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R&D Phenomena Table for a Generic High Temperature Gas Reactor
Thermofluids, Accident Analysis, and Neutronics

System/component	Phenomena	Importance	Knowledge
Reactor vessel	Flow and thermal properties for mixed gases in vessel	High	High
Reactor core	Heat transfer correlations for mixed gases in core	Medium	Medium
Reactor cavity	RCCS performance with “gray gas” in cavity	Medium	Low
Reactor core	Fuel performance with oxygen attack	High	Medium
Core support	Core support structures oxidation	High	Medium
Reactor core	Core oxidation	High	Medium
Reactor cavity	RCCS gas stratification and mixing	Medium	Medium
Cavity/confinement	Confinement-to-reactor cavity air ingress	High	Medium
Reactor cavity	Cavity structural integrity during blowdown	Medium	Medium
Reactor cavity	Cavity filtering performance	High	Medium
Reactor vessel	Molecular diffusion from cavity to vessel	High	Medium
Reactor vessel	Chimney effects and air ingress	Medium	Medium
Reactor vessel	Thermal stratification/ mixing in the lower plenum	High	Medium
Reactor core	Core effective thermal conductivity	High	Medium
Reactor core	Decay heat and distribution vs. time	High	Medium
Reactor core	Heatup accident fuel performance modeling	High	Medium
Reactor vessel	Hydrodynamics of dust suspension	High	Medium
Reactor cavity	Pressure pulse in confinement	High	Medium
Vessel/cavity	Reactor vessel and cavity air circulation and heat transfer	High	Low
Reactor core	Reflectors conductivity and annealing	High	Medium
Reactor core	Core barrel emissivity	High	Medium
Reactor vessel	Inlet plenum stratification & plumes	High	Medium
Reactor cavity	RCCS spatial heat loadings, heat removal	High	Medium
Reactor vessel	Radiant heat transfer from core to vessel head	High	Medium
Reactor core	Core coolant flow and properties	High	Medium
Reactor core	Core coolant bypass flow	High	Low
Reactor core	Core flow distribution changes due to graphite irradiation	Medium	Low

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System/component	Phenomena	Importance	Knowledge
Reactor core	Core flow distribution changes due to core barrel geometry changes and core block stability	Medium	Medium
Reactor vessel/core	Pebble bed core wall interface effects on bypass flow	High	Low
Reactor core	Pebble flow	High	Medium
Reactor components	Shutdown cooling system startup transients during core heatup	High	Medium
Reactor core	Power and flux profile during normal operation	High	Low
Reactor core	Reactivity-temperature feedback coefficients	High	Low
Reactor core	Fuel performance modeling	High	Low
Core/vessel/confinement/environment	Ag-110m release and plateout	High	Low
IHX loop/ confinement bypass	Fission product transport through IHX loop (part of confinement bypass)	High	Medium
Reactor vessel and components	Ingress of molten salt into primary system and RPV; riser and lower plenum fill	High	Medium
Reactor vessel	Molten salt to core support/vessel heat transfer	High	Medium
Reactor vessel	Reactor cavity to vessel air ingress	High	Medium
Reactor cavity	RCCS heat transfer characteristics	High	Medium
Reactor cavity	RCCS fouling	High	Medium
IHX loop/ confinement bypass	Helium transport through IHX loop (part of confinement bypass)	Medium	Medium
Reactor vessel	Outlet plenum flow distribution	High	Low
Core/vessel	Side reflector/core barrel/vessel heat transfer	Medium	Medium
Components	Thermal shock in SCS due to startup flow transient	Medium	Medium
Reactor core	Reactivity insertion due to pebble core compaction	Medium	Medium
Reactor core	Reactivity insertion due to steam/water ingress	High	Medium
Reactor core	Control and scram rods, and reactor shutdown worth	High	Medium
Reactor core	Xenon and Samarium buildup	Medium	Medium
Reactor core	Coolant flow restart during ATWS	Medium	Low

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High Temperature Materials and Graphite

System/component	Phenomena	Importance	Knowledge
Reactor vessel	Long-term thermal aging of Gr. 91 material	High	Medium
Reactor vessel	Short-term high temperature thermal aging Gr. 91 material	Medium	Medium
Reactor vessel	Crack initial and subcritical crack growth Gr. 91 material	High	Low
Reactor vessel	Radiation degradation of Gr. 91 material	High	Low
Reactor vessel	Emissivity degradation due to loss of desired surface layer properties	High	Low
Reactor vessel	Transient creep in Gr. 91 and LWR materials	Medium	Medium
Reactor vessel	Creep during normal operations Gr. 91 material	Medium	Low
Reactor vessel	Field fabrication process control	High	Low
Reactor vessel	Properties control in heavy sections	High	Low
Vessel internals	Radiation induced degradation of control rods	Medium	Medium
Vessel internals	Oxidation of control rods	Medium	Medium
Vessel internals	Structural design methodology limitation for C-C composites for control rods and RPV internals	High	Low
Vessel internals	Change in emissivity of RPV internals	High	Low
Vessel internals	Radiation induced creep of RPV internals	High	Low
Vessel internals	Radiation induced embrittlement of RPV internals	Medium	Medium
Vessel internals	Environmental and radiation degradation of RPV internals (non-metallic)	High	Low
Vessel internals	Oxidation of RPV internals	Medium	Medium
Reactor components	Isolation valve failure	High	Low
Reactor cavity	Inadequate heat removal	High	High
Power conversion vessel & components	Missile failure	Medium	Medium
Power conversion vessel & components	Creep, creep crack growth, thermal loading, fatigue	Medium	Medium
Power conversion vessel & components	Primary coolant contamination	Medium	Medium
Intermediate heat exchanger	Creep, fatigue, subcritical crack growth	High	Low

