Adopted own occupant vulnerability correlation as allowed by API RP 752
  - Predicts lower vulnerability than CCPS
- Overpressure at trailers: 2.5psi peak side-on
- 430 psi.ms impulse
  - At 2.5 psi (side) CCPS/API predicts 50% vul.
- **Lessons Learned**
  - API RP 752 may not be as conservative as thought and is currently under review
  - BP commitment – no trailers in h-c areas



Note: Figure taken from CCPS, *Guidelines for Evaluating Process-Plant Buildings for External Explosions and Fires* (work in progress).

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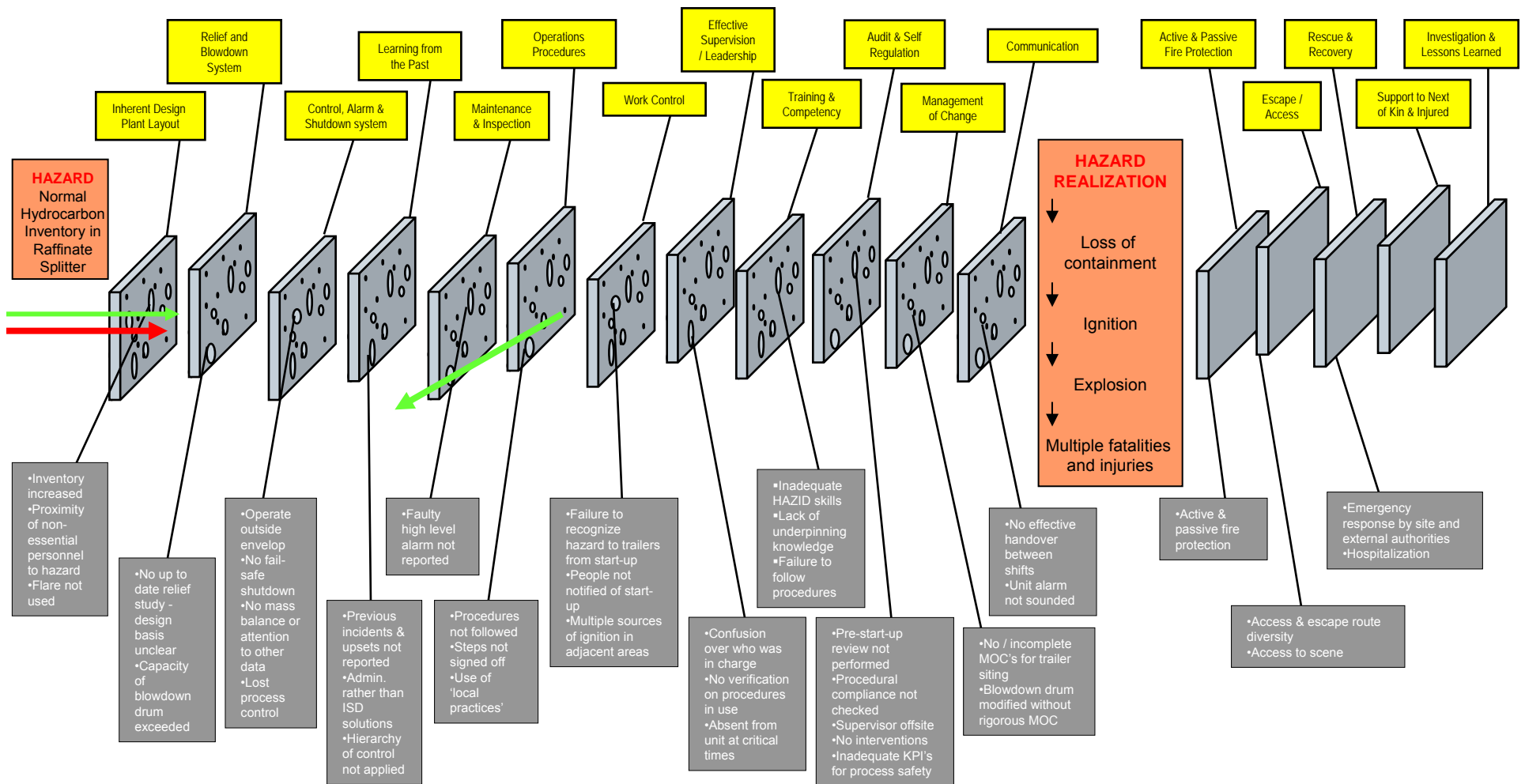
## Reminder of the 'Swiss Cheese Model'



