

## Publikationen & Vorträge Risk & Safety

- 1) **Szabó T.**, "Gas Coolability of Decayed BWR Fuel in SFP Loss of Coolant Accidents", 9<sup>th</sup> European MELCOR User Group Meeting (EMUG), Centro de Investigaciones Energéticas, Medio Ambientales y Tecnológicas (CIEMAT), [https://www.psi.ch/emug/Emug2017EN/EMUG\\_2017\\_11.pdf](https://www.psi.ch/emug/Emug2017EN/EMUG_2017_11.pdf), Madrid, Spain, April 7, 2017
- 2) Grosse M., Schlegel R., **Friedl H.**, "Simulation des Flugzeuganpralls auf Stahlbetonstrukturen", 14. Deutsches LS-DYNA Forum, Bamberg, Deutschland, Oktober 10-12, 2016.

### Abstract:

Die Attentate vom 11. September 2001 auf das World Trade Center lösten weltweit eine Diskussion zur Überprüfung der Sicherheit von Kernkraftwerken gegenüber Flugzeuganprall aus. Oftmals sind dabei Stahlbetonkonstruktionen gegenüber Einwirkungen aus Flugzeuganprall zu untersuchen. In den letzten 15 Jahren gab es daher viele Untersuchungen zum Widerstandsverhalten gegen die mechanischen Auswirkungen eines Flugzeugabsturzes. Neben experimentellen Untersuchungen und analytischen Betrachtungen haben insbesondere numerische Simulationen für die Beurteilung der mechanischen Auswirkungen bei einem Flugzeuganprall zunehmende Bedeutung gewonnen. Der vorliegende Beitrag zeigt das Vorgehen zur Untersuchung eines Stahlbeton-Reaktorgebäudes gegen Flugzeuganprall mittels Impaktsimulationen mit LS-DYNA.

- 3) **Friedl H.**, Bayraktarli Y.Y., "Multi-perspective Post Fukushima evaluation of the seismic safety of the Nuclear Power Plant Mühleberg – From Analysis to Mitigation", Post-SMiRT23 Seminar, Istanbul, Turkey, October 21-23, 2015.

### Abstract:

Mühleberg nuclear power plant (KKM) is a General Electric (GE) type BWR4 boiling water reactor plant with Mark I containment and an electrical net output of 373 MW. The power plant is owned and operated by Bernische Kraftwerke AG, Berne (BKW) and started commercial operation in 1972. New insights in geosciences especially processed according to the guidelines released by the Senior Seismic Hazard Analyses Committee (SSHAC) led to substantial higher estimates of the seismic hazard for the Swiss nuclear power plants compared to the seismic design level. A re-evaluation of the seismic capacities of the KKM structures, systems and components (SSC) and a refined assessment of the seismic risk was hence required. After Fukushima the seismic safety of KKM was re-evaluated in detail probabilistically (seismic PSA) as well as deterministically. Being one of the major contributors to the risk for KKM, the seismic-induced failure of the gravity dam 2 km upstream of KKM was re-evaluated too. The gravity dam retains an artificial lake with a water reservoir of 25 million cubic meters. The failure of the dam may lead to functional failure of the bunkered safety systems of KKM through loss of the primary heat sink Aare river. We implemented backfitting measures both for prevention as well as for mitigation. As a mid-term mitigation measure the seismic capacity of the dam was strengthened. The strengthening was done by 72 concrete-filled steel pipe piles. The piles with a diameter of 1.5m and a length of 18m increase the shear capacity of the dam foundation significantly. In parallel an additional mitigation procedure (feed & bleed) was established in order to bridge the time till completion of the dam strengthening. As a long term measure KKM completed in August 2015 an alternative cooling water supply independent of the primary heat sink. The contribution presents an overview of the safety checks performed after Fukushima. Special emphasis will be given to the probabilistic nonlinear analyses conducted to evaluate the seismic fragility of the dam for seismic hazard levels from the PEGASOS Refinement Project.

