Prevention of Natech Risks due to earthquakes at Seveso establishments

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• What is a NaTech accident?

• Seismic risk control in French industrial establishments;

• Participation in the elaboration of methodological guides;

• Technical support for the Ministry of Ecology in the evolution of the 4th of October 2010 ministerial order for existing equipment;

• Conclusion
• NaTech accidents = **Natural-hazard triggered** **Technological** accidents;
• They represent 5% of the known industrial accidents in France (according to the BARPI, the French Bureau for Analysis of Industrial Risks and Pollutions);
• The BARPI lists 920 NaTech accidents between 1992 et 2012 in its ARIA database.
Remarkable NaTech accidents

**Flood:**
Fire in the Mohammedia refinery (Morocco), the 22\textsuperscript{nd} of November 2002

**Earthquake:**
Fire and explosions in the Chiba harbor refinery (Japan), the 11\textsuperscript{th} of March 2011. The fire lasted 10 days.

**Lightning:**
Explosion of an ethanol tank in a French distillery, the 24\textsuperscript{th} of July 2000
Seismic risk control in French industrial establishments

- In Europe, the analysis of accidental risks caused by natural causes are required for industrial facilities subjected to the Seveso III Directive (with earthquakes and floods explicitly mentioned);
- The French seismic regulation is governed by the 22nd of October 2010 decree, the 4th of October 2010 and the 15th of February 2018 ministerial orders and requests the following:
  - The determination of the hazard levels;
  - The diagnosis of the earthquake resistance of industrial equipment using technical guides (methodological and specific guides).

Because of the complexity of the 2010 ministerial order, there was a need to accompany operators and public authorities in the implementation of its provisions.

- INERIS works:
  - Participation in the elaboration of methodological guides;
  - Technical support for the Ministry of Ecology in the evolution of the 4th of October 2010 ministerial order: reassessment and adaptation of the scope of application and the regulations provisions relating to the seismic protection of existing industrial installations.
Seismic risk control in French industrial establishments – INERIS works

- Participation in the elaboration of methodological guides:
  - Methodological guides redacted by operators and seismic specialists appointed by the Ministry of Ecology and supervised bien the French Association for Earthquake Engineering and the French Chemical Industry Association;
  - Goal: To help industries and operators in demonstrating the compliance of their facilities with the regulatory requirements imposed by the legislation;
  - 8 guides were written:
    - **Equipment safety procedures** (UIC/AFPS DT105 guide);
    - **General methodology** (UIC/AFPS DT106 guide);
    - **Technical guides** for different equipment families:
      - Atmospheric, cryogenic and horizontal storage tanks (from UIC/AFPS DT108 to 110 guides);
      - Support structures (UIC/AFPS DT111 guide);
      - Pipes, valves et fittings (UIC/AFPS DT113 guide);
      - Various equipment (UIC/AFPS DT114 guide).
• Participation in the elaboration of methodological guides:
  • Example: the atmospheric vertical tank guide (UIC/AFPS DT108 guide): table of contents:
    • Generalities: scope of application, description of the atmospheric vertical tanks seismic behavior and main damage modes, organization scheme of calculations;

• General analytical methodology to study the seismic behavior of atmospheric vertical tanks for each of their damage modes. The guide allows for the possibility of using one out of 3 building codes: the EN 1998-4, the API 650 or the CODRES;

• General numerical methodology to study the seismic resistance of atmospheric vertical tanks for each damage modes;
• Examples.
Participation in the elaboration of methodological guides:

Example: the atmospheric vertical tank (UIC/AFPS DT108 guide): main failure modes:

- Buckling in shell;
- Hoop stress in shell;
- Uplift;
- Mechanical anchorages failure;
- Convective wave height;
- Drifting.

On the left: elastic diamond buckling; on the right: elephants foot buckling
Participation in the elaboration of methodological guides:

- Example: the atmospheric vertical tank (UIC/AFPS DT108 guide): general methodology:

  1\textsuperscript{st} step: Calculation of the fundamental frequencies of the equipment

  2\textsuperscript{nd} step: Calculation of the induced accelerations for each equivalent {mass-spring} system

  3\textsuperscript{rd} step: Calculation of the induced stresses in the equipment

  4\textsuperscript{th} step: Comparison between the induced stresses and the acceptability criteria

Modal/spectral analysis methodology
Seismic risk control in French industrial establishments – INERIS works

- Accompaniment of the Ministry of Ecology in the evolution of the 4th of October 2010 ministerial order for existing equipment:
  
  - Revaluation of the implementation of the provisions of the 4th of October 2010 ministerial order – Section II – Article 15 – Presentation of a report by the Minister in charge of the installations classified for the protection of the environment synthesizing the conclusions of seismic studies realized for a significant number of existing equipment.

Proposal for a panel of deemed representative equipment by the professional federations to the Minister in charge of the installations classified for the protection of the environment (end of 2016)

Seismic studies on the proposed industrial equipment panel (16 pilot sites) (2016-2017)

Production of a summary report by the Minister in charge of the installations classified for the protection of the environment

INERIS opinion on the proposed industrial equipment panel

INERIS analysis and expert opinion on all seismic studies

INERIS summary report
Seismic risk control in French industrial establishments – INERIS works

• Accompaniment of the Ministry of Ecology in the evolution of the 4\textsuperscript{th} of October 2010 ministerial order for existing equipment:

  • Production of a summary report by INERIS:

    • Goal: proposal for a simplification of the seismic studies for existing industrial equipment in the seismic zones levels 1 and 2;
    • Simplifications realized for 10 equipment family.
• Accompaniment of the Ministry of Ecology in the evolution of the 4th of October 2010 ministerial order for existing equipment:
  • Production of a summary report by INERIS
  • Chosen approach:

  Summary of the seismic studies of the panel industrial equipment by equipment families
  Definition of complementary equipment for some equipment family to extend the panel
  Seismic studies for complementary and panel equipment for the seismic zones levels 1 and 2
  Proposal to simplify the seismic studies realized for the 10 equipment family in the seismic zones levels 1 and 2
• Because of the complexity of the 4th of October 2010 ministerial order, there was a need to accompany industrialists and authorities in the implementation of its provisions;

• As a result of its skills in structural engineering, INERIS was tasked with:
  • Participating in the elaboration of methodological guides to help industries in their seismic studies by giving technical and practicability advices;
  • Accompanying the Ministry of Ecology in the evolution of the 4th of October 2010 ministerial order for existing equipment by analyzing a large panel of seismic studies.
Thank you for your attention

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