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Update on FEP Catalogue for SNF/HLW Disposal in Rock Salt

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Generic Salt FEPs Catalogue

- U.S.-German collaboration to produce a common FEP list
 - Identify relevant features, events, and processes (FEPs) for disposal of heat-generating waste (SNF and HLW) in salt
 - Applicable to all potential salt concepts and sites (bedded and domal)
 - Develop FEP matrix as an organizational structure for the salt FEPs
- Salt Club
 - FEP Catalogue for use by all Salt Club members
 - Countries with potential interest in salt
 - Consistency with new NEA FEP database

FEP Matrix Approach

Characteristics, Processes, and Events		Processes												Events				
Features and Components	(CP) Characteristics	(TM) Mechanical and Thermal-Mechanical	(TH) Hydrologic and Thermal-Hydrologic	(IC) Chemical and Thermal-Chemical	(TB) Biological and Thermal-Biological	(TT) Transport and Thermal-Transport	(TR) Thermal	(RA) Radiological	(LG) Long-Term Geologic	(CL) Climatic	(HP) Human Activities (long timescale)	(OP) Other	(NC) Nuclear	(EF) Early Failure	(SM) Seismic	(IG) Igneous	(HE) Human Activities (short timescale)	(OE) Other
Waste and Engineered Barriers Region																		
(WF) Waste Form and Cladding																		
• Commercial SNF & Cladding																		
• Commercial HLW Glass																		
• Naval SNF & Cladding																		
• Defense SNF & Cladding																		
• Defense HLW																		
• Other																		
(WP) Waste Package and Internals																		
• Commercial SNF																		
• Commercial HLW																		
• Naval SNF																		
• Defense SNF																		
• Defense HLW																		
• Other Packages																		
(BB) Buffer/Backfill																		
• Waste Package Buffer																		
• Tunnel/Drift/Room Backfill																		
(MW) Emplacement Tunnels/ Drifts and Mine Workings																		
• Open Excavations																		
• Drift Support																		
• Liners																		
• Other																		
(SP) Seals/Plugs																		
• Drift/Panel Seals/Closures																		
• Shaft Seals																		
• Plugged Boreholes																		
Geosphere and Natural Barriers Region																		
(HR) Host Rock (Repos. Horizon)																		
• Bedded or Domal Salt																		
• Disturbed Rock Zone																		
• Interbeds and Seams																		
(OU) Other Geologic Units																		
• Aquifer(s)																		
• Unsaturated Zone																		
• Pressurized Brine Reservoir(s)																		
Surface Region																		
(BP) Biosphere																		
• Natural Surface and Near-Surface Environment																		
• Flora and Fauna																		
• Humans																		
• Food and Drinking Water																		
• Dwellings and Man-Made Surface Features/Materials																		
System Region																		
(RS) Repository System																		
• Assessment Basis																		
• Pre-closure and Operational																		
• Other Global																		

- Two-dimensional organization structure
 - Matrix rows = Features and Components
 - Matrix columns = Processes and Events
- Matrix Cell contains all FEPs related to the “Process/Event” acting upon or within the “Feature”
- FEP Identification
 - Matrix-based alpha-numeric
 - Can still be mapped to the NEA Database for traceability

Work for Current Salt Club Mandate Period (2014-2016)



- Continued development of detailed FEP Descriptions
 - 25 Example FEPs – highlighting differences between bedded and domal salt
- Generic Salt FEPs Catalogue, Volume II, Revision 0
 - June 2015 Progress Report
- Ongoing testing/review of NEA FEP Database Version 0.3
- Developing complete list of Matrix-based FEPs
- 2016 Documentation
 - TBD

