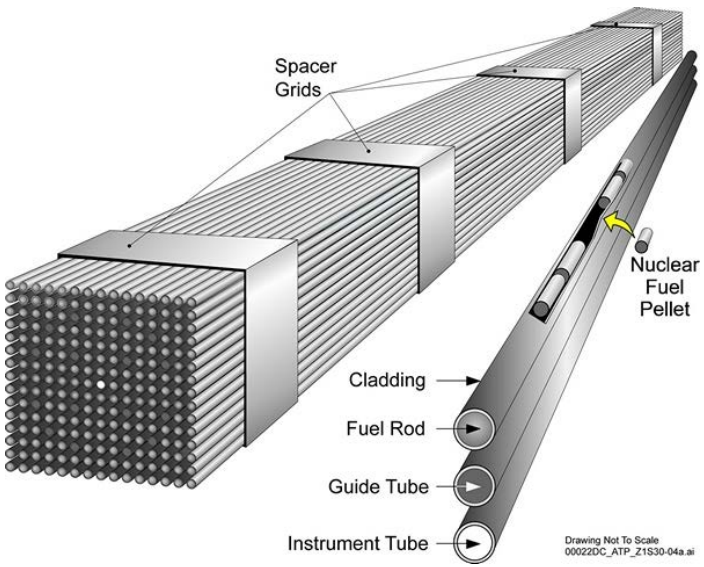
moltex energy
safer, cheaper, nuclear

Static Fuel Molten Salt Reactors Simpler, Cheaper and Safer

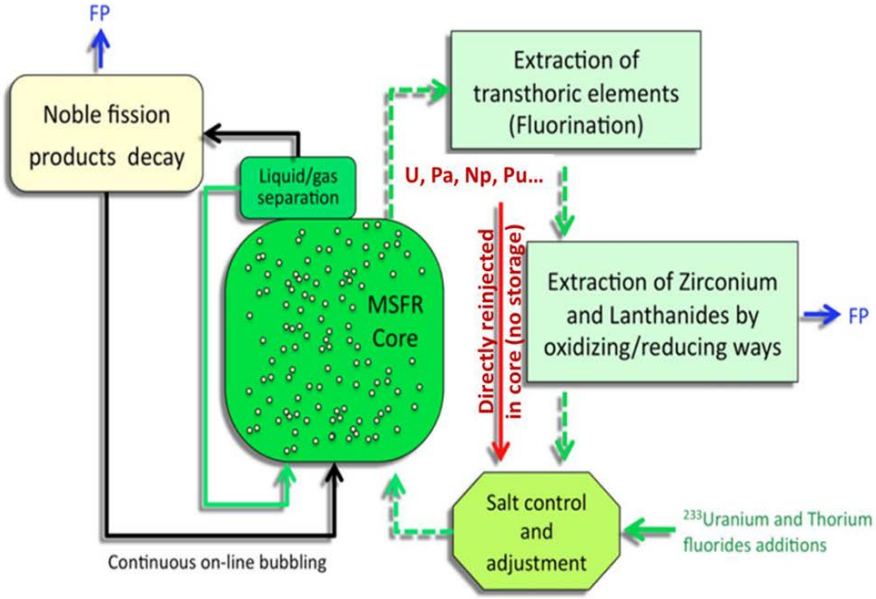
Ian Scott

THE KEY AIRCRAFT NUCLEAR REACTOR EXPERIMENT DECISION

1949



1950



Decision to abandon simple static fuel salt concept has been the basis of every MSR design from 1950 to 2013

WHY STATIC MOLTEN SALT WAS ABANDONED

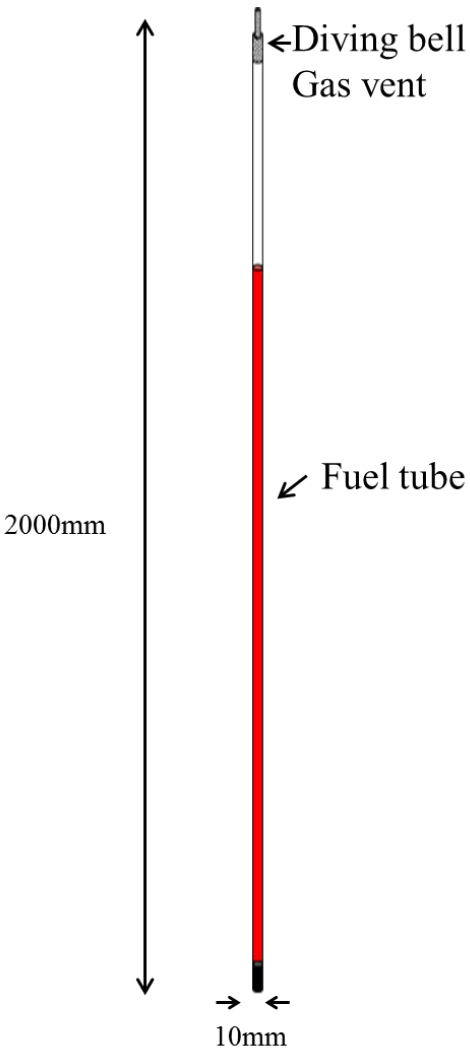
- Molten salts are poor heat conductors – 10 times worse than uranium oxide
- With conduction alone molten salt fuel tubes had to be less than 2mm diameter
- **Convection was ignored even though known to be more important than conduction because it was an aircraft reactor – zero g possibility**