- Hazards are contained by multiple protective barriers
- Barriers may have weaknesses or 'holes'
- When holes align hazard energy is released, resulting in the potential for harm
- Barriers may be physical engineered containment or behavioral controls dependent on people
- Holes can be latent/incipient, or actively opened by people

# Texas City Explosion – Hazard Management Diagram

Hierarchy of control – Bias towards hardware/inherent safety & reducing the scope for human error – multi barrier defence

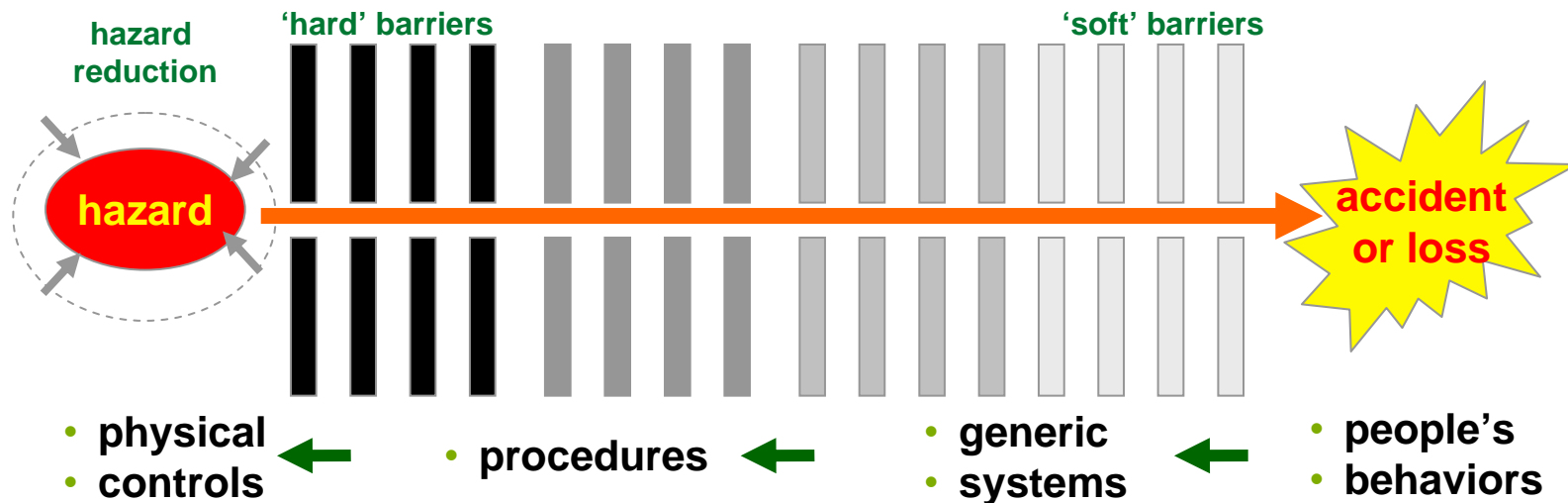


# Strategic Concepts

In order to reduce the potential for future major incidents and losses, three layers of protection are to be considered:

- **plant** – engineering hardware, control systems, and layouts to eliminate, control and mitigate potential hazards to people, and improve productivity
- **processes** – management systems to identify, control and mitigate risks, and drive continuous operational improvement
- **people** – capability of our people in terms of leadership skills, relevant knowledge and experience, and the organizational culture they create

In layers of protection, 'hard barriers' are more reliable than 'soft barriers', but all rely on people



# Texas City Actions

- **Focus on the Future**

More than **\$1 billion dollars** has been committed to enhance safety, renovate the plant infrastructure, and facilitate cultural change. Emphasizing safety and operational integrity, the program:

- Combines, prioritizes and coordinates 28 major initiatives that include nearly 600 recommendations and 1,000 specific actions
- Includes all recommendations from September 2005 agreement with OSHA and BP's own internal accident investigation report

