Société de Calcul Mathématique SA
(Mathematical Modelling Company, Corp.)
Tools for decision help
since 1995

Nuclear Safety

It is a set of methods, of disciplines, aimed at ensuring that no accident occurs, throughout the chain of operation of the power plants: this goes from the extraction of the ore to the dismantling of the installations in end of life.

A safety demonstration must meet two requirements:

– Those expressed by the Safety Authorities, in particular regarding the probabilistic aspects.

– Those expressed by the population, who want to be sure that their concerns are answered.

We can intervene in the drafting of the file, because, for us, a safety demonstration is just a demonstration. It must be shown that all possible cases have been considered and that, in each of these cases, an appropriate analysis has been made. Our writing will therefore be precise, complete, scientific, and indisputable.

We have worked on the various aspects of nuclear safety:

I. Natural hazards

The assessment of natural risks (for example earthquakes) concerns nuclear safety, but more generally economic life. The objective here is to have sufficiently reliable data to assess the probability of occurrence of each risk and the magnitude of the possible consequences.

II. Probabilistic methods for safety

A safety concern translates into the description of scenarios leading to an accident, such as reactor core meltdown. Many parameters are likely to have an influence on these scenarios, and the probabilistic methods designed by SCM make it possible to "hierarchize" these parameters, i.e., to arrange them in order of importance: those which occur first are those which need to be monitored most precisely.

Our methods also make it possible to determine "dangerous zones" in the space of configurations: this involves highlighting configurations, relating to all the control parameters, which are likely to lead to situations danger, such as an excessive rise in temperature.

The computer codes generally used to simulate accidents (e.g. core meltdown) are now old and adapting them to meet the requirements of the Safety Authority is difficult. We recommend the development of a new generation of codes, more robust and coarser. See article [13] below.

III. Methodological support for actors in the field

We have worked with most players in the nuclear industry, and mainly:

A. The Institute for Radiation Protection and Nuclear Safety (IRSN)

We had a framework collaboration agreement with IRSN for the period 2010-2015. Theme: Probabilistic Methods for Nuclear Safety. Our main works concern:

- improving measurements.
- assistance with inspections.
- improving the methodology in probabilistic safety assessments.
- the consideration of uncertainties in the calculation codes.
- calculations of economic indicators.
- analysis of the performance of sensor networks, such as the TELERAY network.
- monitoring of the future EPR reactor: analysis of the consequences of a failure of the devices measuring the quantity of neutrons in the reactor core.
- malfunctions in sensor networks.

Most of this work has given rise to publication; see below.

B. The OECD Nuclear Energy Agency

The NEA is a nuclear-oriented intergovernmental organization that brings together countries from North America, Europe and the Asia-Pacific region; its objective is to share and disseminate the best expertise in the field of nuclear energy.

The NEA has on the one hand "archive" type databases, such as the EXFOR database which contains information relating to nuclear reactions in the form of numerical data and text, and on the other hand so-called "evaluated", of the ENDF type, which have been processed by experts; the result of this processing is generally to obtain a continuous curve from the isolated experimental points.

The questions that arise relate to the existence of aberrant data in the "archive" databases and to poor evaluations in the processed databases. We worked on both aspects. Through six contracts (from 2010 to 2017), we have developed robust probabilistic tools that have enabled the NEA to detect outliers (isolated or in groups) in its databases.

This work gave rise to a publication, with the heads of the NEA; see below.

C. Drafting a safety case

This is generally difficult, because the Safety Authorities require (it is their role) to eliminate all the uncertainties, which designers and operators consider impossible. Our role here is to participate in the definition of specifications which explains why we retain, or we do not retain, such "aggression" (for example such magnitude for the reference earthquake). This is done based on probabilistic assessments from historical data. From there, the realization of these specifications is entirely deterministic, as required by the Safety Authorities.

IV. Books

[IEPE] Bernard Beauzamy : Introduction à l'étude des Probabilités Expérimentales. SCM SA, ISBN 979-10-95773-02-3, ISSN 1767-1175. Relié, 192 pages. Janvier 2023.