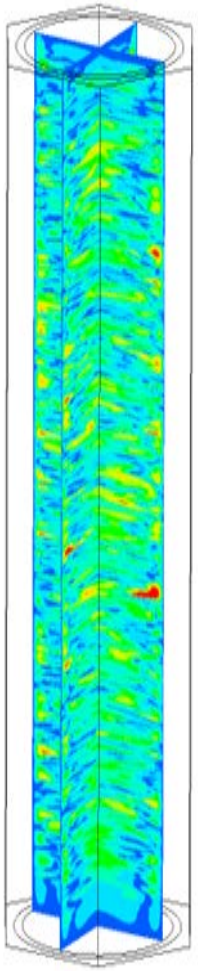
DECISION TO IGNORE CONVECTION WAS NEVER REVISITED WHEN AIRCRAFT PROGRAM ABANDONED AND REACTORS BECAME LAND BASED

SALT SELECTION

- No lithium-7 due to problem of tritium management and lack of availability
- Chloride fuel salts chosen for fast reactor option
  - $UCl_3/PuCl_3/NaCl$ melting point ~ 460°C
- $ZrF_4/NaF/KF$ chosen for coolant
  - Melting point 385°C

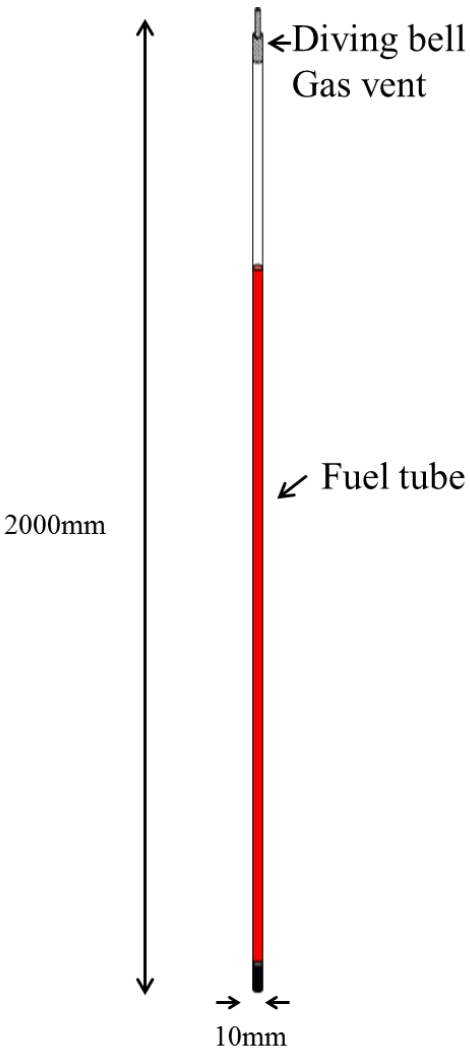
FUEL FLOW VELOCITIES

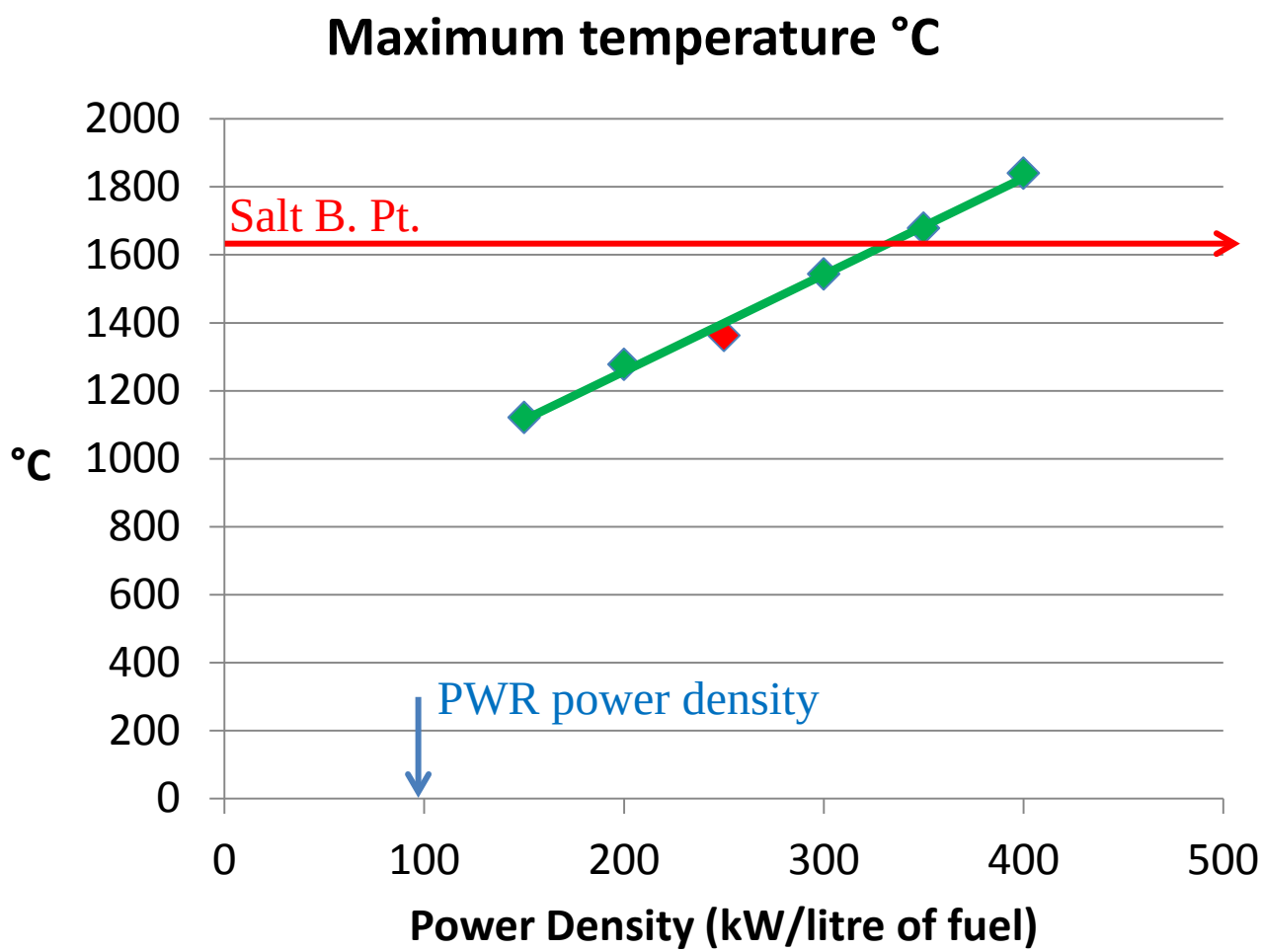