## **Change Management Program – Accomplishments to date:**

- Removed more than 200 temporary structures from the site
- Relocated more than 400 non-operating personnel off the site to a new 100,000 sq. ft. office building in the city of Texas City
- Began constructing a 60,000 sq. ft. Employee Services Building outside the hardened perimeter of the plant
- Introduced a new site-wide transit system, removing more than 500 vehicles from the site
- Removed 11 blow-down stacks and installed new flares
- Redesigned major plant work processes including new control of work, inspection renewal, maintenance acceleration
- Instituted major cultural change including comprehensive training programs, leadership development, communication and accountability

# Texas City Actions

## Major New Programs and Progress

**Established new management team** and introduced a new functional organization built around an operations-centric model

**Implemented a 'What You Say Matters' Program** that, as an example, led to a major engineering breakthrough on blowdown stacks and Flares

- All blowdown stacks in light hydrocarbon service have now been isolated or removed
- All units have been commissioned without blowdown stacks
- A new flare system has been constructed and installed

**Instituted Leadership Development Programs** that will involve a projected 300,000 man hours annually, including:

- Training programs for all employees, from orientation for new hires, to start-up and distillation training, and education on safety and environmental compliance, operations, operator competency
- New apprenticeship program for Machinists and Instrumentation and Electrical technician positions, the first in a series of apprenticeships
- Special leadership training for more than 300 key people at the site

**Significantly expanded Safety and Environmental Team**, concentrating the Site on improving safety performance and environmental compliance

**Commissioning of Steam System and Process Units**, renovating entire 27-mile steam system and all process units before they go into production

**Implemented Pre-Start Up Safety Reviews** with more detailed checklists. No unit can come on line without sign-off

**Overhauled Control of Work** which addresses the process by which projects are set up, handed off, overseen and signed off

**Introduced a Maintenance Accelerator Program** that is designed to speed the pace of maintenance activity; and an **Expanded Site Inspection Program** that doubled the number of inspectors to more than 100. The inspection team's work has resulted in the replacement of more than 60,000 feet of pipe and more than 2,500 valves

**Improved and clarified accountabilities on site** so that accountability is more clear in every aspect of work

**Instituted Exclusion Zones** during unit start-ups or shut-downs

**Expanded safety and emergency response drilling teams** and implemented new site notification and alarm system improvements

**Implemented a rigorous investigation process** that includes all incidents, whether they are near misses or actual events

**Expanded community outreach** through an extensive Community Care program that actively engages with neighbors, local organizations and the local community

# James Baker Independent Panel

## Focus Areas:

- Leadership
  - Set the process safety “tone at the top”; establish process safety goals matched by actions
  - Define expectations & strengthen accountability for process safety performance at all levels
  - Transform the company into a recognised industry leader in process safety management
- Integrated Process Safety Management System
  - Establish a system that systematically and continuously identifies, reduces, and manages process safety risks
  - Develop a set of leading and lagging indicators for more effectively monitoring process safety performance
  - Establish and implement an effective system to audit process safety performance
  - Board to oversee implementation of recommendations and performance of US refining process safety
  - Engage independent third party to report progress annually to the Board.
- Process Safety Knowledge and Expertise
  - Develop and implement a system to ensure appropriate levels of process safety knowledge and expertise at all levels
  - Provide more effective process safety support for US refining line organization
- Process Safety Culture
  - Involve the relevant stakeholders to develop positive, trusting, and open process safety culture

# BP Group Actions

## **Organization**

- GORC established (strategic direction, “tone at the top”, etc.)
- Regional US organization strengthened
- HSE & Operations organization
  - Audit, Operations Excellence, Organizational Capability
  - Process Safety Director

