

Corrosion of Materials in Molten Salts

David Mancey

Background:

- Molten Salt Reactor (MSR) technology was developed at Oak Ridge National Laboratories (ORNL) from 1945-1976.
- Recent revival in interest in MSRs.
- Some MSR concepts are Small Modular Reactors (SMRs).
- Molten salts compatibility with construction materials is a key consideration for MSRs.
- For all MSR concepts, further work is required to characterize the rate and forms of component corrosion.
- Few facilities available for corrosion testing in molten salts.

Stakeholder: CNSC.

Tasks:

1. Decide on the type of corrosion testing facility to build.
2. Plan, design and construct facility.

Objective:

- Characterize degradation of candidate construction materials under simulated out-of-core MSR coolant circuit conditions.

MSR Concepts

Technologically Diverse:

- Fast & Thermal
- Burners & Breeders
- Th & U Fuel Cycles
- Liquid & Solid Fuels
- Differing U-235 Enrichments
- Fluoride & Chloride Salts
- Various Salt Mixtures
- Salts of Li, Na, K, Rb, Be, Zr
- Variety of Construction Alloys Proposed

Materials Performance Challenges:

- Outlet temperature 700 °C.
- No materials are inert.
- Passivation cannot be used to protect materials.

Challenges Arise in Some MSR Concepts:

- Fission Product Accumulate in Fuel Salts
- Graphite exposed to Molten Salt
- Significant Tritium Production
- Requirement for Prompt Removal Noble-Gas Fission Products

Corrosion Tests in Molten Salts

Prerequisites for All Types of Corrosion Tests:

- All wetted parts of test system made from a single alloy
- Complete exclusion of air and moisture from test system
- Use of high-purity salts
- Salt purification system co-located with test facilities
- Salt purification system capable of producing kg quantities of salt

Types of Testing (in order of increasing value and cost):

- Static Capsule
- Natural-Circulation Loop (NCL)
- Forced-Circulation Loop (FCL)

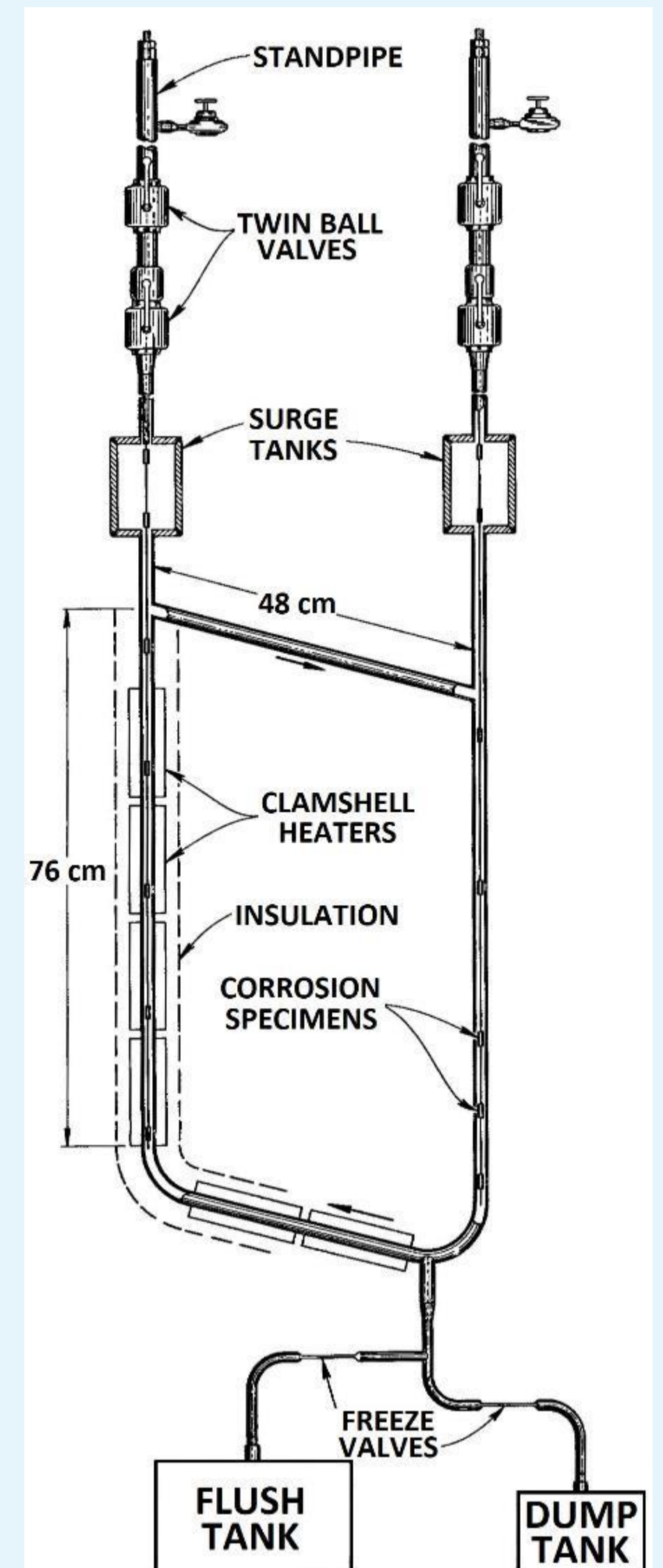
Loops

NCL (ORNL Design from 1960's shown →)