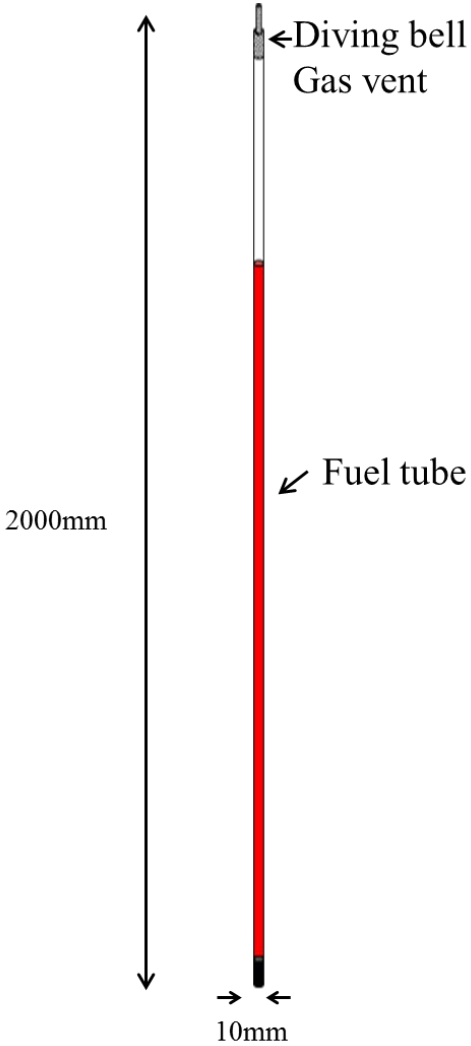
CFD Simulations with ANSYS FLUENT

MAXIMUM FUEL TEMPERATURE





CHALLENGES WITH MOLTEN SALT IN FUEL TUBES

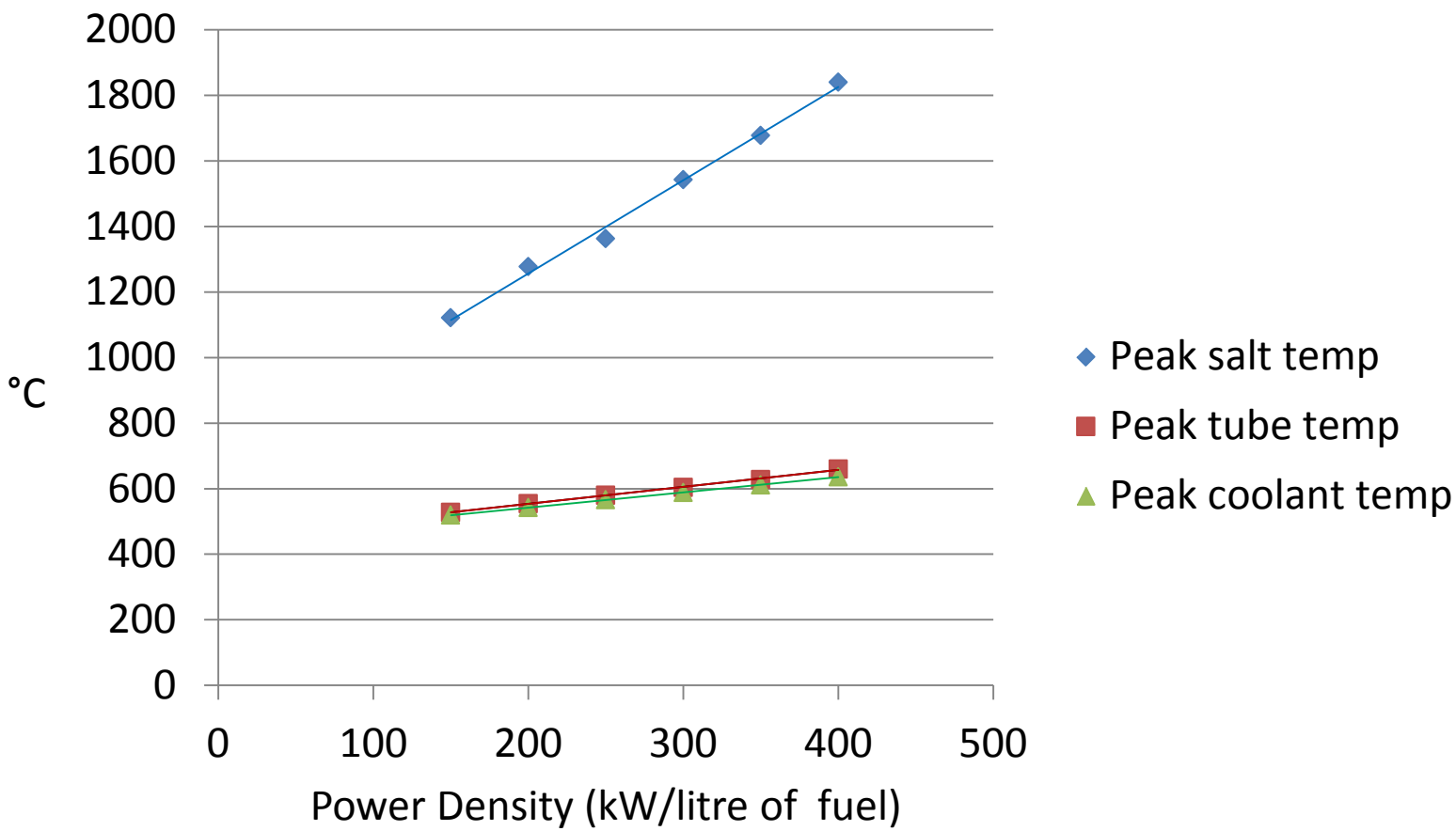


HIGH TEMPERATURE SALT

CORROSION

FISSION GASSES

HOT FUEL DOES NOT MEAN HOT TUBES



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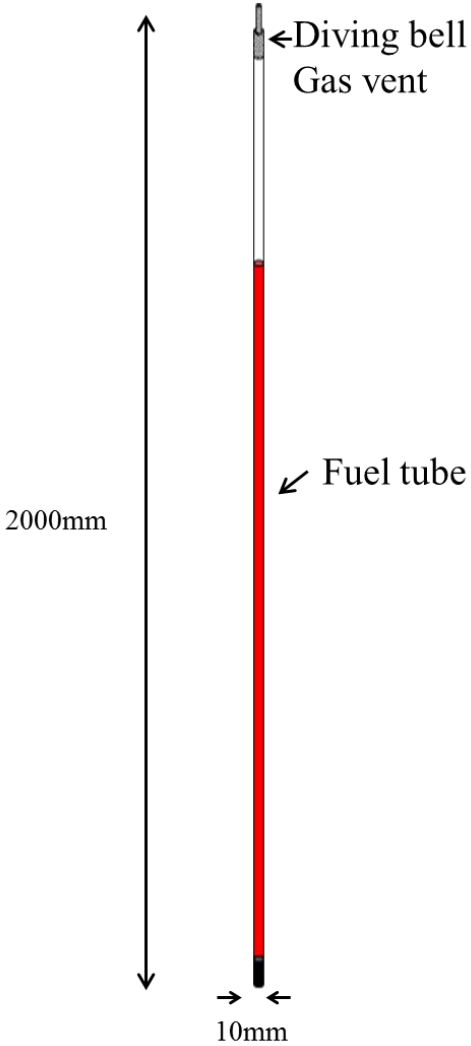


HIGH TEMPERATURE SALT

CORROSION

FISSION GASSES

CORROSION BY FISSIONED FUEL SALT

