ONDERZOEKSRAAD VOOR VEILIGHEID

Explosions MSPO2 Shell Moerdijk

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Why did it make sense?

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Interpreting selected data

Human behaviour: basic assumptions

- Human error is a construct made in hindsight.
- Safety is part of a larger complex, therefore it can never have highest priority.
- All people use heuristics and have limited cognitive capacity
- Context influences human behaviour
- Changing underlying causes in the system is the most effective en efficient way to influence human behaviour

Methodology: basic principle

- Reflect on your assumptions and interpretations by asking people to challenge your hypotheses

Shell Moerdijk 2014

Critical process boundaries were breached when the reactors were warmed up (triggering alarm and automatic protection systems).

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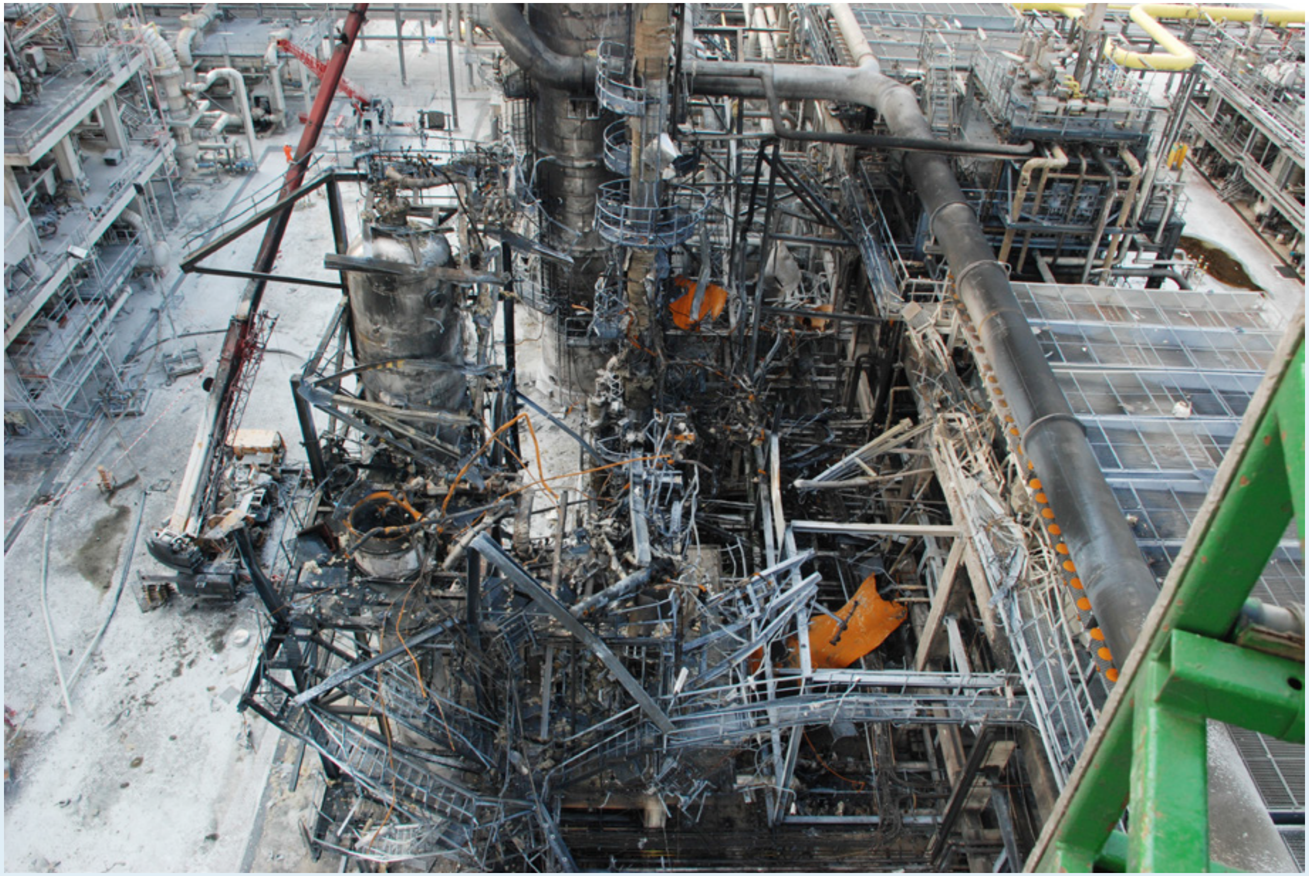
The 'unthinkable' happens



How can we understand how it could have happened that nobody could fore see this accident? Who can learn from this accident in order to prevent new 'unthinkable' accidents in the future?

Context information

The main purpose of the pit stop was to replace the catalyst containing granules

In 1977 Shell performed a reactivity test which involved warming up ethylbenzene and the catalyst type used at that time to 130°C. During the test Shell established that there was no possible chemical reaction between ethylbenzene and the catalyst used.

