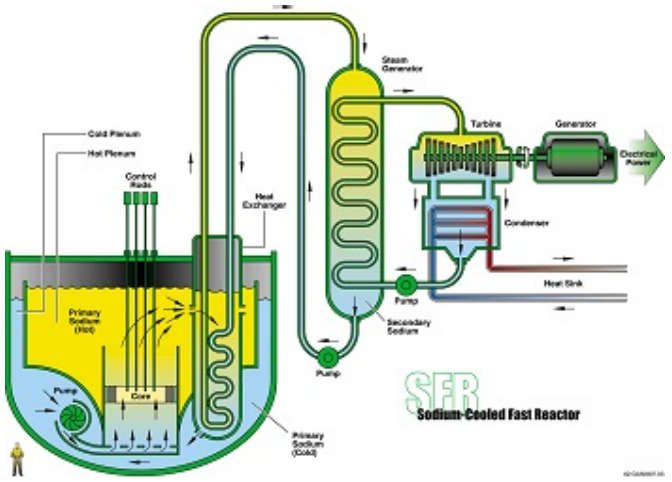
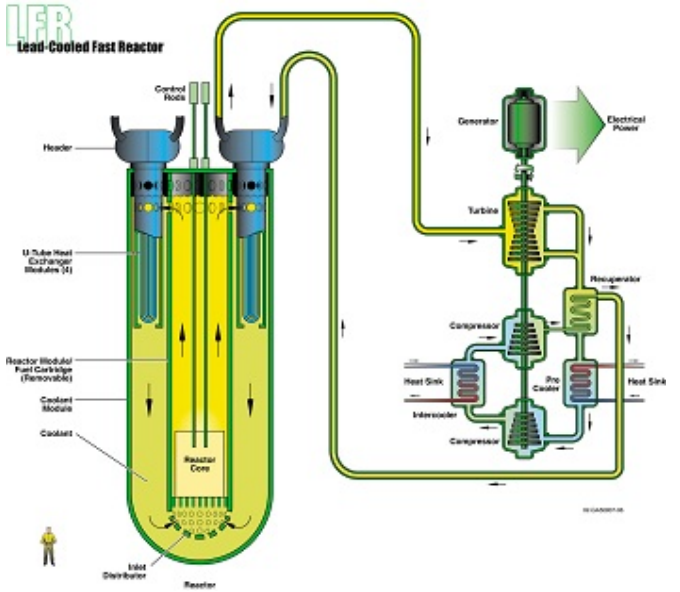
Massachusetts Institute of Technology Nuclear Science and Engineering

Doctoral Qualifying Oral Exam. Part 2 Question. Nuclear Reactor Engineering

May 2016

Among the Gen IV reactor concepts, two different Liquid Metal Cooled Fast Breeder reactors (LMFBRs) are present, which rely on Sodium and Lead as reactor coolants.
Based on an assumed equal thermal power of 2400 MWt we want to compare the two concepts from a neutronics, T/H, materials and general economics point of view.