Moles of elements and compounds in simulated fuel salt							
Kr	1.13	Nd	7.99	Tc	3.03	Te	1.47
Xe	10.40	Pm	0.75	Ru	9.94	Br	0.09
Rb	0.96	Sm	2.16	Rh	2.95	I	0.75
Cs	9.34	Eu	0.31	Pd	6.71	UCl_3	200
Sr	2.06	Gd	0.22	Ag	0.64	$PuCl_3$	150
Ba	3.36	Tb	0.02	Cd	0.38	NaCl	600
Y	1.15	Dy	0.01	In	0.04	$AmCl_3$	9
La	2.80	Zr	10.76	Sn	0.37	$CmCl_3$	1.8
Ce	6.12	Nb	0.07	Sb	0.14	$NpCl_3$	12
Pr	2.31	Mo	11.28	Se	0.24	Total	1200

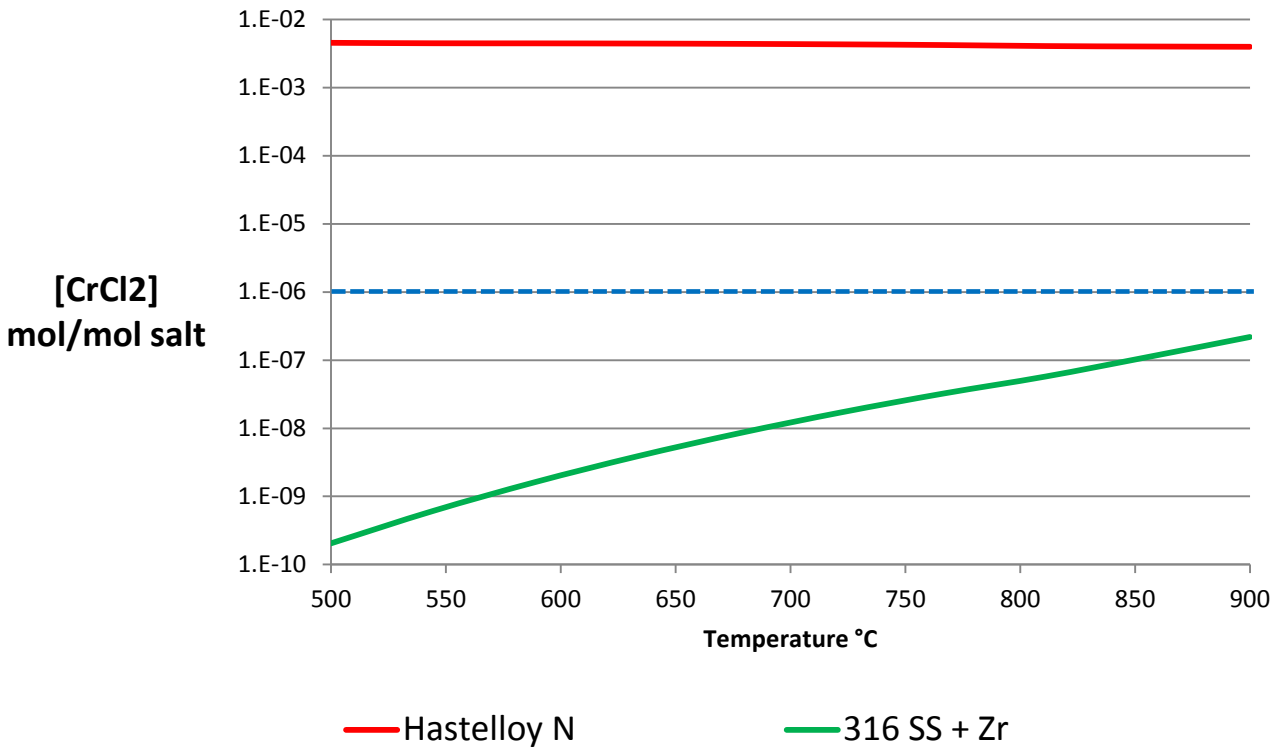
Table 1 Composition of molten salt fuel after 5mol% burnup

