U.S. DEPARTMENT OF ENERGY
OFFICE OF CIVILIAN RADIOACTIVE WASTE MANAGEMENT

NUCLEAR WASTE TECHNICAL REVIEW BOARD
FULL BOARD MEETING

SUBJECT: THERMAL TESTING STRATEGY

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Goal of *In Situ* Thermal Testing

- To generate observational data to develop, refine, and build confidence in heat-driven process models
  - Models will be used to predict preclosure drift stability and performance of Engineered Barrier System and total system
  - Test results, by themselves, will not provide discriminator to select repository areal thermal load

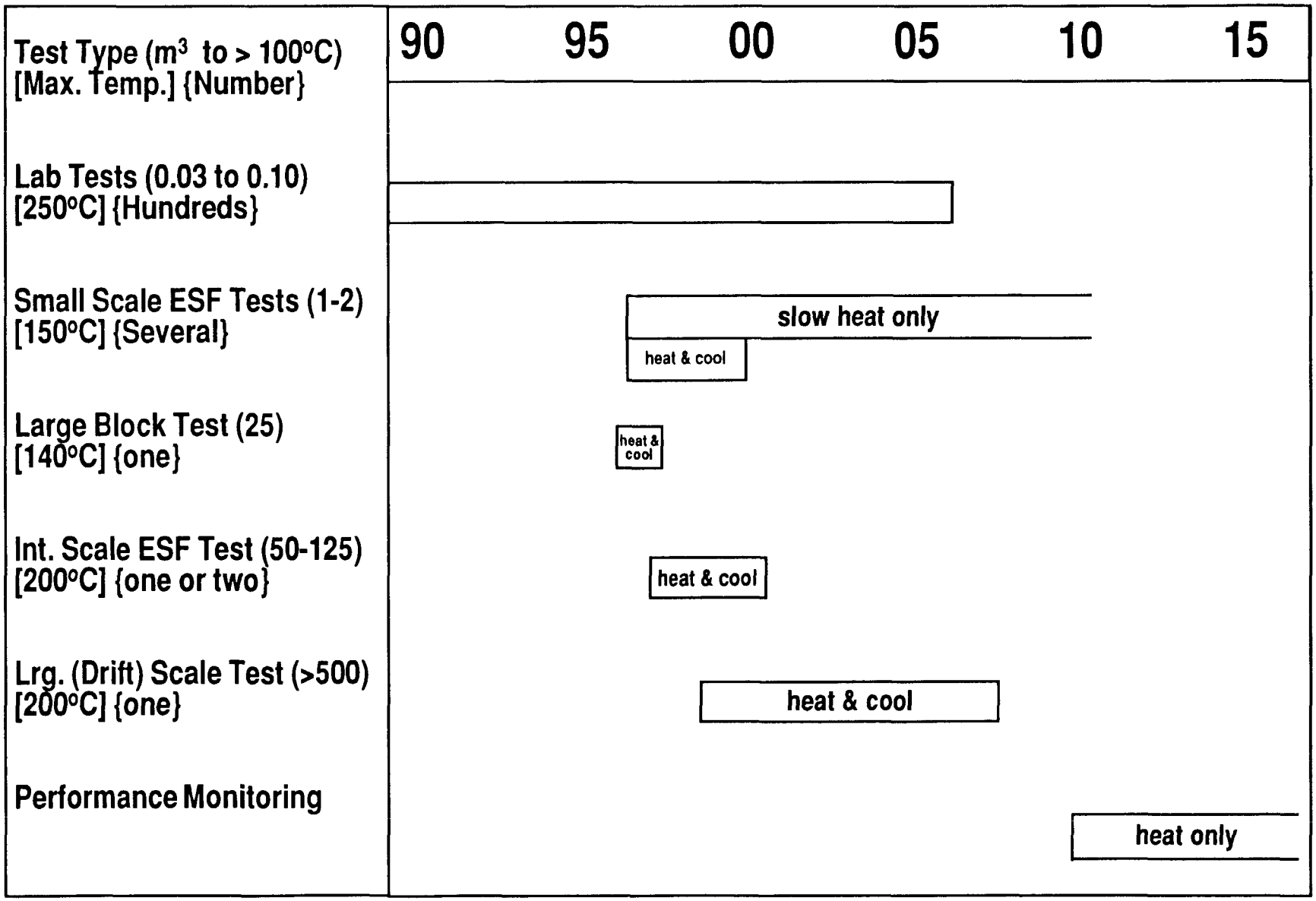
Assumption

- Testing focused on observations up to operational temperature range; not mapping failure envelopes