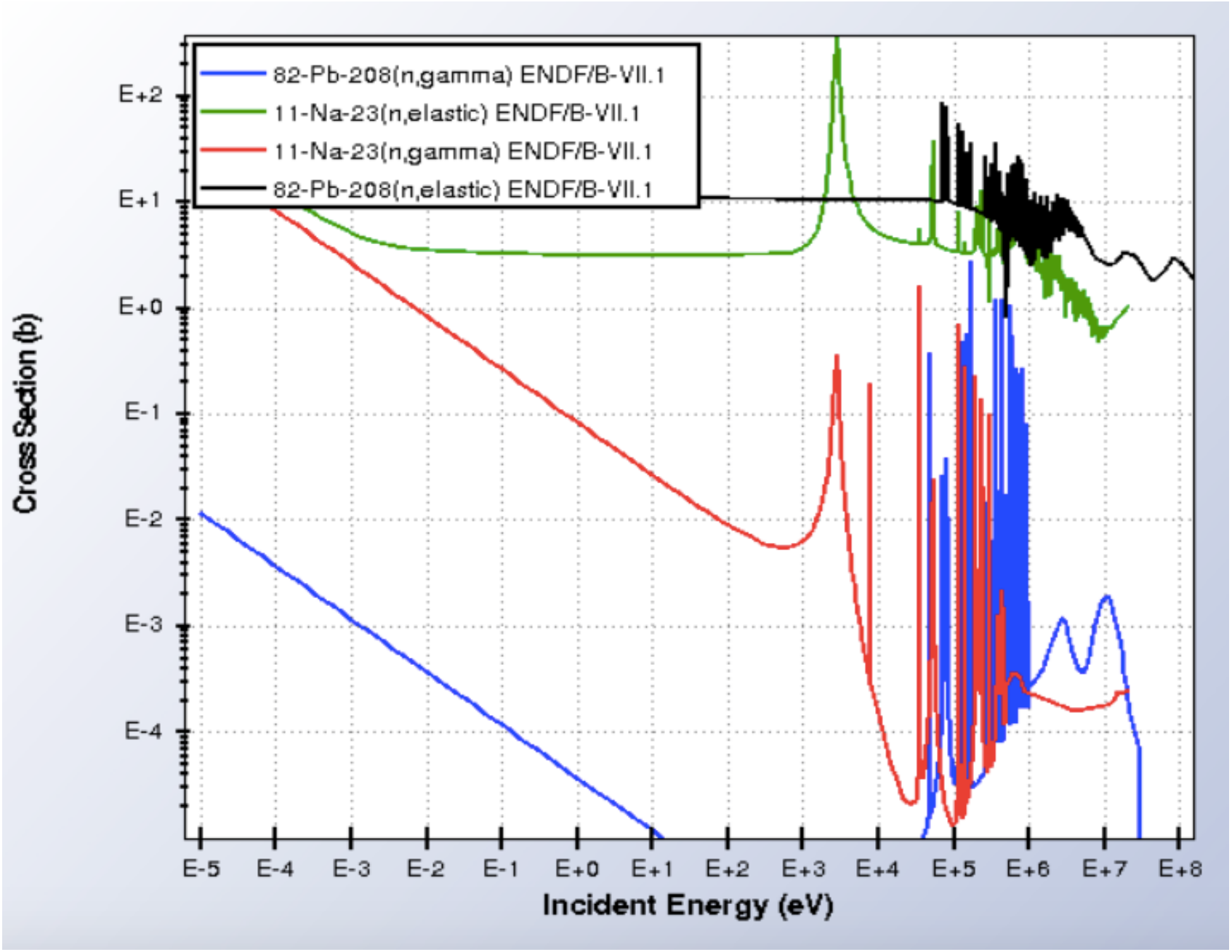
The reactor schematics from the Generation IV Intern. forum *are provided only as a basic reference*, the student should maintain an open view and discuss advantages and disadvantages of various design options, including the power cycle selection.

You are asked to compare the following aspects for the SFR and LFR plant concept. As far as possible give quantitative answers to the questions below:

1. How do the achievable power densities of the two designs compare?
2. What are the thermal hydraulics implications of the proposed design?
3. What are the implications on fuel and cladding materials?
4. What are the neutronics and control implications?
5. What are the economics implications, starting from the thermodynamic efficiency (the student is free to select the most appropriate power cycle)?

	Lead	Sodium
Boiling Point (°C)	1737	892
Melting Point (°C)	327.4	97.8
Density, ρ (Kg/m^3)		
at 450°C	10,536	842
at 700°C	10,242	780
Dynamic Viscosity, μ (Kg/(ms))		
at 450°C	0.011	0.029
at 700°C	0.012	0.031
Thermal expansion coefficient, α (%Vol/K)		
at 450°C	2.01×10^{-3}	2.59×10^{-4}
at 700°C	1.40×10^{-3}	1.81×10^{-4}
Thermal conductivity, k (W/(mK))		
at 450°C	15.4	66.1
at 700°C	17.7	59.1
Specific Heat, c_p (J/(KgK))		
at 450°C	147	1272
at 700°C	147	1276
Pr number		
at 450°C	0.0192	0.0050
at 700°C	0.0116	0.0039
Avg. Lethargy Gain per scattering collision (ξ)	0.0096	0.085

