

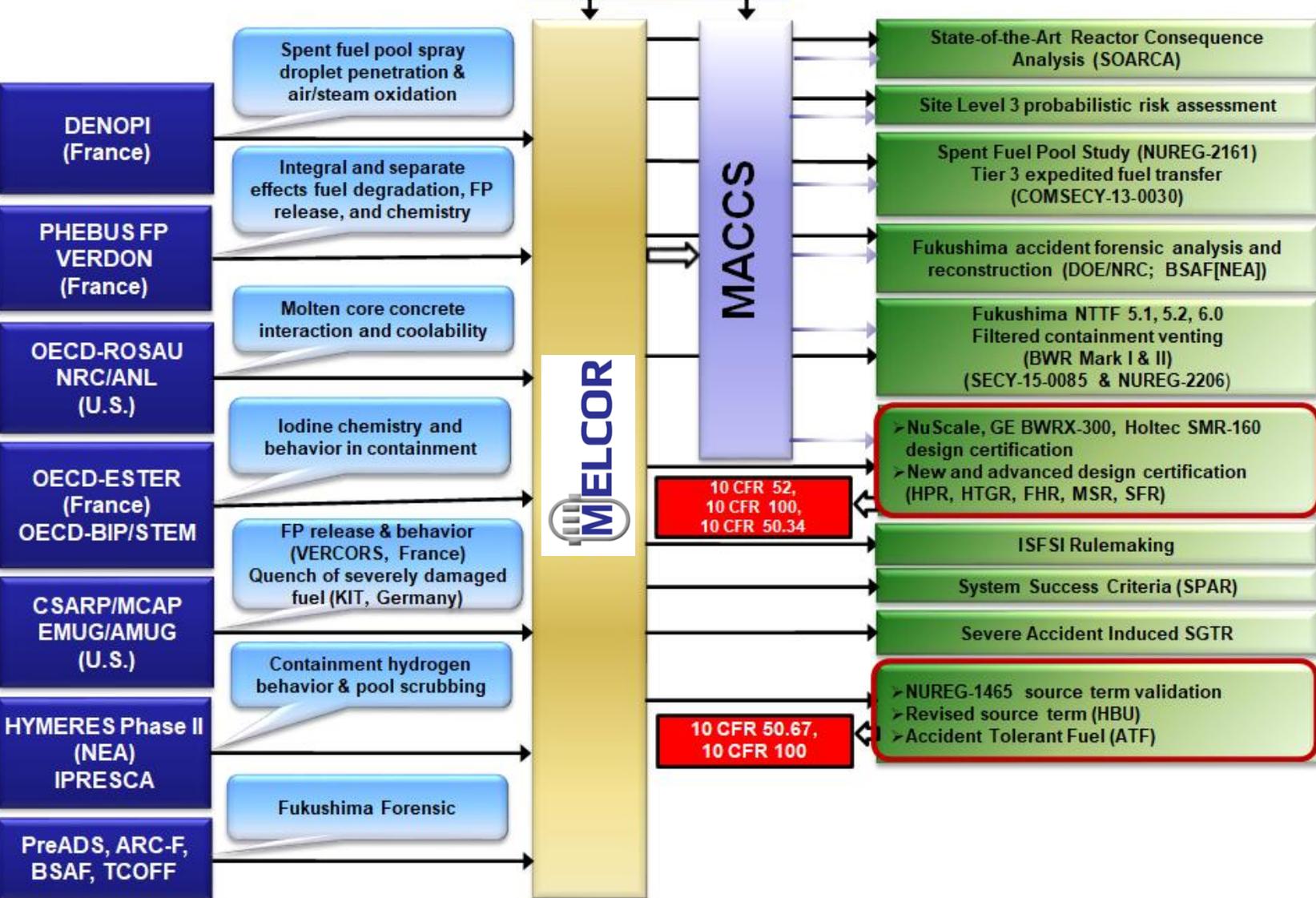
U.S. NRC Research Activities on Severe Accident Progression and Source Term Analysis

Shawn Campbell, PhD
Office of Nuclear Regulatory Research



European MELCOR User Group Meeting
Ljubljana, Slovenia
April 12-14, 2023

Severe Accident Code Development & Regulatory Applications

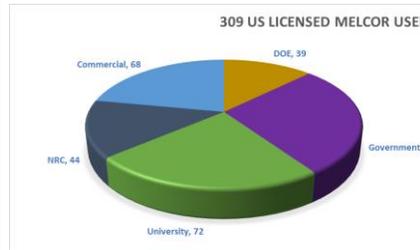


What Is It?
 MELCOR is an engineering-level code that simulates the response of the reactor core, primary coolant system, containment, and surrounding buildings to a severe accident.

