Sustainable infrastructure: Upgrading infrastructures and retrofitting chemical industries - Taking earthquakes into consideration

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Major Accident Prevention Section
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Swiss Major accidents Ordinance (MAO)

- Entered into force in 1991

Aims at protecting the population & the environment from damage due to major accidents that may occur during the operation of facilities.

Scope

- 2'400 Chemical establishments
- 3'600 km railway lines
- 7'800 km main roads
- 2'500 km gas and oil pipelines
The MAO; principles

• Individual responsibility of owners of establishments (Art.3), according to principle of precaution.

Art. 3¹: The owner of an establishment shall take all appropriate measures that are available to reduce risk in accordance with the state of the art of safety technology, supplemented by personal experience, and which are economically viable. These shall include measures to reduce the hazard potential, to prevent major accidents and to limit the impacts thereof.

→ Ongoing process to keep installations «up to date» and to keep risk as low as possible.

→ Controlled by federal and cantonal authorities.
The MAO; procedures for chemical establishments

Step 1

Summary report
Estimation of magnitude of possible harm to population and / or environment based on worst case scenario.

- nb. potential fatalities
- Major accident index (MAI)

If serious damages cannot be excluded (MAI ≥ 0.3)

Step 2

Risk study
- Quantitative Risk Assessment based on multiple scenarios → F/N Curves
- Evaluation of risk acceptability is made upon MAO risk criteria

MAI < 0.3
< 10 fatalities

MAI ≥ 0.3
≥ 10 fatalities
Consideration of seismic risk

Must be taken into consideration as a possible cause of Major accidents.

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MAI < 0.3 - SIA 2018 Standard

- Min. compliance level to be fulfilled.
- Decision criteria for proportionality of measures.

Usual costs of measures in Switzerland are between 5% to 10% of building value (variability 1% to 30%)
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PROBLEMATIC: No existing criteria!
MAI \geq 0.3 - ????

• When seismic risk is taken into consideration in Risk Studies:

→ Risk systematically **UNACCEPTABLE** according to MAO criteria (even for extremely – unreasonable-high seismic design factors).

Current practice:

• Seismic risk is inadequately addressed.
• Building codes applied outside their scope of application.

→ **Inconsistent approach !!**
Solutions ? – Research project

- Currently running a project (collab. authorities / industry) aiming at defining clear guidelines on how to take seismic risk into consideration in risk studies for new and existing establishments with MAI ≥ 0.3.

Approach
- Only increasing seismic design factors is not sufficient (and very expensive) to reach an acceptable level of risk.
- We must in addition define further measures to reduce the damage potential by:
  - Reducing quantities of hazardous substances.
  - Implementing further technical (passive) measures.
  - …
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Example of ammonia tank retrofitting

Schnitt A - A 1 : 200

Use of base isolators:
Reservoir has a high level of seismic design but risk remains unacceptable.

Secondary containment: ringwall
In case of spill or tank collapse limits ammonia evaporation by limiting spill size
Example of ammonia tank retrofitting

Ammonia plume simulation

Total release of ammonia

**Without ringwall**
- Width: 200 m
- Total length: 1200 m
- Total evaporation time: 40 h
- Fatalities: more than 100 people
- MAI > 0.6 (catastrophic)

**With ringwall**
- Width: 80 m
- Total length: 220 m
- Total evaporation time: 30 days
- Fatalities: < 10 people
- MAI < 0.3

Source: TNO Effects V 9.0.20
Remaining questions to be addressed

- What if all possible reasonable measures have been implemented and the risk remains too high?
  - Relaxing safety objectives for scenarios due to earthquakes?
  - Define minimum seismic design factors and accept risk?
  - Close establishment?
Thank you for your attention

Reference

Seismic retrofitting of Structures
Strategies and collection of examples in Switzerland
Installations with a high industrial accident index

Return period of seismic design action:
- 1'000 years (max. in buildings codes)
- 2’500 years (max. for Seveso instl. in F)
- 10’000 years (at the limit of technical feasibility)

Regulatory safety objectives in CH are problematic to fulfill for the earthquake risk
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