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High Temperature Materials and Graphite

System/component	Phenomena	Importance	Knowledge
Intermediate heat exchanger	Design methodology limitation for structures and components	High	Low
Intermediate heat exchanger	Manufacturing phenomena, inspection and testing	High	Low
Intermediate heat exchanger	Water or chemical ingress/attack	Medium	Medium
Other components	Primary coolant contamination in circulators	Medium	Medium
Other components	Creep, fatigue, subcritical crack growth	Medium	Medium
Other components	Aging fatigue, environmental degradation of piping	High	Low
Other components	Creep, fatigue, subcritical crack growth	Medium	Medium
Reactor core and components	Statistical variation of non-irradiated graphite properties	High	Medium
Reactor core and components	Consistency in graphite properties over the reactor life	High	Medium
Reactor core and components	NDE techniques for detection of flaws in graphite	Medium	Medium
Reactor core and components	Fatigue of graphite core components	Medium	Medium
Reactor core and components	Irradiation induced dimensional changes in graphite	High	Medium
Reactor core and components	Irradiation induced creep	High	Low
Reactor core and components	Irradiation induced thermal conductivity changes	High	Medium
Reactor core and components	Irradiation induced changes in elastic constants	High	Medium
Reactor core and components	Irradiation induced changes in CTE	High	Low
Reactor core and components	Irradiation induced changes in mechanical properties	High	Low
Reactor core and components	Annealing of graphite thermal conductivity	Medium	Medium
Reactor core and components	Graphite dust generation	Medium	Low

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System/component	Phenomena	Importance	Knowledge
Reactor core and components	Tribology of graphite in helium environment	High	Medium
Reactor core and components	Degradation of thermal conductivity of graphite	High	Medium
Reactor core and components	Graphite spalling	High	Low
Reactor core and components	Channel distortion	Medium	Medium
Reactor core and components	Increased bypass coolant flow channels by breaks	Medium	Medium
Reactor core and components	Effect on chronic chemical attack on graphite properties	Medium	Medium

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R&D Phenomena Table for a Generic High Temperature Gas Reactor
Process Heat Applications

System/component	Phenomena	Importance	Knowledge
Intermediate heat exchanger	Blowdown effects, large mass transfer, and pressurization of primary and secondary sides due to IHX failure	High	Medium
Process heat exchanger	Fuel and primary system corrosion due to PHX failure	High	Medium
Process heat components	Cyclic loading due to temperature transients	Medium	Medium
Reactor core	Reactivity spike due to neutron serialization	High	Medium
Other components	Turbomachinery response due to mass addition to reactor	Medium	Medium
Reactor core and internals	Chemical attack of TRISO layers and graphite	High	Medium
Intermediate heat exchanger	Loss of heat sink and loading of IHX	High	Medium
Intermediate heat exchanger	Radiologic release through IHX loops and plant	Medium	Medium

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R&D Phenomena Table for a Generic High Temperature Gas Reactor

Fission Product Transport and Dose

System/component	Phenomena	Importance	Knowledge
Reactor core	Material and structural properties of graphite	High	Medium
Reactor core	Graphite geometry and dimensional changes due to air ingress	High	Medium
Reactor core	Thermofluids properties	High	Medium
Reactor core/vessel	Gas composition for oxygen potential and chemical activity	High	Medium
Reactor vessel	Gas flow path	High	High
Reactor core/vessel	FP Plate-out and dust distribution under normal operation	High	Low
Reactor core/vessel	Matrix permeability and tortuosity	High	Low
Reactor core/vessel	Fission roduct transport through matrix	High	Low
Reactor core	Fuel block permeability, tortuosity	High	Medium
Reactor core	Fission product transport through fuel block	High	Medium
Reactor core/vessel	Sorbtivity of graphite	High	Medium
Reactor core/vessel	Fluence effect on transport in graphite	High	Medium
Reactor core/vessel	Air/steam attack on graphite	High	Medium
Reactor core/vessel	Fission product Speciation in carbonatious material	High	Low
Reactor vessel	Fission product Speciation during mass transfer	High	Medium
Reactor core/vessel	Dust generation	High	Medium
Reactor vessel	Fission product absorption in dust	High	Medium
Reactor vessel/ components	Tritium generation and circulating coolant inventory	High	Medium
Vessel/confinement	Ag-110m generation, transport	High	Low
Vessel/confinement	Aerosol growth	High	Low
Vessel/confinement	Surface roughness effect on aerosol deposition	Medium	Medium
Vessel/confinement	Coolant chemical interaction with surfaces	High	Medium
Vessel/confinement	FP diffusivity, sorbtivity in non-graphite surfaces	High	Low
Vessel/confinement	Aerosol/dust deposition	High	Medium
Vessel/confinement	Aerosol dust bounce, breakup during deposition	High	Medium

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R&D Phenomena Table for a Generic High Temperature Gas Reactor

Fission Product Transport and Dose

System/component	Phenomena	Importance	Knowledge
Vessel/confinement	Resuspension of fission products	High	Low
Confinement	Confinement aerosol physics	High	Medium
Vessel/confinement	Fission product and aerosol wash-off	High	Medium
Other components	Failure modes of auxiliary systems (e.g. gas cleanup, holdup, refueling)	Medium	Medium
Confinement	Radiolysis effects in confinement	High	Medium
Confinement	Combustion of dust in confinement	High	Medium
Confinement	Confinement leakage path, release rate through penetrations	High	Medium
Other components	Cable pyrolysis, fire	High	Medium
Reactor core	Recriticality (slow)	High	Medium
Reactor core	Fuel-damaging reactivity insertion accidents	High	Medium