Who Uses It?
 MELCOR is used by domestic universities and national laboratories, and international organizations in around 30 countries. It is distributed as part of NRC's Cooperative Severe Accident Research Program (CSARP).

How Is It Used?
 MELCOR is used to support severe accident and source term activities at NRC, including the development of regulatory source terms for LWRs, analysis of success criteria for probabilistic risk assessment models, site risk studies, and forensic analysis of the Fukushima accident.

How Has It Been Assessed?
 MELCOR has been validated against numerous international standard problems, benchmarks, separate effects (e.g., VERCORS) and integral experiments (e.g., Phebus FPT), and reactor accidents (e.g., TMI-2, Fukushima).

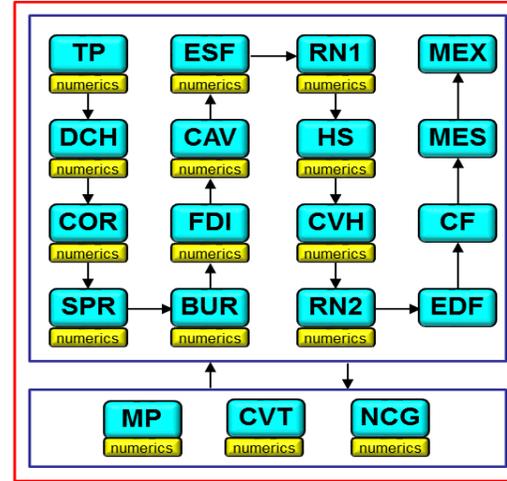
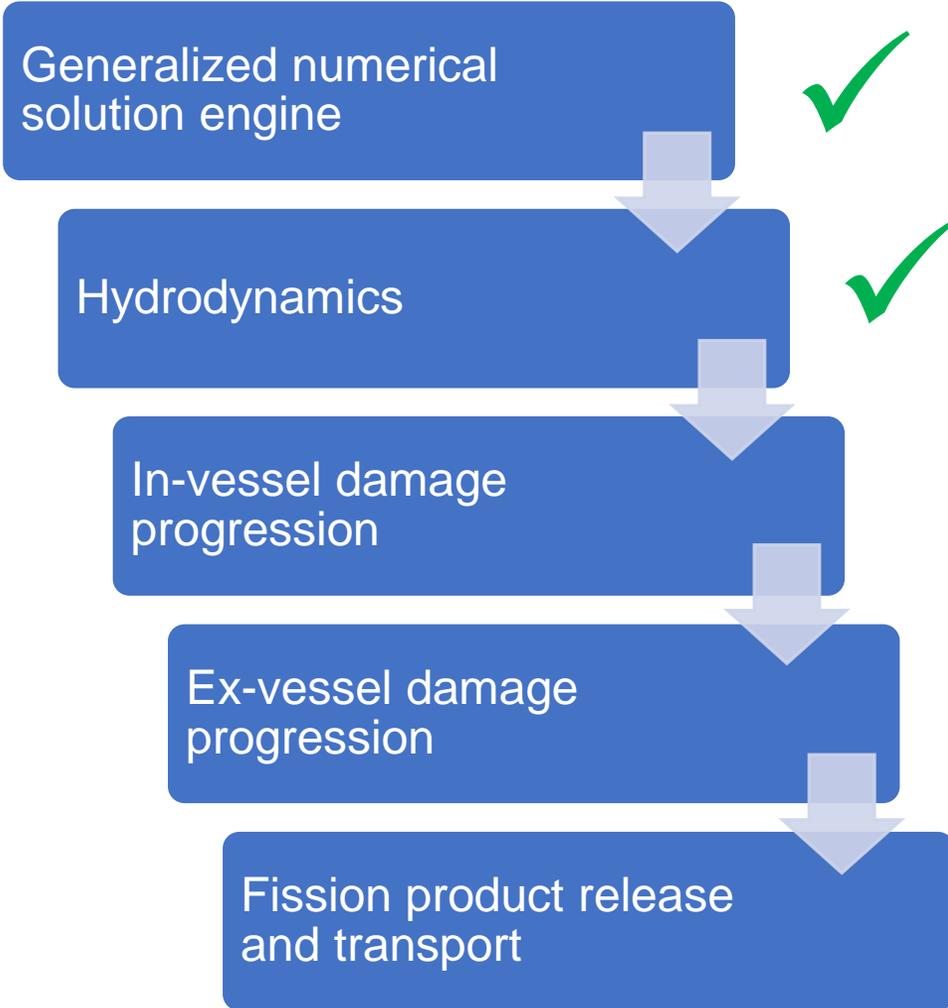