- 4) **Friedl H.**, Lu S., Ralbovsky M., "Erdbebenlasten Eurocode 8: Praxisbeispiele Hochbau aus Stahlbeton, Stahlbau-Halle und Hochbau aus Mauerwerk"; Austrian Standards, ISBN 978-3-85402-293-0, Wien, 2014.

### Abstract:

Mit der Einführung des Eurocodes 8 „Auslastung von Bauwerken gegen Erdbeben“ wurde eine neue Normengeneration hinsichtlich Entwurf und Bemessung von Bauwerken für den Lastfall Erdbebeneinwirkung eingeführt. Im Vergleich zu älteren Normgeneration gibt der Eurocode 8 eine Vielzahl von ergänzenden Bestimmungen und Anforderungen für die Tragwerksauslegung und Nachweisführung für den Grenzzustand der Tragfähigkeit und Gebrauchstauglichkeit vor. Im vorliegenden Band wird die Anwendung des Eurocodes 8 für drei Praxisbeispiele – einen Hochbau aus Stahlbeton, eine Stahlhalle und einen Hochbau aus Mauerwerk – demonstriert. Besonderes Augenmerk wurde auf die detaillierte Aufarbeitung und Angabe aller Berechnungsschritte sowie Verweise auf die zugehörigen Abschnitte der ÖNORM EN 1998-1 (2013 06 15) und die nationale ÖNORM B 1998-1 (2011 06 15) gelegt. Das Buch verarbeitet praxisgerecht die langjährigen Erfahrungen und profunden Kenntnisse der Autoren, die Top-Experten der Materie sind, und gibt wertvolle Empfehlungen für den Planungs- und Bemessungsingenieur. Es gibt einen Vergleich über die im Eurocode 8 vorgegebenen Berechnungsverfahren und zeigt neben linear elastischen Berechnungsverfahren auch das Potenzial von nichtlinearen statischen Berechnungsverfahren wie der Pushover-Berechnung.

- 5) BKW, EOP at Mühleberg, Presentation on "BWR-club workshop covering issues related to EOP/SAMG and on using mobile systems to handle severe accidents" in Mühleberg NPP, 21-22 November 2013.

Abstract:

The goal of the workshop, which had participants from most of the BWR utilities in Europe and vendor representatives from US and Europe, was to establish the current EOPs and Severe Accident Management Guidelines (SAMGs) position across European utilities. This presentation gives an overview about the Mühleberg NPP and describes the after the Fukushima accident new installed emergency operation systems.

- 6) BKW, Mühleberg SAMG, Presentation on "8. Sitzung des Technischen Forums Kernkraftwerke" in Brugg, 12 December 2014.

Abstract:

The Technical Forum on Nuclear Power Plants (TFK) provides the Federal Nuclear Safety Inspectorate (ENSI) with a platform where questions raised by the general public on the safety of Swiss nuclear power plants can be discussed. Comments on safety issues are made by members of this permanent body, who include representatives of communes, cantons, non-governmental organizations, nuclear power plant operators/licensees and the authorities involved. This presentation explains the severe accident management systems and procedures to interested participants.

- 7) BKW, SAMG Exercises at Mühleberg NPP, Presentation on "JRC workshop on Severe Accident Simulators for Nuclear Power Plants", Schiphol - NL, 02-03 March 2015.

Abstract:

JRC workshop on Severe Accident Simulators for Nuclear Power Plants addresses current industry and regulatory perspectives on use of severe accident simulation in training as well as trends in the technology's use. This presentation explains the practical training courses carried out at the Mühleberg NPP with the onsite simulator as well as with the computer program SNAP/MELCOR.

- 8) BKW, Modelling of Mobile Systems and SAMG Actions in KKM PSA, Presentation on "BWR-club workshop Probabilistic Safety Analysis in Adelsried, 21-22 September 2015.

Abstract:

The BWR Club Europe provides a forum, which allows its member utilities to maintain and improve plant safety, achieve higher plant reliability, facilitate regulatory interaction, and effectively apply limited technical resources for mutual resolution of issues applicable to two or more members. This presentation explains how mobile systems and severe accident management actions are modeled in the probabilistic safety assessment of the Mühleberg NPP.