- In the following years modifications were made to the plants and procedures involved in this chemical process.

The investigation

- Aim
  - Learning lessons for the future and, ultimately, improving safety in the Netherlands.
- Question
  - What were the direct and underlying causes of the incident? (How did the context ‘seduce’ people to do what they did? How did it made sense? Who had the means to contribute to preventing this?)
- Scope
  - covers the period from design phase of the MSPO2 plant in 1996 until the day of the explosion.

Hazard and Safety Constraint Violated

- Accident: loss of reactors, injury,
- System hazard: Explosion of reactors
- System safety constraint: *The safety control structure must prevent reactors to explode during start up*
- <u>*Goal:*</u> *Figure out why the safety control structure did not do this*

Physical Components

What physical failures occurred? NONE

What unsafe interactions?

- By warming up the reactors, energy was released and unforeseen chemical reactions occurred between the warming-up liquid (ethylbenzene) and the catalyst pellets that were used
- From the start of the heating phase liquid levels and flows were unstable. Consequently, alarm limits were exceeded at various times.

Physical Components (2)

- These reactions caused gas formation and increased the pressure in the reactors.

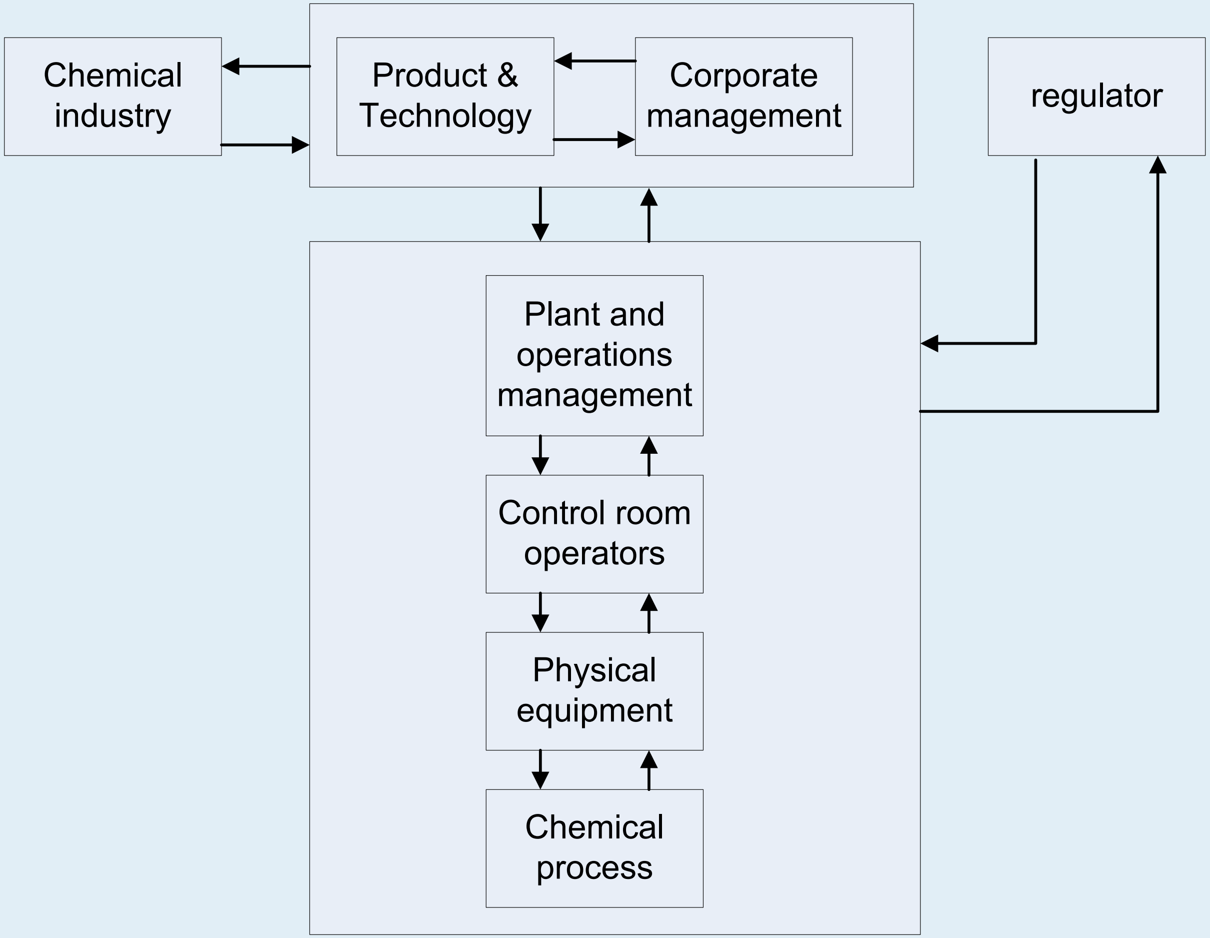
- The chemical reaction remained unnoticed and developed into an uncontrolled or *runaway* reaction, causing pressure to rise rapidly and the reactor to subsequently explode.