## **Plant**

- Assessment of temporary buildings
- Removal of blowdown drums

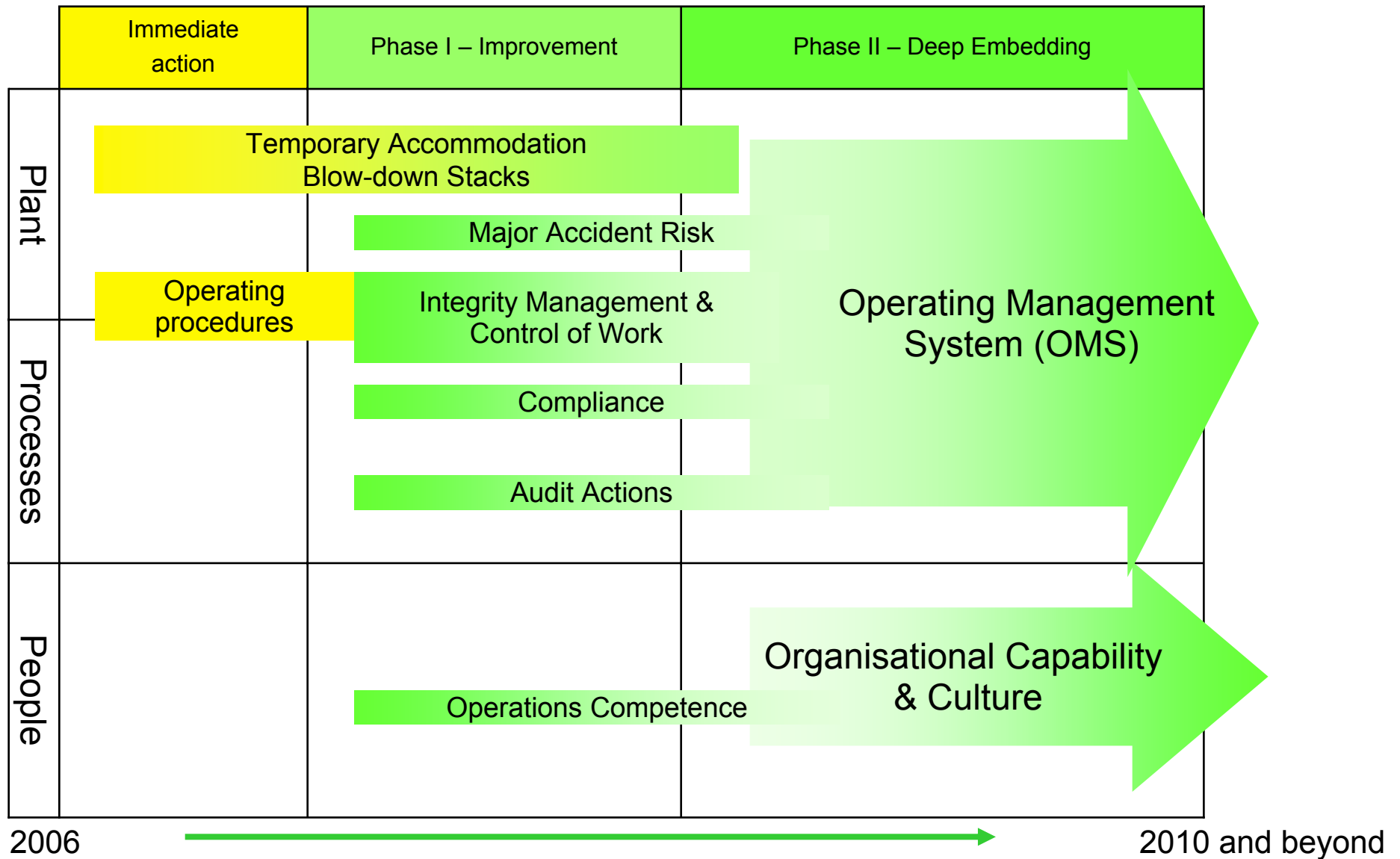
## **Process**

- Implementation of CoW and IM standards

## **People**

- Competency criteria and training programmes

# The path forward



## What can we learn from this incident ?

- Many lessons that can be learnt from Texas City, including:
  - Temporary building siting is a critical step in managing flammable / toxic risks
  - Atmospheric venting needs careful design and operation
  - Procedures are ineffective if they are not up-to-date and routinely followed
  - Competency and behaviors of Operations leadership, supervision and workforce are fundamental to safe operations
- Other lessons involve management visibility and accountability, hazard identification, hazards of startup operations, performance measures for process safety, emergency drills, etc.