- 9) NPSAG Report 11-004-01, Evaluation of Existing Applications and Guidance on Methods for HRA – EXAM-HRA, Final Summary Report from the NPSAG / SAFIR project EXAM-HRA, 2015-05-19.

10) NPSAG Report 11-004-02, Evaluation of Existing Applications and Guidance on Methods for HRA – EXAM-HRA, A Practical Guide to HRA, 2015-05-19.

11) NPSAG Report 11-004-03, Evaluation of Existing Applications and Guidance on Methods for HRA – EXAM-HRA, HRA Application guide, 2015-05-19.

Abstract:

EXAM-HRA is a Nordic, Swiss and German project which assesses human reliability analysis (HRA) applications in existing probabilistic safety analysis (PSA) studies. The overall project objective is to provide guidance for a state of the art HRA for purposes of PSA, to ensure that plant specific properties are properly taken into consideration in the analysis. This shall also provide means to improve the experience feedback on plant features based on HRA and PSA results.

The project is performed in several consecutive phases. The objective for the first phase is to provide a framework for identifying discrepancies in existing HRA applications. This includes development of a survey and screening process for operator actions in existing PSA studies as well as development of an evaluation guide.

The second phase consisted of performing the survey. The survey provides an overview of performed HRA applications, including approximately 420 operator actions from six PSA studies, and constitutes basis for the selection of scenarios and actions for assessment in the upcoming phases. The case studies resulted in observations that allow for improvements of both plant features as well as the HRA itself. In the third phase additional assessments were performed on a number of operator actions in order to generate more comprehensive observations regarding both the plant features and HRA applications.

The evaluation format that has been developed within the EXAM-HRA project has been found useful and the assessments of actions performed in the case studies has resulted in findings regarding plant features as well as features of the HRA and PSA applications.

The aim is to improve consistency in in-depth HRA and human error probability (HEP) assessment by providing a common basis for methods and guidance for HRA application and assessment. These results are used in the final phase of the project to define good practice and provide guidance for inclusion of plant specific aspects in HRA applications in the context of PSA.

- 12) P. Mueller, K. Nikitin, W. van Doesburg, and D. Hiltbrand, "RELAP5 BWR-4 model development and validation for NPP Mühleberg (KKM)", NURETH-16, Chicago, IL, August 30-September 4, 2015.
- 13) K. Nikitin, P. Mueller, J. Martin, W. van Doesburg, and D. Hiltbrand, "BWR loss of coolant accident simulation by means of RELAP5", Nuclear Engineering and Design 309 (2016) 113–121.
- 14) S. Lafountain, B. Sarikaya, K. Nikitin, W. van Doesburg, " KKM TRACG Validation", NURETH-16, Chicago, IL, August 30-September 4, 2015.
- 15) S. Lafountain, B. Sarikaya, J. Hagaman, P. Sharpe, D. Pappone, K. Muftuoglu, W. van Doesburg, K. Nikitin, " KKM TRACG LOCA", NURETH-16, Chicago, IL, August 30-September 4, 2015.
- 16) K. Nikitin, S. Walser, BKW Engineering, P. Mueller, U. Amherd, J. Judd, D. Hiltbrand, "BWR-4 ATWS modeling with RELAP-S3K coupled code", 2016 Spring CAMP Meeting, April 26 - 28, 2016 Khalifa University, Al Zafranah, Abu Dhabi, United Arab Emirates.
- 17) K. Nikitin, P. Mueller, J.Freixa, " BWR-4 LOCA modeling with RELAP5", 2015 Spring CAMP Meeting, Prague, Czech Republic.
- 18) K. Nikitin, S. Domesi, M. Klemenz, P. Mueller, T.Kim, " Siphon breaker modeling with TRACE and RELAP", 2014 Spring CAMP Meeting, Zagreb, Croatia.
- 19) H. J. Leber, S. Roy, M. Klemenz, P. Graedel, C. Weber, U. Imobersteg, R. Jakab, "Mitigation and Assessment of SCC at the Core Shroud of Muehleberg Nuclear Power Plant (KKM)", "International Light

Water Reactors Material Reliability Conference and Exhibition 2016", August 1 - August 4, 2016, Chicago, IL, USA.