Detailed FEP Descriptions

Characteristics, Processes, and Events	Processes																Events			
	(CP) Characteristics	(TM) Mechanical and Thermal-Mechanical	(TH) Hydrologic and Thermal-Hydrologic	(TC) Chemical and Thermal-Chemical	(TB) Biological and Thermal-Biological	(TT) Transport and Thermal-Transport	(TR) Thermal	(RA) Radiological	(LG) Long-Term Geologic	(CL) Climatic	(HP) Human Activities (long timescale)	(OP) Other	(NC) Nuclear Criticality	(EF) Early Failure	(SM) Seismic	(IG) Igneous	(HE) Human Activities (short timescale)	(OE) Other		
Features and Components	Waste and Engineered Barriers Region																			
(WF) Waste Form and Cladding																				
• Commercial SNF & Cladding																				
• Commercial HLW Glass																				
• Naval SNF & Cladding																				
• Defense SNF & Cladding																				
• Defense HLW																				
• Other																				
(WP) Waste Package and Internals																				
• Commercial SNF																				
• Commercial HLW																				
• Naval SNF																				
• Defense SNF																				
• Defense HLW																				
• Other Packages																				
(BB) Buffer/Backfill																				
• Waste Package Buffer																				
• Tunnel/Drift/Room Backfill	1	2																		
(MW) Emplacement Tunnels/ Drifts and Mine Workings			1														1			
• Open Excavations																				
• Drift Support																				
• Liners																				
• Other																				
(SP) Seals/Plugs																				
• Drift/Panel Seals/Closures																				
• Shaft Seals	1		1																	
• Plugged Boreholes																				
Geosphere and Natural Barriers Region																				
(HR) Host Rock (Repos. Horizon)		1														1				
• Bedded or Domal Salt	1																			
• Disturbed Rock Zone	1	1	1																	
• Interbeds and Seams	1																2			
(OU) Other Geologic Units																				
• Aquifer(s)																				
• Unsaturated Zone																				
• Pressurized Brine Reservoir(s)																				
Surface Region																				
(BP) Biosphere																				
• Natural Surface and Near-Surface Environment																				
• Flora and Fauna																				
• Humans																				
• Food and Drinking Water																				
• Dwellings and Man-Made Surface Features/Materials																				
System Region																				
(RS) Repository System																				
• Assessment Basis																				
• Pre-closure and Operational																				
• Other Global	1																			

5 Original FEPs

- BB.02.CP.01 Backfill Materials
- BB.02.TM.01 Mechanical Effects on Backfill or from Backfill
- BB.02.TM.02 Thermal-Mechanical Effects on Backfill or from Backfill
- HR.02.TH.01 Flow Through the DRZ
- SP.02.TC.01 Chemical Interaction of Groundwater with Shaft Seals

20 Additional FEPs

- RS.03.CP.01 Repository Design
- WP.00.TC.01 Gas Generation at Waste Packages
- MW.00.TH.01 Flow of Gas in Mine Workings
- MW.00.TC.01 Gas Generation in Mine Workings
- MW.00.HE.01 Human Intrusion into the Emplacement Drifts
- SP.02.TM.01 Mechanical Effects on Shaft Seals or From Shaft Seals
- HR.02.TM.01 Mechanical Effects on the Evolution of the DRZ
- HR.01.CP.01 Stratigraphy and Properties of Bedded and Domal Salt
- HR.02.CP.01 Stratigraphy and Properties of the Disturbed Rock Zone in the Host Rock
- HR.03.CP.01 Stratigraphy and Properties of Interbeds and Seams in the Host Rock
- HR.00.OP.01 Alteration and Evolution of Flow Pathways in Host Rock
- HR.00.TM.01 Mechanical Effects on Host Rock
- HR.01.TT.01 Advection of Dissolved Radionuclides in Bedded or Domal Salt
- HR.02.TT.01 Advection of Dissolved Radionuclides in the Disturbed Rock Zone
- HR.03.TT.01 Advection of Dissolved Radionuclides in Interbeds and Seams
- HR.01.TT.02 Diffusion/Dispersion of Dissolved Radionuclides in Bedded or Domal Salt
- HR.02.TT.02 Diffusion/Dispersion of Dissolved Radionuclides in Disturbed Rock Zone
- HR.03.TT.02 Diffusion/Dispersion of Dissolved Radionuclides in Interbeds and Seams
- BB.02.TT.01 Advection of Dissolved Radionuclides in Crushed Salt
- BB.02.TT.02 Diffusion/Dispersion of Dissolved Radionuclides in Crushed Salt

Generic Salt FEPs Catalogue, Vol. II



Sandia National Laboratories
Waste Isolation Pilot Plant

Generic Salt FEPs Catalogue, Volume II

Revision 0

June 29, 2015

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WBS 1.2.3.03.03.06
International R&D

Full List of Matrix-Based FEPs

- SNL-GRS working meeting in Washington DC in February 2016
 - Identified approximately 350 FEPs with Associated Processes

