

Types of Nuclear Reactors

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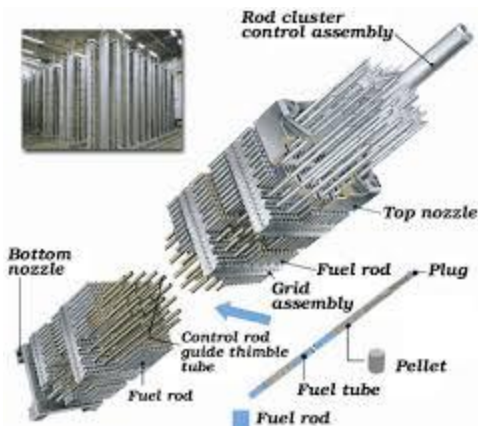
Nuclear Science and Technology Engineer

Types of Reactors (Fuel)

- As far as the type of fuels are concerned, three types of reactors exist:
 - Solid Core Reactors
 - Liquid Core Reactors
 - Gas Core Reactors

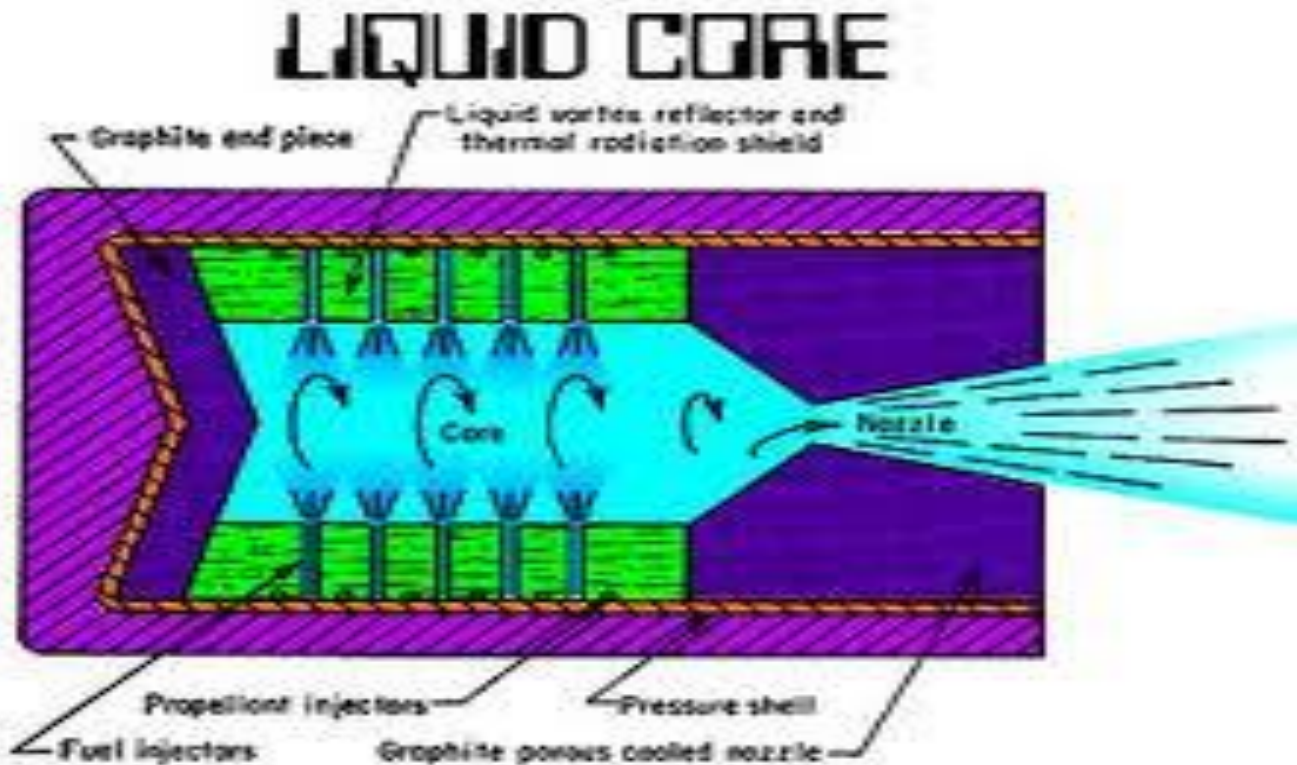
Solid Core Reactors

- Nuclear Fuel is put into fuel rods in Geometrical form in which nuclear fuel surrounded by cladding material is inserted into a reactor.
- They generally use water as a coolant.



