

The 25th Annual Regulatory Information Conference, RIC 2011, March 8-11 2011

In session "Developments in International Nuclear Safety Research"
on Wednesday, March 9, 2011 at 1:30 pm – 3:00 pm

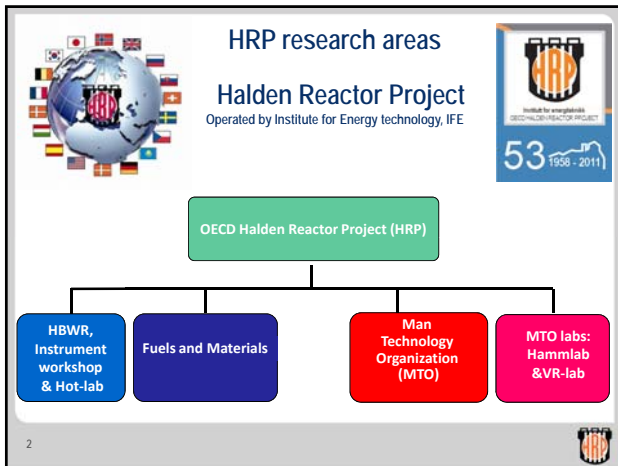
Examples from the planned Safety Research program for 2012-14 at the OECD Halden Reactor Project (HRP)

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Bethesda North Marriott Hotel and Conference Center, Washington USA





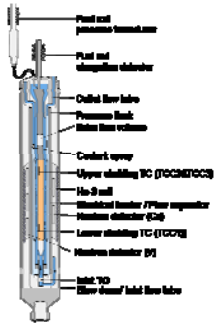


Examples of key fuels research issues in the ongoing and proposed program

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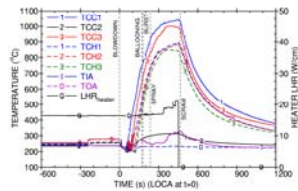


LOCA testing in the Halden Reactor



Safety motivation and background

- Introduction of new claddings and higher burnup generate need to verify continued validity of LOCA safety criteria
- Halden's LOCA tests study integral in-reactor behavior of NPP fuel under expected and bounding conditions



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Findings on High burnup fuel in LOCA

- 2 earlier LOCA tests (IFA 650.4/.9) with high burnup fuel (90 MWd/kgU) that had low corrosion duplex clad (7-8 μm oxide and ~ 30 ppm H)
- 2 very similar, but originally unexpected outcomes:
 - well developed balloon filled with fuel fragments
 - upper part of fuel stack missing – fragmented, relocated, dispersed
 - some fuel at the bottom of the pressure flask
 - cladding burst at $\sim 800^\circ\text{C}$

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“Industry burn-up level” for PWR fuel in LOCA?

- Objective
 - Does the strong fragmentation / relocation observed in IFA-650.4 also occur in fuel with industry-realistic discharge burn-up (and normal clad corrosion level)?
- Test rod provided by EDF/Areva
 - Burn-up 61 MWd/kg U
 - Zry-4, oxide layer 20-30 µm, H 150-220 ppm
 - Rod pressurised to 40 bar (RT)
 - Target peak clad temp of 850 °C
- Outcome – NOT like IFA-650.4/9:
 - Mid-height small balloon and failure
 - Limited fuel expulsion from the rod (gamma signal from bottom of pressure flask)
- Significant result which suggests a burn-up threshold for fuel fragmentation/ relocation/ dispersal

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“Industry burn-up level” BWR fuel in LOCA

- Next proposed test in the LOCA series is
 - an **“Industry burn-up level” BWR fuel in LOCA:**
 - This test will use 70 MWd/kg BWR fuel.
- The aim is
 - to achieve **ballooning without failure** to see whether fuel relocation will occur without the driving force of the gas expanding through the breach.
- The test
 - will take place in May 2011. If successful the Halden Program Group will decide on the conditions for the next test in 2012.

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A new safety related issue

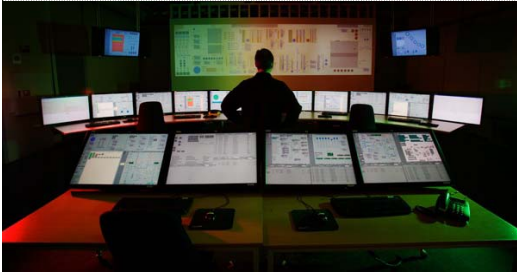
- A dry-out / **departure from nuclear boiling (DNB)** / critical heat flux (CHF) experiment has recently been proposed for future Halden investigations
 - The phenomena are related to Class III and Class IV power accidents
 - The aims
 - would be to demonstrate that fuel having undergone dry-out (during a certain period of time) **still has sufficient integrity to withstand continued operation,**
- and
- to **quantify the extent of that continued operation** (probably both in terms of duration and power level/power variation).