+ 150 mole of Chlorine

Calculate equilibrium concentration of chromium chlorides using HSC Chemistry Gibbs Free Energy minimisation program

- High concentration means corrosion **MIGHT** occur (kinetic factors)
- Low concentration (<1ppm) means corrosion **WILL NOT** occur

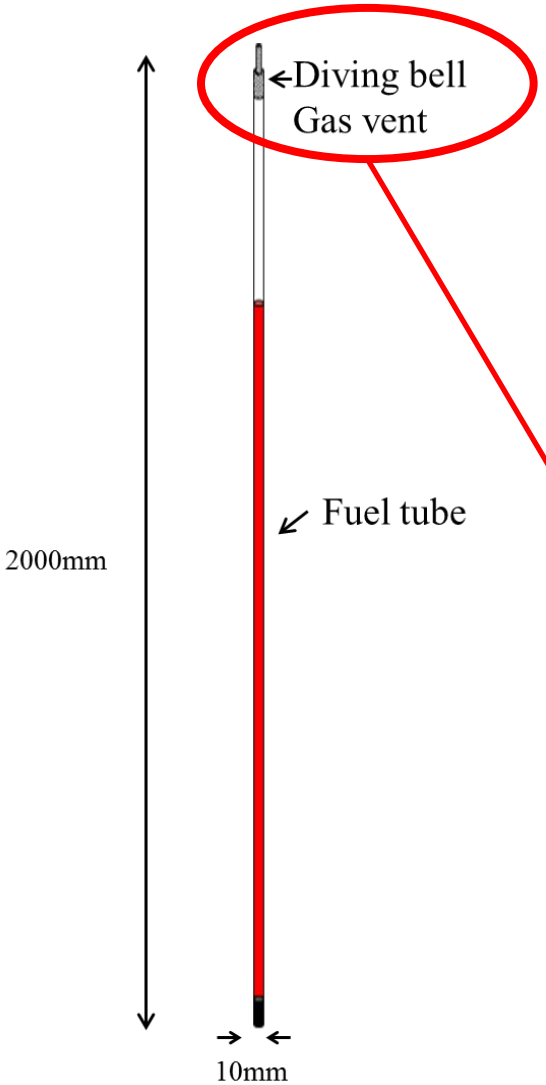
SACRIFICAL ZIRCONIUM
NO NEED FOR SPECIAL ALLOYS



Hastelloy N alone

316 Stainless steel with sacrificial zirconium

CHALLENGES WITH MOLTEN SALT IN FUEL TUBES

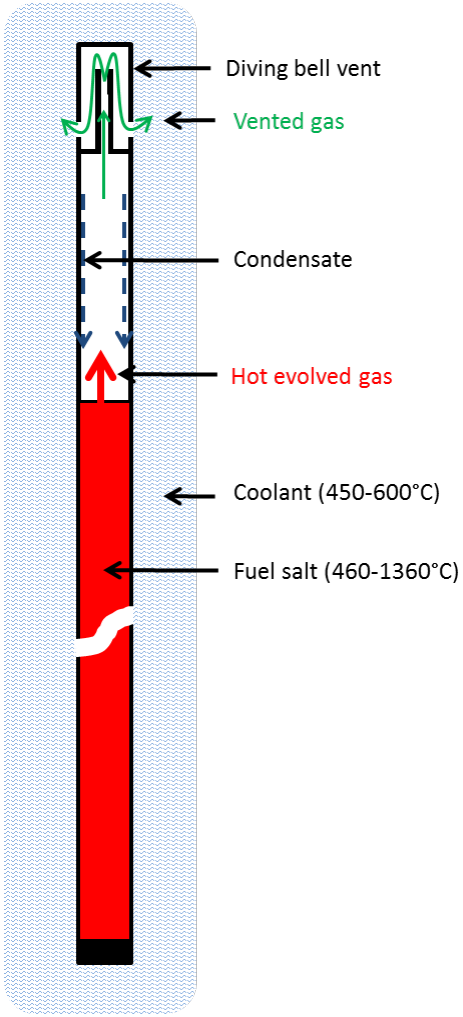