MELCOR User Groups & Technical Meetings

Cooperative Severe Accident Research Program (CSARP) – June/U.S.A
MELCOR Code Assessment Program (MCAP) – June/U.S.A
European MELCOR User Group (EMUG) Meeting – Spring/Europe
Asian MELCOR User Group (AMUG) Meeting – Fall/Asia

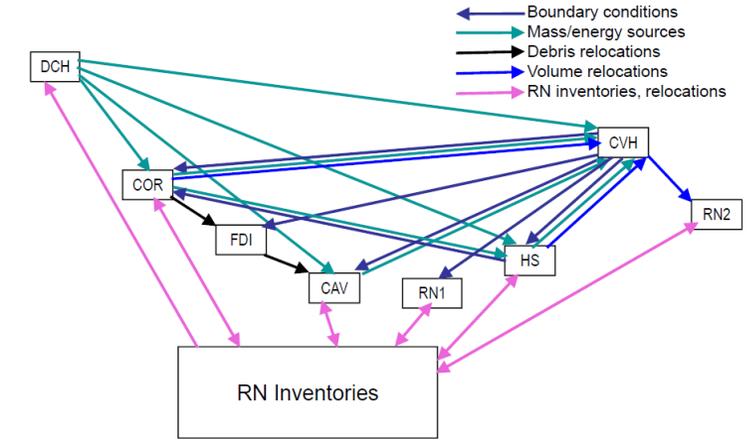


MELCOR Modernization (2024)

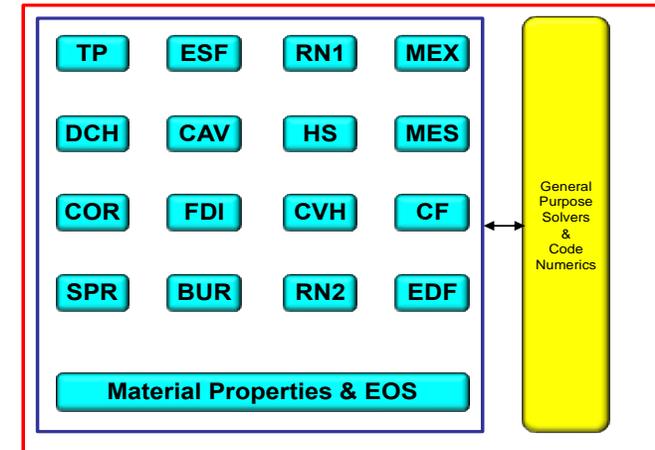


TP = Transfer Process
 DCH = Decay Heat
 COR = Core
 SPR = Containment Spray
 BUR = Gas Combustion
 FDI = Fuel Dispersal Interaction
 CAV = Cavity (MCCI)
 ESF = Engineered Safety Features
 MP = Material Properties