Test Types

Test	Approx. Vol. (m^3) of rock heated to >100°C	Max. Rock Temp.°C	Duration
Lab Tests	0.03 to 0.1	250	0-12 months
Small Scale *In Situ* Tests	1-2	150	1-8 years
Large Block Test	25	140	1 year
Intermediate Scale *In Situ* Tests	50-125	200	2-3 years
Large Drift Scale Test	>500	200	7+ years
Performance Monitoring	1,000s	200	through closure

Thermal Testing



Thermal Testing Strategy

TSS	• Preliminary process models based on lab tests, small scale *in situ* tests, empirical analyses, numerical simulations, and analog studies
LA	• Refined process model and confidence building by scaling up from small scale *in situ* tests, intermediate scale test, early large-scale test results, and analog studies
LA Update	• Pre-closure performance demonstration under operational limit conditions based on large-scale long-duration test • Confirmation of near-field process models based on large-scale long duration test
Operation	• Performance confirmation monitoring

Thermal-Mechanical Process Model

Program Milestones	96	97	98	99	00	01	02	03	04	05	06	07	08
Tech. Site Suitability													
SRR / EIS													
LA (to Construct)													
Const. Authorization													
Updated LA													

Thermal-Mechanical Process	effect of heat on stress distribution numerical analyses empirical analyses	mathematical models refined	preclosure operational stability demonstrated
Data Source	lab tests Large Block Test *in situ* small-scale tests early part of intermediate scale *in situ* test empirical experience	intermediate scale in situ test early part of large scale *in situ* test	large scale long duration *in situ* test

Heat Transfer Model

Program Milestones	96	97	98	99	00	01	02	03	04	05	06	07	08
Tech. Site Suitability													
SRR / EIS													
LA (to Construct)													
Const. Authorization													
Updated LA													

Heat Transfer Model	conduction based/ convective overprint role of non-fracture heterogeneities characterized	convective overprint refinement	confirmation by large-scale *in situ* test
Data Source	lab tests large block test *in situ* small-scale test G-Tunnel tests Climax test numerical simulations	slow heating small-scale *in situ* tests intermediate-scale *in situ* test early part of large-scale *in situ* test numerical simulations	large-scale long-duration *in situ* test numerical simulations

Moisture Movement Model

Program Milestones	96	97	98	99	00	01	02	03	04	05	06	07	08
Tech. Site Suitability													
SRR / EIS													
LA (to Construct)													
Const. Authorization													
Updated LA													

Moisture Movement Model	matrix dryout buoyant convection evaluation role of fracture by equiv. continuum	role of fractures characterized buoyant convection modeled role of discrete fracture flow modeled	shedding and re-wetting characterized buoyant convection bounded mobilized water coalescing modeled at repository scale
Data Source	lab tests large block test small-scale *in situ* tests G-Tunnel test numerical simulations	small-scale *in situ* tests intermediate scale *in situ* test early part of large-scale test numerical simulations	large-scale long-duration *in situ* test numerical simulations

Geochemical Process Model

Program Milestones	96	97	98	99	00	01	02	03	04	05	06	07	08
Tech. Site Suitability													
SRR / EIS													
LA (to Construct)													
Const. Authorization													
Updated LA													
Geochemical Processes	conceptual model of rock-water interaction temperature/boiling effects characterized			models refined thermal gradient effects on reaction paths characterized			effects of long-duration heating and cooling incorporated coupling of flow and reaction path modeled						
Data Source	lab tests small block tests (laboratory) large block test analog studies numerical simulations			lab tests small-scale *in situ* tests intermediate-scale *in situ* test early part of large-scale test analog studies numerical simulations			large-scale long duration *in situ* test numerical simulations						

Coupled Process Models

Program Milestones	96	97	98	99	00	01	02	03	04	05	06	07	08
Tech. Site Suitability													
SRR / EIS													
LA (to Construct)													
Const. Authorization													
Updated LA													

Observational underpinnings from thermal testing for coupled process models	T-M Coupling	T-M Coupling	T-H-C Coupling
	T-H Coupling	T-H and T-M-H	T-M-H-C Coupling
	T-C Coupling	T-C Coupling	
	T-M-H-C Coupling	T-H-C Coupling	
		T-M-H-C Coupling	

Summary

- Thermal testing strategy is to generate supporting observations for
  - thermal stress distribution, water movement, conductive heat transfer, and the conceptual role of fractures by the TSS time frame
  - fracture flow, conductive/convective heat transfer, vapor-phase moisture movement, and demonstration of thermal-mechanical stability by LA time frame
  - buoyant convection, role of mobilized moisture in re-wetting, geochemical changes and transport, and coupled processes (T-M-H-C) by LA update time frame