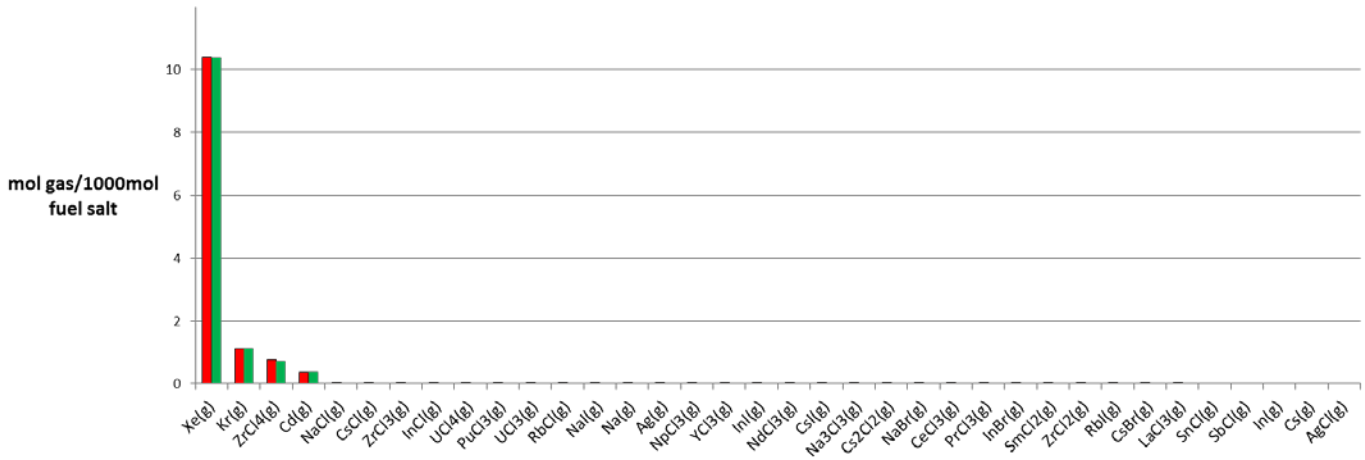
HIGH TEMPERATURE SALT

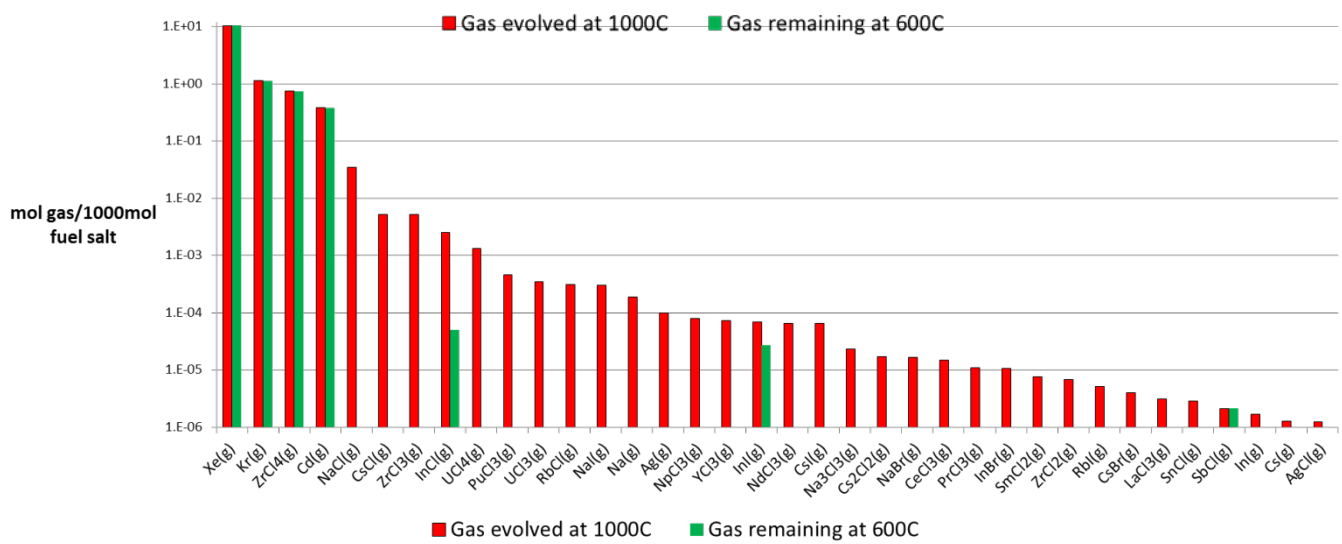
CORROSION

FISSION GASSES

FISSION GAS COMPOSITION

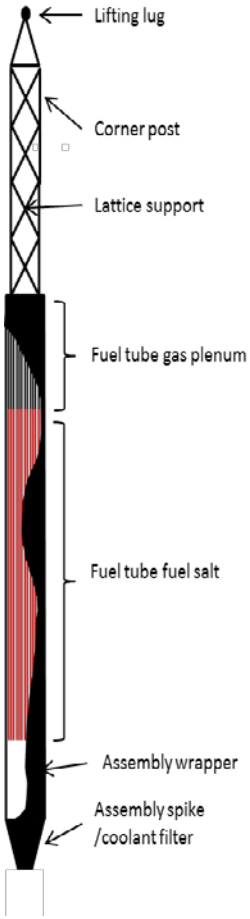




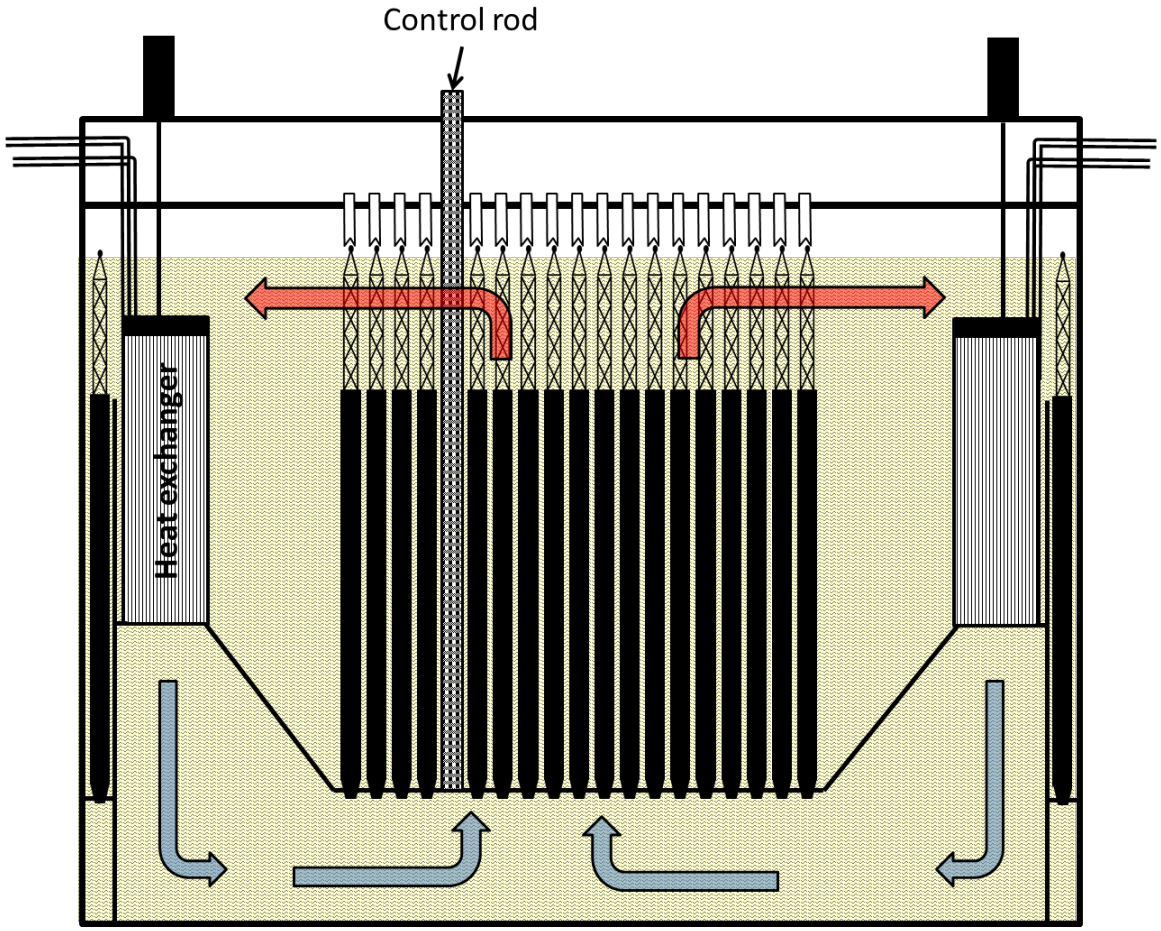


FUEL ASSEMBLIES FOR STABLE SALT REACTOR

- **Fuel tubes similar size to solid fuel pins**
- **Same alloys can be used – nuclear certified**
- **Vented tubes pioneered at Dounreay**
- **Reactor takes advantage of 60 years of fuel assembly R&D**