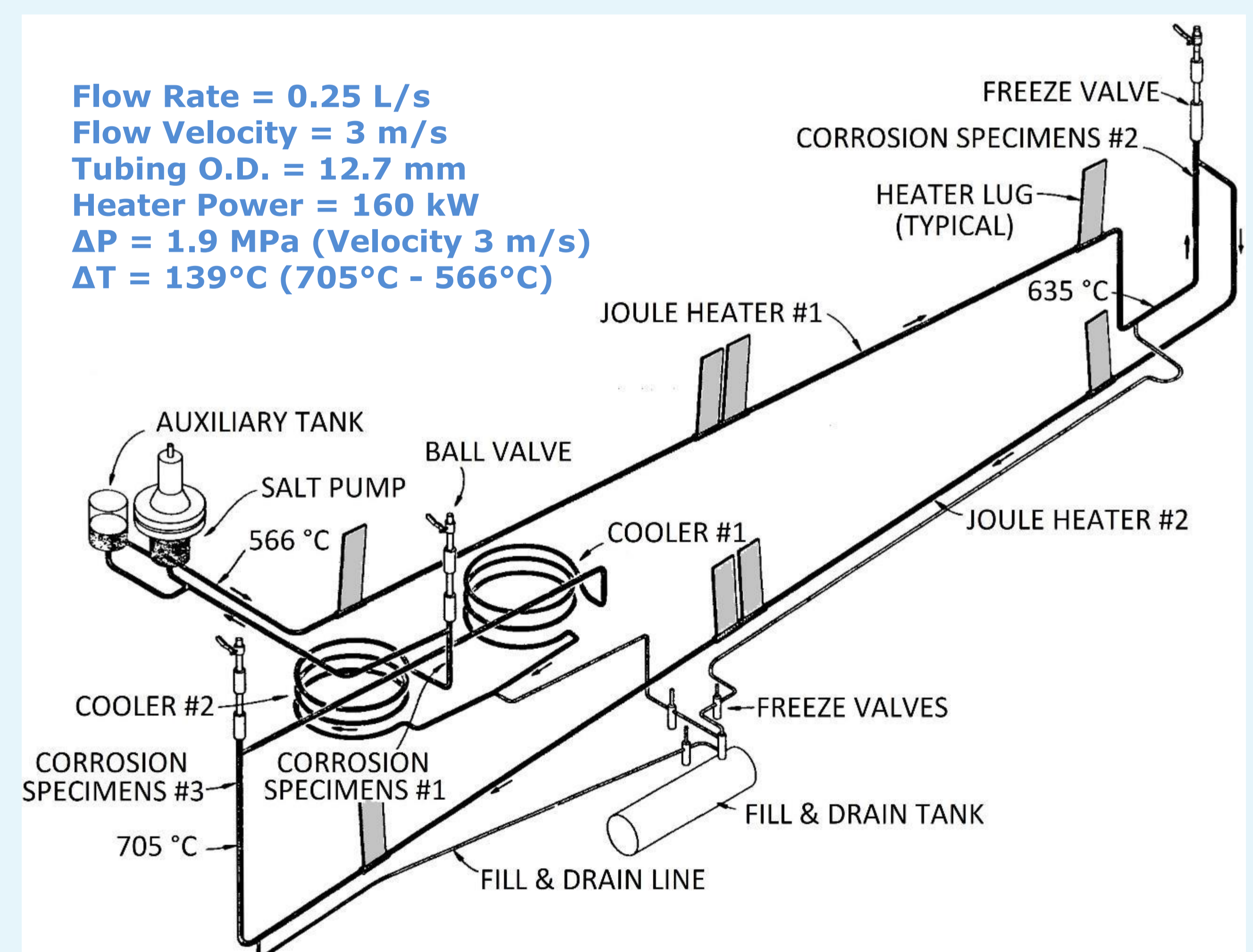
- No pump or moving parts
- Low and fixed flow velocity (2-5 cm/s)
- Most NCLs were single-use.
- Corrosion assessment from loop tubing
- Could operate continuously for years
- Require about 1 kg of salt

FCL (ORNL Design from 1970's shown ↓)

- Pump (all wetted parts made from loop alloy)
- High and variable flow velocity (≤ 6 m/s)
- Multi-use.
- Corrosion assessment from removable specimens
- Period of continuous operation set primarily by pump.
- Require about 10 kg of salt



Flow Rate = 0.25 L/s
Flow Velocity = 3 m/s
Tubing O.D. = 12.7 mm
Heater Power = 160 kW
 $\Delta P = 1.9$ MPa (Velocity 3 m/s)
 $\Delta T = 139^\circ\text{C}$ (705°C - 566°C)



Status

- Construction of generic corrosion test facility is not possible (Diversity of construction materials, salt types and MSR designs is too great).
- Development of corrosion test facility needs to be targeted on selected MSR concept(s).