See next slide for additional neutronics data


82-Pb-208(n,gamma) ENDF/B-VII.1
11-Na-23(n,elastic) ENDF/B-VII.1
11-Na-23(n,gamma) ENDF/B-VII.1
82-Pb-208(n,elastic) ENDF/B-VII.1
Cross Section (b)
E+2
E+1
E+0
E-1
E-2
E-3
E-4
E-5
E-4
E-3
E-2
E-1
E+0
E+1
E+2
E+3
E+4
E+5
E+6
E+7
E+8
Incident Energy (eV)

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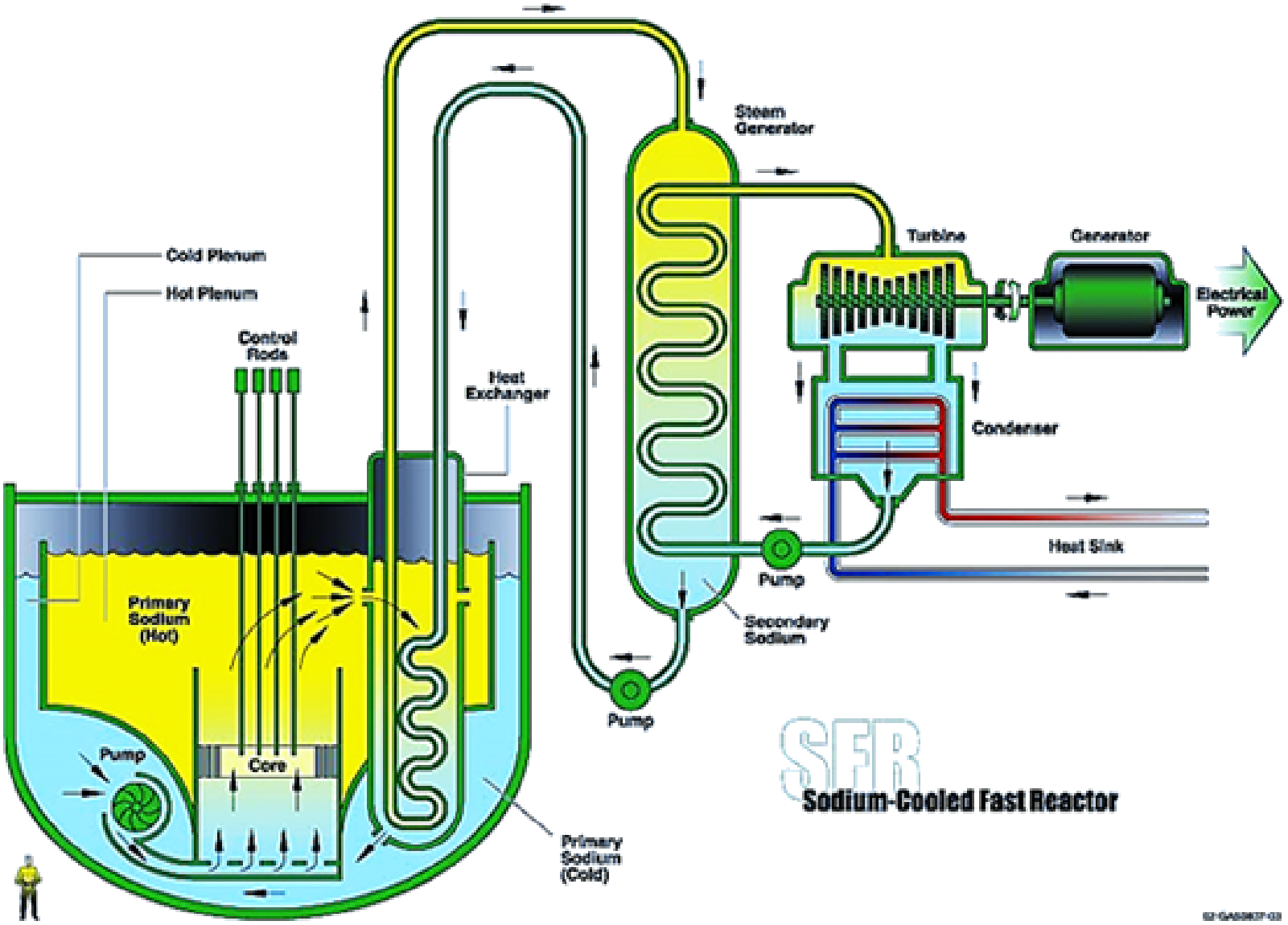

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