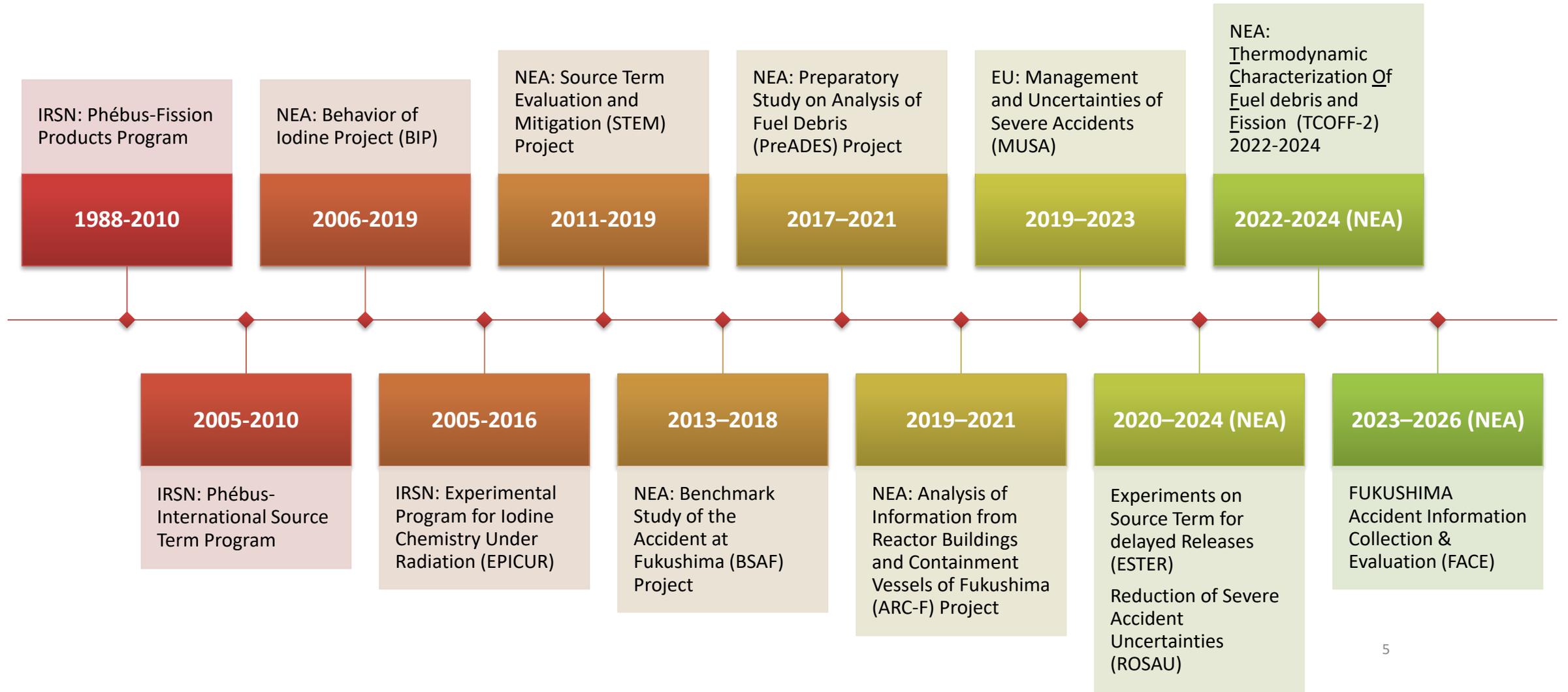
RN = Radionuclide
 HS = Heat Structure
 CVH = CV Hydrodynamics
 EDF = External Data File
 CF = Control Function
 MES = Special Messages
 MEX = Executive
 CVT = CV Thermodynamics
 NCG = Non Condensable Gas