[NMP] Bernard Beauzamy : Nouvelles Méthodes Probabilistes pour l'évaluation des risques. Ouvrage édité et commercialisé par la Société de Calcul Mathématique SA. ISBN 978-2-9521458-4-8. ISSN 1767-1175, avril 2010.

[PIT] Olga Zeydina - Bernard Beauzamy : Probabilistic Information Transfer (in English), SCM SA, ISBN 978-2-9521458-6-2, ISSN 1767-1175, avril 2013.

[GRE] Bernard Beauzamy : Méthodes probabilistes pour la gestion des risques extrêmes. SCM SA, ISBN : 978-2-9521458-9-3, ISSN : 1767-1175, juin 2015.

V. Thesis

Olga Zeydina: Probabilistic Methods for Nuclear Safety. Thesis defended in December 2011.

VI. Articles

[1] Bernard Beauzamy, Hélène Bickert, Olga Zeydina (SCM), Giovanni Bruna (IRSN): Probabilistic Safety Assessment and Reliability Engineering: Reactor Safety and Incomplete Information. Proceedings of ICAPP 2011 Nice, France, May 2-5, 2011, Paper 11399. http://scmsa.eu/RMM/ART_2011_ICAPP_11399.pdf

[2] Emmeric Dupont (NEA), Bernard Beauzamy (SCM), Hélène Bickert (SCM), M. Bossant (NEA), Carmen Rodriguez (SCM), N. Soppera (NEA): Statistical Methods for the verification of databases. Publication de la Nuclear Energy Agency de l'OCDE, 2011.
http://www.oecd-nea.org/nea-news/2011/29-1/29-1-int-e.pdf#page=31

[3] O. Zeydina (SCM), A.J. Koning (NEA), N. Soppera (NEA), D. Raffanel (SCM), M. Bossant (NEA), E. Dupont (NEA), and B. Beauzamy (SCM): Cross-checking of large evaluated and experimental databases, Science Direct, Nuclear Data Sheets 120 (2014) 277–280.
http://www.scmsa.eu/archives/NEA_SCM_2014.pdf

[4] F. Godan (SCM), O. Zeydina (SCM), Y. Richet (IRSN), B. Beauzamy (SCM): Reactor Safety and Incomplete Information: Comparison of Extrapolation Methods for the Extension of Computational Codes. Proceedings of ICAPP 2015 Nice, France, May 3-6, 2015, Paper 15377. http://scmsa.eu/archives/ART_IRSN_SCM_15377.pdf

[5] Emmeric Dupont (CEA): Exfor Improving the quality of International Databases. NEA News, 2014, 32.1, p 28.
http://www.scmsa.eu/archives/EXFOR_NEA_News_2014_32.pdf

[6] Achim Albrecht (ANDRA) and Stephan Miquel (SCM): Modelling soil and soil to plant transfer processes of radionuclides and toxic chemicals at long time scales for performance assessment of Radwaste disposal. Geophysical Research Abstracts, Vol. 17, EGU2015-10476-1, 2015
http://www.scmsa.eu/archives/ART_Albrecht_Miquel_Modelling_Soil_2015.pdf

[7] Bernard Beauzamy: La Méthode de Wilks, utilisation incorrecte pour les études de sûreté, publications de la SCM, janvier 2016.
http://www.scmsa.eu/archives/BB_Wilks_2016_01_11.pdf

[8] Gottfried Berton (SCM): Verification of the databases EXFOR and ENDF. Nuclear Energy Agency, JEFF Meetings - Session JEFF Experiments, November 28 - December 1, 2016.
http://www.scmsa.eu/archives/SCM_NEA_JEFF_Meeting_2016_11.pdf

[9] (2017) Gottfried Berton, SCM SA, and Oscal Cabellos, NEA: Checking the resolved resonance region in EXFOR database.
http://www.scmsa.eu/archives/SCM_NEA_JEFF_Meeting_november_2017.pdf