MOLTEX ENERGY
STABLE SALT REACTOR



Static Fuel Molten Salt Reactors Simpler, Cheaper and Safer

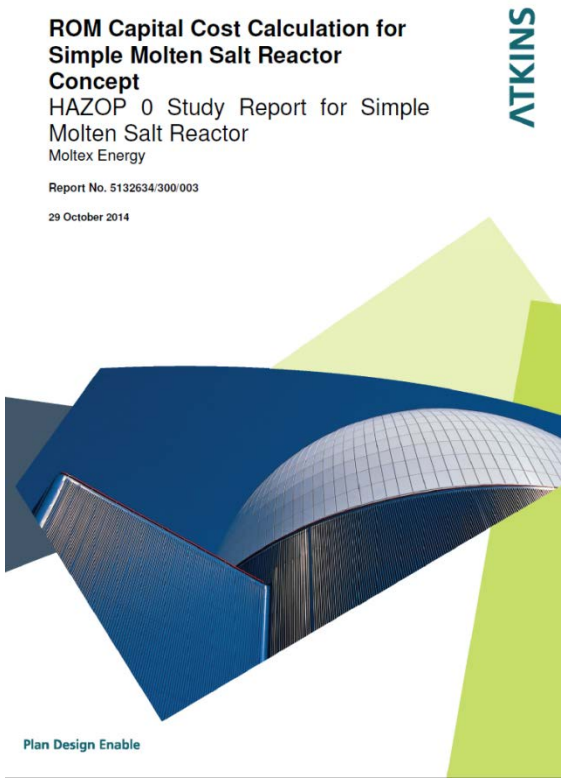
Simpler

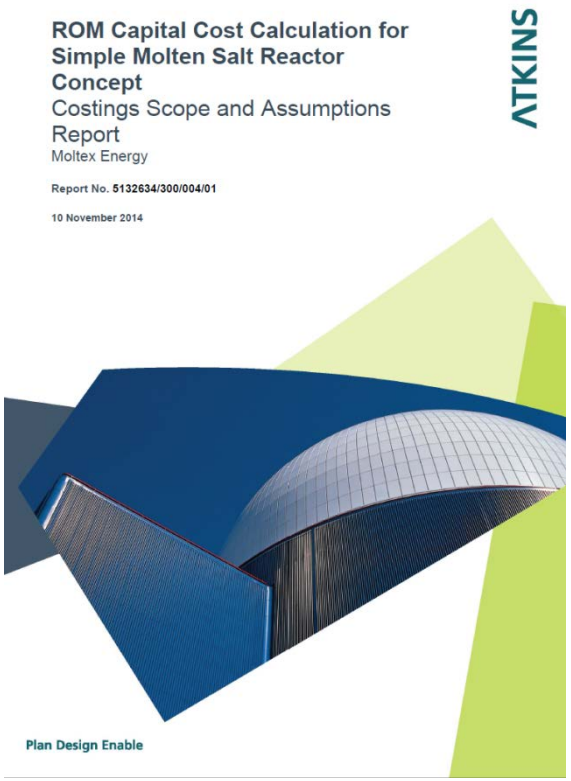
No pumping intensely radioactive molten fuel
Tubes need only a 5 year life
No emergency drain system needed
No online chemical processing
No filters or gas management
Refuelling is industry standard process

Safer

All the safety benefits of molten salt fuel
Pool design passively safe cooling
Fuel salt leakage contained/cooled in coolant salt