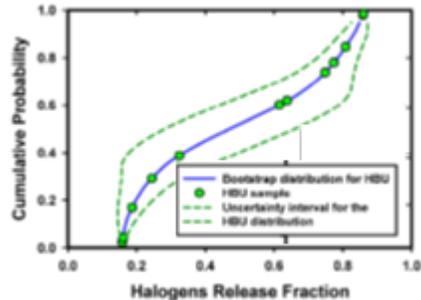
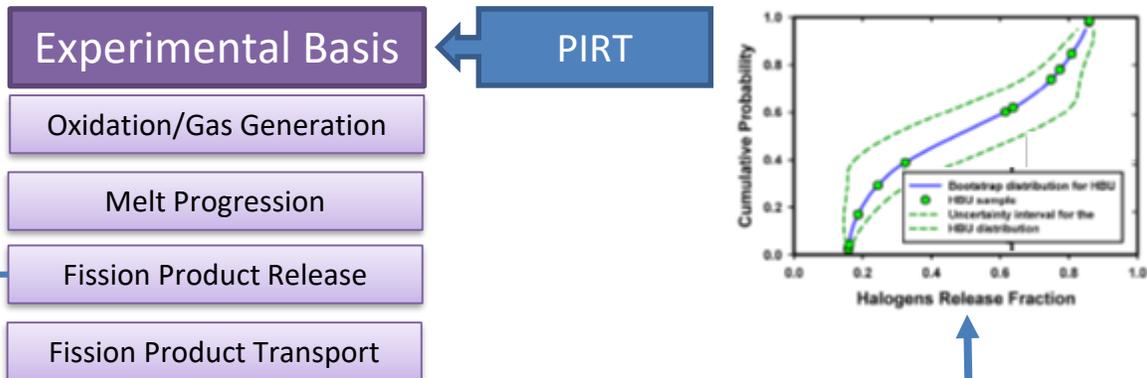
Separate **Physics** & **Numerics**



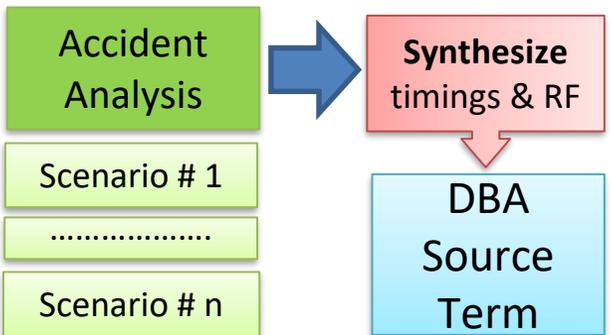
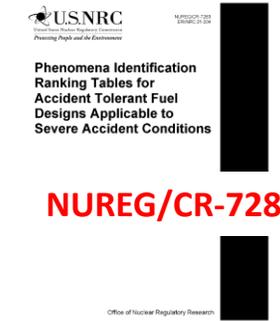
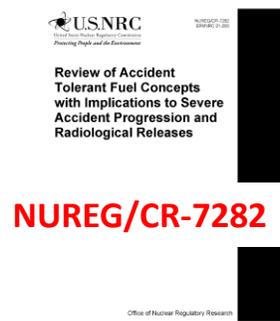
International Severe Accident Projects



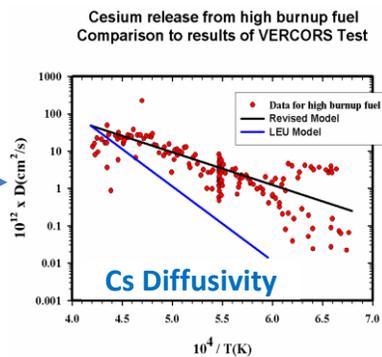
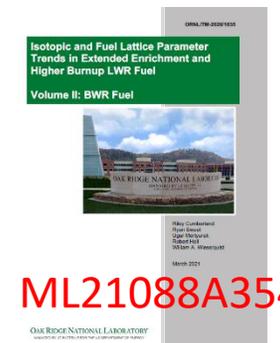
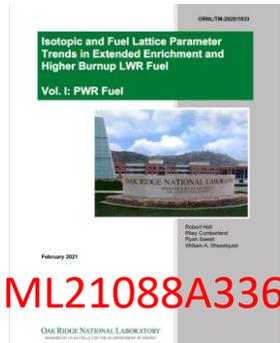
Source term for HBU/ATF



Panel of international severe accident experts Phenomena Identification and Ranking Tables (PIRT) that addressed significant phenomenological issues to improve MELCOR