[10] (2017) Bernard Beauzamy: The role of mathematics in the enhancement of safety; article présenté dans le cadre du colloque Esreda (sûreté nucléaire)
http://www.scmsa.eu/archives/ESReDA-53rd_Beauzamy.pdf

[11] (2018) Gottfried Berton, SCMSA: Comparison between two interpolation methods: Kriging and EPH. 7th International Conference on Mathematical Modelling in Physical Sciences (IC-MSQUARE), Moscow, Dorodnitsyn Computing Centre, Russian Academy of Science, August 27 to 31, 2018.

[12] (2018) Adrien Schmitt, Gottfried Berton et Alisson Stocchetti, SCM SA: Utilisation des Extensomètres à Corde Vibrante et des Fibres Optiques pour la surveillance d'ouvrages en génie civil. Le point sur les connaissances disponibles, rapport ANDRA.

[13] (2019) Bernard Beauzamy: L'utilisation des codes de calcul pour les démonstrations de sûreté : http://www.scmsa.eu/archives/BB_dem_surete_2019_09.pdf

VII. Recent contracts

- IRSN, 2003-2007: Improving the methodology in order to handle enrichment in Uranium and Plutonium
- Framatome-ANP, 2003-2004. Probabilistic methods for the study of accidents (thermo-hydraulic analyses)
- CEA, Saclay, 2005-2006: Analysis of the risks connected with the transportation of dangerous materials and connected with the flight of planes over the site
- ANDRA, 2007: Probabilistic analysis of radionuclides transfer
- Institut de Radioprotection et de Sûreté Nucléaire, 2007-2011: Applying the Probabilistic Hypersurface Method to the problems of safety for nuclear reactors
- EdF, CIDEN, 2007: Probabilistic methods for nuclear plants decommissioning
- CEA, Saclay, 2007: Probabilistic methods for earthquakes analysis
- CEA, Saclay, 2007-2008: Probabilistic methods for epidemiology
- Delegation for Nuclear Safety, Defense concerns, 2007-2008: Probabilistic studies
- IRSN, 2009, 2012: Tools for inspections help
- IRSN, 2009: Methodology for probabilistic studies for safety
- ANDRA, 2009-2012: Mathematical models for the propagation of radionuclides in the soil
- Areva, 2010: Probabilistic methods for the study of a site devoted to nuclear waste
- IRSN, 2010-2011: Mathematical analysis of the surveillance sensors in a nuclear reactor
- Nuclear Energy Agency (OCDE), 2010-2015: detection of aberrant data
- IRSN, 2012: Computing economic indicators in the case of serious nuclear accidents
- Areva, 2012-2013: Probabilistic methods for the assessment of mechanical properties of steel parts
- IRSN, 2013: Statistical analysis on tritium data
- IRSN, 2013-2015: Methodological help about the national accounting for nuclear components
- IRSN, 2013-2015: Analysis of the TELERAY Network: surveillance of radioactivity in the environment
- IRSN, 2014: Analysis of the "residual risk", for nuclear safety
- EDF/SEPTEN, 2015: Considering uncertainties in the Probabilistic Studies for Safety
- IRSN, 2015: Comparison of two extrapolation methods (EPH and Kriging) for the reconstruction of missing data
- IRSN, 2015-2016: Malfunctions in sensors' networks
- ANDRA, 2016, 2017, 2018, 2019: Optimization of the position of sensors in a site for nuclear waste.
- Framatome, 2018: Critical analysis of a safety demonstration.
- French "Commissariat pour l'Energie Atomique" (CEA/STXN), 2019: Hierarchy of parameters in a database.

- – Framatome, 2020: Writing of a safety demonstration for a command control board
- – ANDRA, 2022: Analysis of variations in terrestrial temperature in the vicinity of a storage site for radioactive products
- Neext Engineering, 2023 : Critical analysis of a project of Small Modular Reactor