Matrix FEP Number	Description	Associated Processes	UFD FEPs [VSG FEPs]
MW.01.TH.01	Flow In and Through Open Excavation	-(A) Saturated / multi-phase flow -(B) From fluid pressure -(C) Water ponding	[2.1.07.02] [2.1.08.07]
MW.01.TH.02	Thermal Effects on Flow in Open Excavation	-(A) Altered flow / fluid properties -(B) Altered relative humidity (dry-out, resaturation) -(C) Condensation / vaporization -(D) Thermally-Driven Flow (convection, heat pipes) -(E) Density effects on flow	2.1.11.10d 2.1.11.11d 2.1.11.12 2.1.08.07d 2.1.08.01 [2.1.07.02] [2.1.08.07]
MW.01.TH.03 (revised from MW.00.TH.01)	Effects of Gas on Flow Through Open Excavation	-(A) Multi-phase flow -(B) Gas bubbles	2.1.12.02d [2.1.12.01]
MW.02.CP.01	Drift/Room Support Design and Properties	-Geometry -Materials and properties -Fluids and properties	
MW.02.TM.01	Mechanical Effects on or from Drift/Room Supports	-(A) Back-stress from supports -(B) Degradation (cracking, corrosion) of supports -(C) Non-thermally-induced volume changes (corrosion products)	2.1.06.01a 2.1.07.08d [2.2.06.01] [2.1.07.01]

Full List of Matrix-Based FEPs

- Partial view of FEPs within the matrix

Features and Components	Characteristics, Processes, and Events	Processes												Events					
		Mechanical and Thermal-Mechanical	Hydrological and Thermal-Hydrologic	Chemical and Thermal-Chemical	Biological and Thermal-Biological	Transport and Thermal-Transport	Thermal	Radioactive	Long-Term Geologic	Climatic	Human Activities (Long Timescale)	Other	Nuclear Criticality	Early Failure	Seismic	Igneous	Human Activities (Short Timescale)	Other	
Geosphere Features																			
Host Rock	HR.00.CP.01		HR.00.TH.01	HR.00.TC.01	HR.00.TB.01 HR.02.TB.02				HR.00.LG.01 HR.00.LG.02 HR.00.LG.03 HR.00.LG.04 HR.00.LG.05 HR.00.LG.06	HR.00.CL.01 HR.00.CL.02			HR.00.NC.01	HR.00.SM.01	HR.00.IG.01	HR.00.HE.01			
• Disturbed Rock Zone (DRZ)	HR.01.CP.01	HR.01.TM.01 HR.01.TM.02	HR.01.TH.01 HR.01.TH.02 HR.01.TH.03	HR.01.TC.01 HR.01.TC.02		HR.01.TT.01 HR.01.TT.02 HR.01.TT.03 HR.01.TT.04 HR.01.TT.05 HR.01.TT.06 HR.01.TT.07 HR.01.TT.08													
• Emplacement Unit(s)	HR.02.CP.01	HR.02.TM.01	HR.02.TH.01 HR.02.TH.02 HR.02.TH.03 HR.02.TH.04	HR.02.TC.01 HR.02.TC.02		HR.02.TT.01 HR.02.TT.02 HR.02.TT.03 HR.02.TT.04 HR.02.TT.05 HR.02.TT.06 HR.02.TT.07 HR.02.TT.08													
• Other Host Rock Units	HR.03.CP.01			HR.03.TC.01 HR.03.TC.02		HR.03.TT.01 HR.03.TT.02													
Other Geologic Units	OU.00.CP.01		OU.00.TH.01	OU.00.TC.01					OU.00.LG.01 OU.00.LG.02 OU.00.LG.03 OU.00.LG.04 OU.00.LG.05 OU.00.LG.06 OU.00.LG.07	OU.00.HP.01				OU.00.SM.01	OU.00.IG.01	OU.00.HE.01			
• Overlying / Adjacent Units (including Caprock, Aquifers)	OU.01.CP.01	OU.01.TM.01	OU.01.TH.01 OU.01.TH.02 OU.01.TH.03 OU.01.TH.04 OU.01.TH.05	OU.01.TC.01 OU.01.TC.02	OU.01.TB.01 OU.01.TB.02	OU.01.TT.01 OU.01.TT.02 OU.01.TT.03 OU.01.TT.04 OU.01.TT.05 OU.01.TT.06 OU.01.TT.07 OU.01.TT.08			OU.01.CL.01 OU.01.CL.02										
• Underlying Units	OU.02.CP.01	OU.02.TM.01	OU.02.TH.01 OU.02.TH.02 OU.02.TH.03	OU.02.TC.01 OU.02.TC.02	OU.02.TB.01 OU.02.TB.02				OU.02.CL.01										