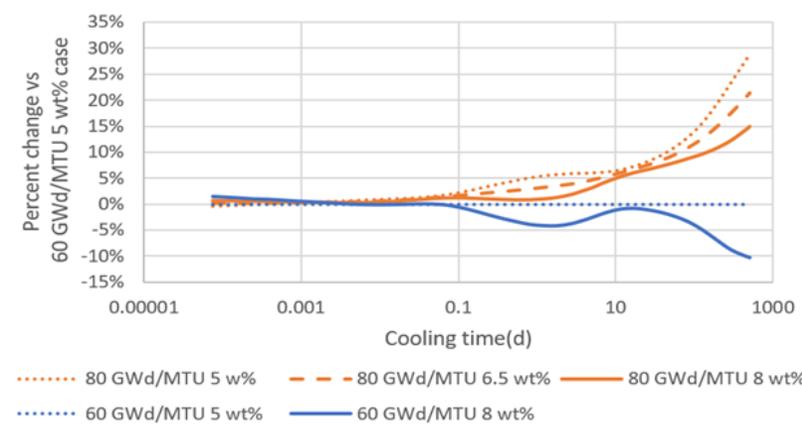


HBU/extended enrichment – SAND2023-01313



Fission Product class	Gap 0.5 hr	In-vessel 1.3 hr	Ex-vessel 2 hr	Late 10 hr
Noble Gases	5%	95%	~0	~0
Iodine, bromine	5%	35%	25%	1%
Cesium	5%	25%	35%	1%
Tellurium	~0	5%	25%	0.5%
Ba, Sr	~0	2%	10%	~0
Ru, Mo, Pd, etc.	~0	0.25%	0.25%	~0
Lanthanides	~0	0.02%	0.5%	~0
Cerium group	~0	0.05%	0.5%	~0

NUREG-1465 (RG 1.183)



Advanced Nuclear Technology Research

Five Major Types of Non-LWRs Analyzed for Source Term:

2021

- Heat Pipe Reactor – INL Design A
- High-Temperature Gas-Cooled Pebble-bed Reactor – PBMR-400
- Molten-salt-cooled Pebble-bed Reactor – UCB Mark 1

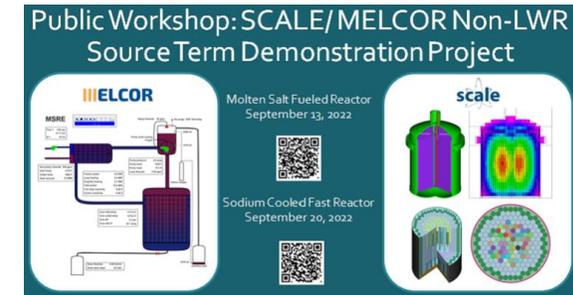
2022

- Molten-salt-fueled Reactor – MSRE
- Sodium-cooled Fast Reactor – ABTR

Also Evaluating the Non-LWR Fuel Cycle

2023

- High-Temperature Gas-Cooled Pebble-bed Reactor – PBMR-400
- Sodium-cooled Fast Reactor – ABTR



SCALE/MELCOR non-LWR source term demonstration project	
<ul style="list-style-type: none">• Heat-pipe reactor workshop on June 29, 2021<ul style="list-style-type: none">• Slides ☐• Video Recording EX11• SCALE report ☐• MELCOR report ☐	June 29, 2021
<ul style="list-style-type: none">• High-temperature gas-cooled reactor workshop on July 20, 2021<ul style="list-style-type: none">• Slides ☐• Video Recording EX11• SCALE report ☐• MELCOR report ☐	July 20, 2021
<ul style="list-style-type: none">• Fluoride-salt-cooled high-temperature reactor workshop on September 14, 2021<ul style="list-style-type: none">• Slides ☐• Video Recording EX11• SCALE report ☐• MELCOR report ☐	September 14, 2021
<ul style="list-style-type: none">• Molten-salt-fueled reactor workshop on September 13, 2022<ul style="list-style-type: none">• Slides ☐• Video Recording EX11• SCALE report ☐	September 13, 2022
<ul style="list-style-type: none">• Sodium-cooled fast reactor workshop on September 20, 2022<ul style="list-style-type: none">• Slides ☐• Video Recording EX11	September 20, 2022

Public workshop videos, slides, reports at [advanced reactor source term webpage](#)

SCALE input models available [here](#).

MELCOR input models available upon request.

2023 CSARP/MCAP meetings

- June 5-9, 2023
- Registration:
 - <https://www.eventbrite.com/e/2023-csarp-mcap-meetings-registration-520604450927>



MELCOR Workshop

- June 12-16, 2023
- Free to all MELCOR users
- Registration:
 - <https://www.eventbrite.com/e/2023-melcor-user-workshop-registration-523009173517>