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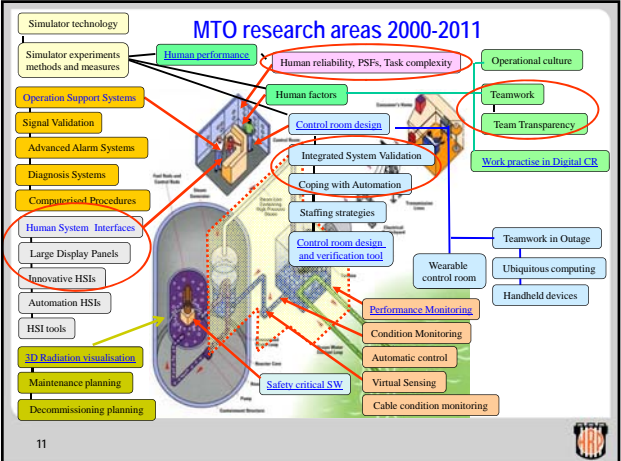


Hammlab as of 2009

Issues in Digital Control Rooms

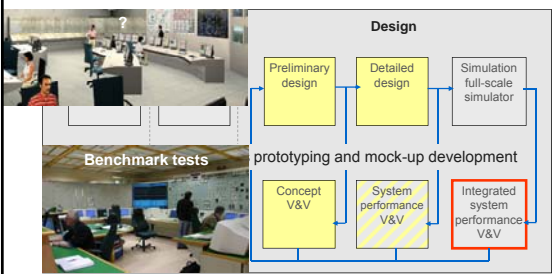


MTO research areas 2000-2011

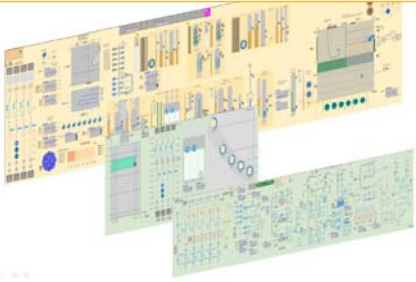


Integrated System Validation (ISV)

NUREG-0711



Multi-layered Integrated HSI design



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Plans

- **Develop** an integrated HSI concept and prototype
 - Accepted by today's operators
 - Supporting existing or improved work practices
 - Complying with guidelines and standards
 - Covering all operational modes
 - Covering different presentation media
 - Including alarm system and computerised procedures
- **Evaluate** the integrated HSI through
 - Various types of user tests
 - Human performance experiments

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The International HRA Empirical Study 2006-2011



Motivation:

- Human performance is an important contributor to risk
- Many different HRA methods in use today
- Diverse underlying models, producing different results
- Reliable estimates are needed for risk-informed decisions
- Lack of data, particularly on cognitive and collaborative aspects of crew performance

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Goals

Based on crew performance data collected in simulated emergencies:

- To analyse HRA methods' performance
- To identify strengths and weaknesses of HRA methods
- To provide the technical basis for improving HRA guidance
- To provide the technical basis for improving HRA methods
 - Improved guidance for each method
 - Further method development

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Main conclusions

- Need for better qualitative analysis
- Need for better treatment of procedure-driven human actions
- Identified inconsistencies in judgments of performance shaping factors (PSFs) and in treatment of dependencies
- Need for empirical data for HRA

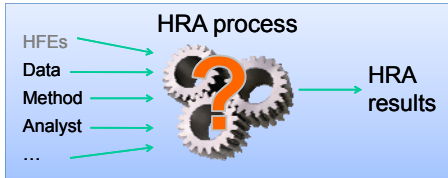
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Motivation

- In order to improve HRA results, we must first understand the analyst's work **as it is actually done**
- HRA practice / process \neq HRA method



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Research questions

- Why & how is scenario analysis **difficult**?
- What is the **role of the analysts**?
 - How do they **adapt** HRA methods?
 - How do they **compensate** for lack of guidance?
 - What skills / experience do they need?
- How can HRA practice be **improved**?
- What is the role of "**data**" in HRA practice?
 - What data do analysts use now (and how)?
 - What kind of data / knowledge is **really needed** in the future?

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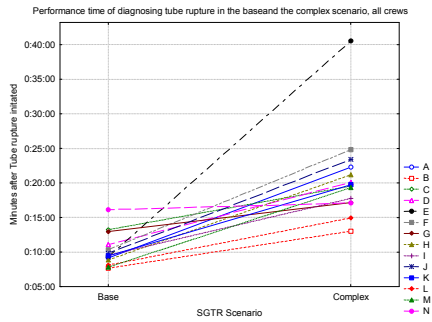


Teamwork/Team Cognition in Complex Accident Scenarios

- The research issue:
 - investigate **team cognition** and **its relationship to performance** in complex accident scenarios.
- Data from the Performance Shaping Factors and Masking Experiment / Empirical HRA study (data collected in 2006)
 - 2 versions of SGTR, 2 versions of LOFW.



Observations



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Results

- **Team cognition** is an **important performance driver** for complex, but highly procedure guided situations.
- The set of **team cognition dimensions** identified do describe aspects of operation that are
 - **important for performance outcome** and
 - for describing **factors related to variability** between teams.
- Issues related to the **difference in diagnosis time** between the **well and poor** performing teams:
 - **Mission analysis** - Cognition beyond procedure guidance.
 - **Process of consultation** while performing technical work.
 - **Distributed leadership** (mainly between Supervisor and Reactor operator).
 - **Team orientation** and Backup and support.



Team cognition, Further Plans

- Already used as input to improve training at one plant
- A similar team cognition analysis of the LOFW scenarios as was performed for the SGTR scenarios
 - Report by the end of 2011.
- Issues
 - Similar observations as for the SGTR? Will inform on how general the findings are across types of scenarios
 - Provide a broader basis (SGTR + LOFW) for analysing the intra team, context and team-context interaction
 - E.g., to what extent are dimensions of team cognition stable intra team characteristics versus driven by situational factors.



Summary

The Halden Reactor Project relies on a range of state-of-the-art **facilities**, skilled **staff**, and 53 years of **experience**

These resources are used to **independently** conduct **safety related fuel and materials tests** and at generating new and improved data on through-life fuel and material properties and behavior

...and to develop concepts and designs, and generate **guidance and prototypes** for the use of **advanced information, instrumentation and control systems** to the various nuclear stakeholders

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The end

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20.03.2011