Analysis of NaTech Accidents recorded in Major Accident Databases

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NaTech events: Natural disaster triggered Technological accidents

- damage to storage tanks and pipelines
- damage to process equipment
- release of hazardous materials

- seismic events
- floods
- landslides
- lightning
- hurricanes
- tsunamis
Aims

- Retrieval and analysis of NaTech accidents recorded in Major Accident Databases
- Identification and analysis of damage modes of equipment items due to natural events
- Identification and analysis of consequences of releases of hazardous substances in NaTech events
- Identification of specific event trees for post-release scenarios during NaTech events
Historical Analysis of accident records

CRITERIA OF SELECTION:
- Industrial activities
- Hazardous materials
- Specific equipment categories

Major accident

- Loading/unloading and transport
  pipeworks, pumps, compressors
- Storage
  atmospheric/pressurized storage
  tanks, warehouse
- Process
  process vessels, reactors, heat
  exchangers, pipeworks, pumps,
  compressors
## Major Accident Databases:

<table>
<thead>
<tr>
<th></th>
<th>% Na-Tech accidents</th>
<th>Total records</th>
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</thead>
<tbody>
<tr>
<td>ARIA (BARPI)</td>
<td>2÷3</td>
<td>30859</td>
</tr>
<tr>
<td>FACTS (TNO)</td>
<td>2÷3</td>
<td>22214</td>
</tr>
<tr>
<td>ICHEME</td>
<td>u.a.</td>
<td>u.a.</td>
</tr>
<tr>
<td>MARS (MAHB)</td>
<td>4÷5</td>
<td>602</td>
</tr>
<tr>
<td>MHIDAS (HSE)</td>
<td>2</td>
<td>7000</td>
</tr>
<tr>
<td>NRC</td>
<td>u.a.</td>
<td>u.a.</td>
</tr>
</tbody>
</table>
Accidents triggered by **floods:**

272 records

(1960-2007)

Accidents triggered by **earthquakes:**

78 records

(1930-2007)
Example I: Floods

272 number total of records
70 records report details on the flood (water height, etc.)

only in 28 records sufficient data were recorded to characterize both natural event severity, equipment damage and consequences of release scenarios

- h>1 m; 10; 42%
- 0.5m<h<1m; 3; 13%
- h<0.5m; 11; 45%
- n.a; 22
Floods: Industrial Activities involved

- Petrochemical storage: 14 cases
- Chemical production and storage: 6 cases
- Textiles: 21 cases
- Paper manufacture: 4 cases
- Phytosanitary production and storage: 10 cases
- Production and storage of explosives: 3 cases
- Other: 7 cases
- Not known: 33 cases
Categories of process equipment damaged in 272 NaTech events triggered by floods
Floods: Damage to Equipment II

Type of damage to equipment (from 66 records where sufficient data was reported)

- Roof failure: 2 cases
- Floating of tank: 10 cases
- Overturn tank: 10 cases
- Failure connections, valves and support structures: 5 cases
- Collapse tank: 7 cases
- No specified damages: 9 cases
- Failure pipelines: 10 cases
- Dragging equipment: 5 cases
- Pipework detachment: 8 cases
Floods: Substances Released

Substances released in NaTech accidents triggered by floods

- u.a.: 49
- ammonia and by-products: 5
- oxides: 5
- aromatics: 8
- hydrocarbons: 8
- no specified chemicals and other: 23
- soap and detergent: 1
- Ca and acetylene: 3
- acid products: 7
- fertilizer: 11
- explosives: 3
- propane and natural gas: 12
- cyanide: 5
- oil, diesel, gasoline: 142
- chlorine: 3
Floods: Final Scenarios

Final scenarios in NaTech events triggered by floods

- Explosion: 5%
- Dispersion: 7%
- Fire: 15%
- Pool no ignition: 16%
- Water contamination: 57%
- Ground contamination: 28%
- Water contamination: 57%
- Fire: 95
- Dispersion: 12
- Explosion: 9
- N.a.: 134
SEVERE WATER CONTAMINATION due to release of hazardous substances

TOXIC and/or FLAMMABLE vapor formation and release due to the reactions of chemicals with water

Release of substances hazardous for aquatic environment
(R51-52-53)

Release of substances reacting with water
(R14/15,R15/21,R29)

Two specific accident scenarios were identified in the case of NaTech accidents triggered by floods:
Example II: Earthquakes
Damage to Equipment

Damage to process equipment experienced during earthquakes – data from 78 events reported in accident databases

- Atmospheric storage tanks: 250
- Pipeworks: 439
- Pressurized storage tanks: 7
- Heat exchanger: 1
- Distillation column: 1
- Cooled tanks: 2
Earthquake: Damage to Equipment

Analysis of damage experienced by 257 process and storage vessels in 33 different earthquake events

- **Minor:** leak from flanges or connections
- **Severe:** failure with loss from shell
- **Catastrophic:** collapse with complete loss of inventory

- **catastrophic:** 45%
- **release:** 5%
- **moderate no release:** 22%
- **minor:** 2%
- **severe:** 26%
- **damage with release:** 70%
Earthquake: Final Scenarios

Final scenarios in 78 release events triggered by earthquakes in process plants

- not known: 27
- explosion: 5
- dispersion: 5
- fire: 14
- water contamination: 10
- pool without ignition: 14

Number of scenarios
Data from the analysis of **33** events with detailed data related to storage tanks and process vessels where the release of of **flammable** substances took place

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<table>
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<tbody>
<tr>
<td>Number of seismic events</td>
<td>29</td>
</tr>
<tr>
<td>Number of damaged equipment</td>
<td>≥254</td>
</tr>
<tr>
<td>Max number of damaged equipments in one event</td>
<td>97</td>
</tr>
<tr>
<td>Medium number of damaged equipments in one event</td>
<td>9</td>
</tr>
<tr>
<td>Number of damaged equipments with release</td>
<td>≥180</td>
</tr>
<tr>
<td>Number of cases of release with ignition</td>
<td>≥137</td>
</tr>
<tr>
<td>Ignition probability</td>
<td>0.761</td>
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</table>
Main expected damage modes were identified for the impact of floods and earthquakes in process plants and storage farms.

Data collected on final scenarios allow the identification of specific event tree for post-release scenarios in NaTech events.

Retrieved data may be one of the elements for the development of simplified equipment damage models in NaTech events.

Quality of available data on NaTech events is scarce: the development of a specific database may be an important element for the analysis, prevention and mitigation of these events.