CONTROLLERS ROLE IN THE ACCIDENT

For each component of the control structure, identify:

Safety Requirements and Constraints
Unsafe Control Actions
Mental Model Flaws
Contex in which decisions made

Safety control structure



Operators

Safety requirements and constraints:

- Operate the plant in accordance with company procedures
- In case of liquid fluctuations during start-up, operators should stabilize or halt the chemical process

Operators

Unsafe Control Actions:

- manually added additional heat to the ethylbenzene
- did not respond to fluctuations in accordance with company procedures, when the warming-up procedure commenced
- erroneously decided to continue the process

Mental Model Flaws (Operators)

Operators:

- believed that fluctuations were normal. The operators were not alarmed by the fluctuating measurement values. In view of similar earlier warming-up procedures, it was also what they had expected.
- could not know that the new catalyst would reacted with ethylbenzene under these circumstances of increased heating.

Context in which decisions were made:

- absence of previous accidents led to an overconfident attitude
- no communication of information about the new catalyst characteristics
- tight schedule due to delay
- management rewarded timely production
- management rewarded 0 incidents

Now, what additional questions might you ask?

Some suggestions

- Why did the operators not know about the chemical properties of the new catalyst pellets, and their safety consequences?
- Why didn’t Shell P&T detect that these new catalyst pellets had different properties (i.e. that they could react with ethylbenzene when heated too fast)
- Why didn’t Shell corporate management ensure that P&T was able to detect critical risks? E.g. through the promotion of counter-arguments to challenge hypotheses/tunnel vision.

CONTROLLERS ROLE IN THE ACCIDENT

For each component of the control structure, identify:

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Corporate management

Safety Requirements

- Responsible for management of change, safe production
- Shell must make available adequate resources for Shell P&T to do an adequate management of change.
- Ensure operators have available all necessary information
- Facilitate an environment that enables operators to focus on safety actions during critical phases of change
- Facilitate learning from accidents
- Facilitate sharing of information / challenging hypotheses

Corporate management

Safety requirements

- should enable Product & technology to perform a critical risk analysis for every change made to the process

Unsafe control action

- did not enable P&T to perform a critical risk analysis for the new catalyst type
- should contribute to learning from incidents and sharing information

Product & Technology

Safety requirement

Should identify new risks

Unsafe Control Actions:

did not identify new risks, i.e. the chemical reaction between ethylbenzene and the new catalyst.

Product & Technology

Mental model flaw

regarded ethylbenzene as a safe substance in this process

Context in which decisions were made

did not always performed new risk analyses on these modifications

absence of challenging hypotheses

culture of confidence

absence of learning thoroughly from incidents (underlying causes)

absence of sharing information

Context in which decisions were made:

- Few incidents in decades of success
- Culture of self-confidence
- No ‘chronic unease to risk’
- did not analyse underlying causes of incidents
- did not learn lessons from a previous incident at a Shell plant in Nanhai. Considered it irrelevant.

CONTROLLERS ROLE IN THE ACCIDENT

For each component of the control structure, identify:

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Regulators/Inspectors

Safety constraints

Identify safety shortcomings at Shell

Encourage companies to improve their safety-critical processes.

Unsafe Control Actions

Did not establish and identify shortcomings

Did not persistently challenge companies that had received a positive assessment to investigate and detect underlying causes of incidents.

Regulators/Inspectors

Process Model Flaws:

- considered Shell to be a positive example
- believed Shell to be alert to risks

Context in which decisions were made:

- ‘0 accidents at Shell’
- Shell always responded **immediately** to warnings
- (heavy work load)
- absence of a culture to challenge / check assumptions

DSB Recommendations

- Shell must increase its awareness of working with safety-critical processes. It must take on an emphatic role in further actively developing and disseminating knowledge and experience, both internally and externally.

To Shell Netherlands B.V.

- Ensure that all Shell employees are constantly alert to the safety risks arising from modifications made to plants, processes and procedures.
- Evaluate how risk analyses are performed and implement changes. This will enable the re-evaluation of earlier presumptions and assumptions. Conduct new risk analyses, put adequate control measures in place and ensure that the team that performs these analyses has sufficient critical ability.
- Pay particular attention to assumptions based on risks that had previously been ruled out.

DSB Recommendations

- Organise the communication of process knowledge and lessons learned from actual and near incidents to employees who are responsible for managing safety risks.

- Ensure that investigations into actual and near incidents also provide insight into the underlying causes. Guarantee that actions arising from these investigations are implemented and contribute to disseminating knowledge within the petrochemical industry.