Molten fuel never leaves reactor core
Continuous refuelling so no excess reactivity

CHEAPER



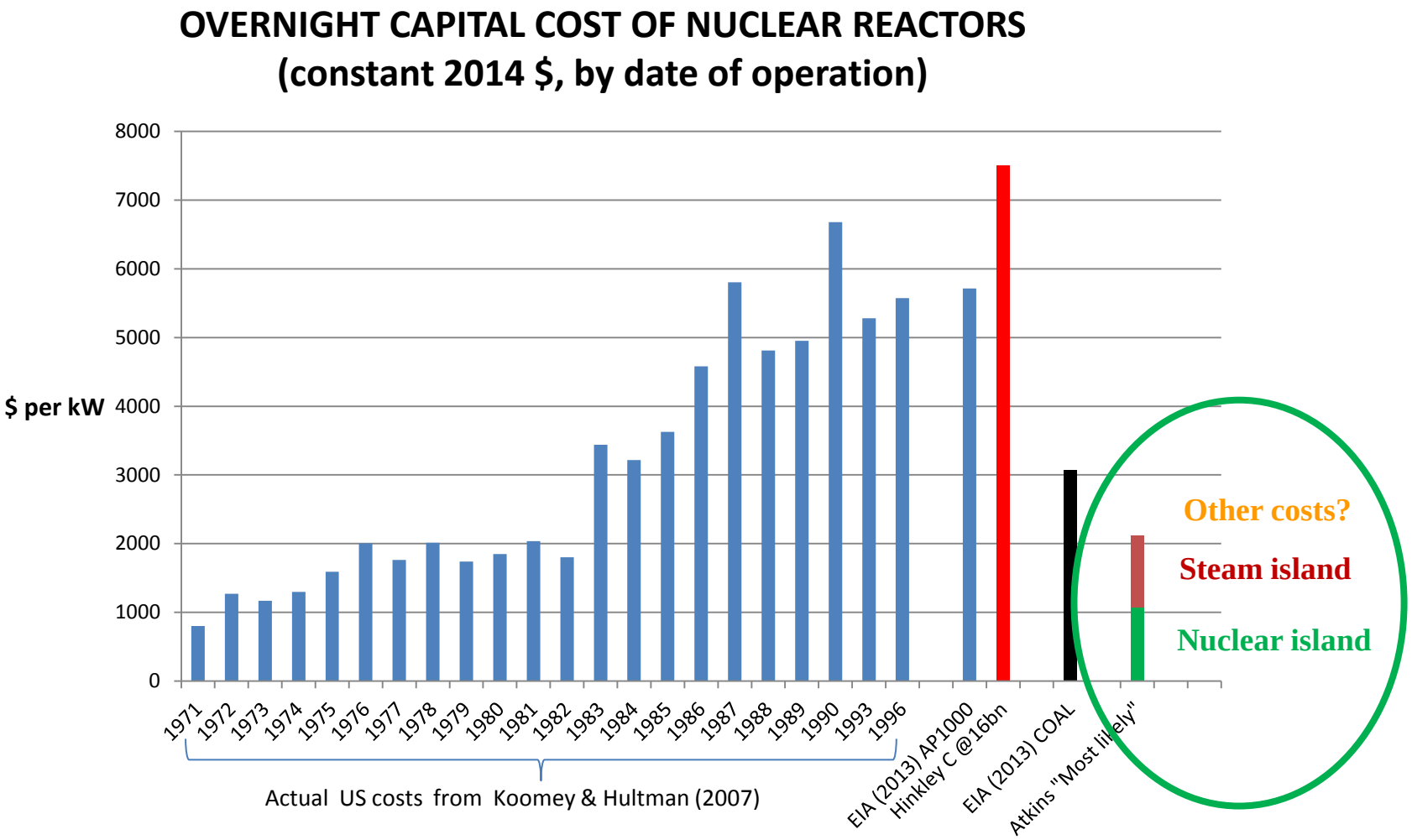


Review conceptual design against UK SAP's (Safety Assessment Principles) from Office of Nuclear Regulation

Carry out HAZOP 0 analysis identifying essential structures, systems and components required for safe operation

Calculate approximate capital cost of the nuclear and electrical generator islands of an Nth of a kind Simple MSR

NUCLEAR CAPITAL COSTS



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THANK YOU ALL!