Liquid Core Reactors

They use Uranium Tetrafluoride in liquid form as fuel or variants.



Gas Core Reactors

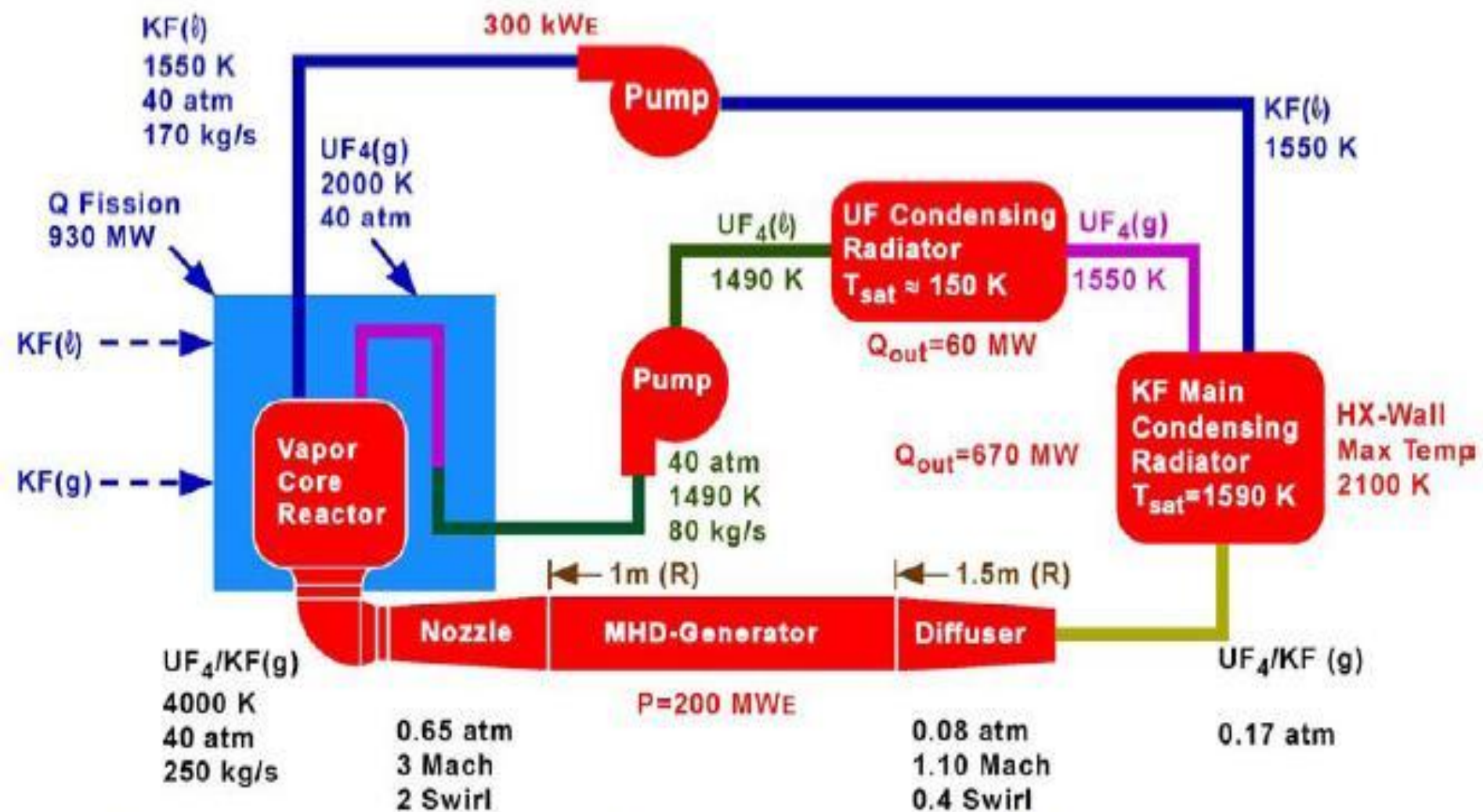
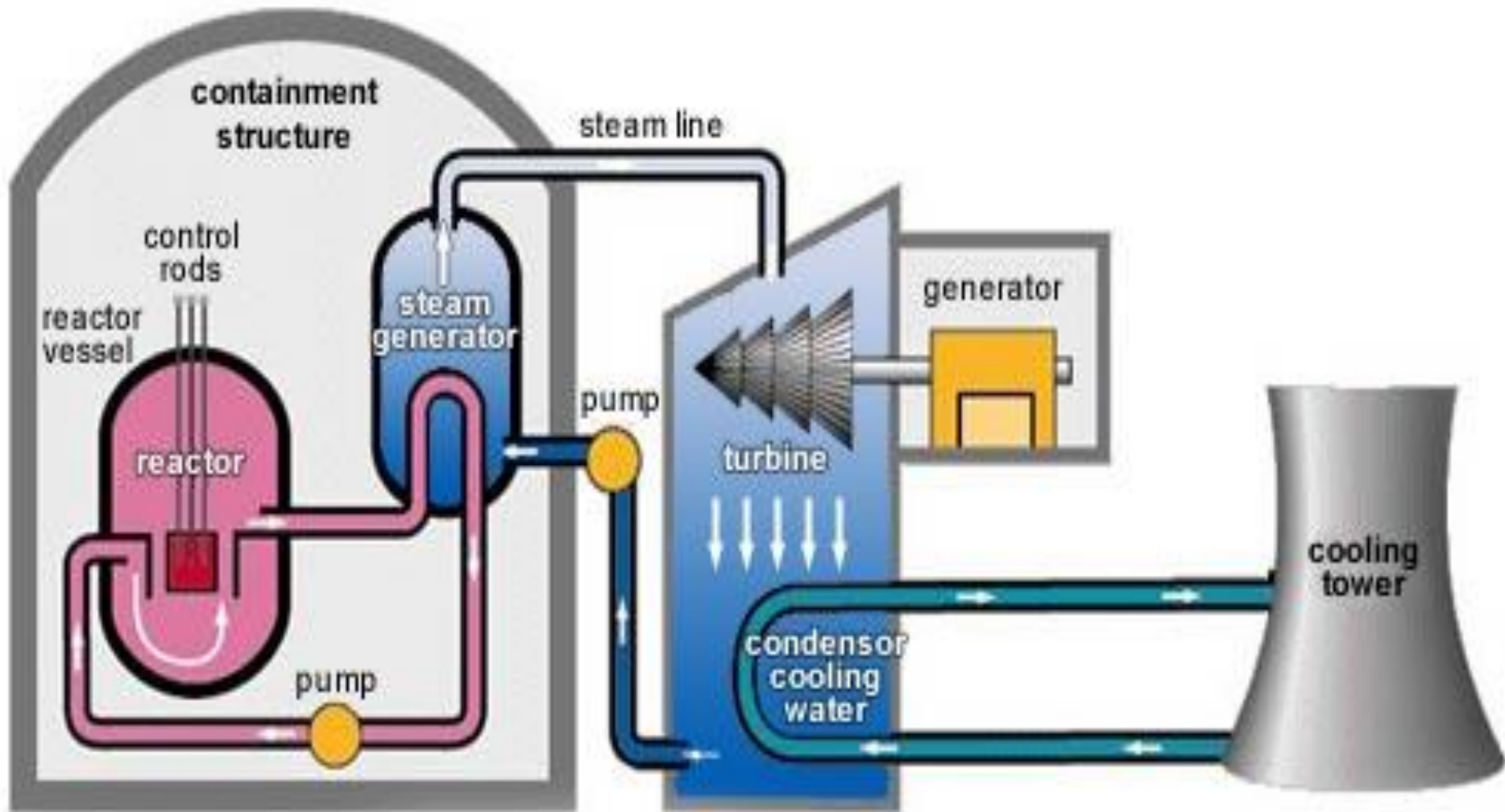


Figure 1. Illustration of a 200 MWe gas core reactor with MHD energy conversion in a closed Rankine cycle (specific mass 0.37 kg/kWe.)

Types of Reactors (Coolant)

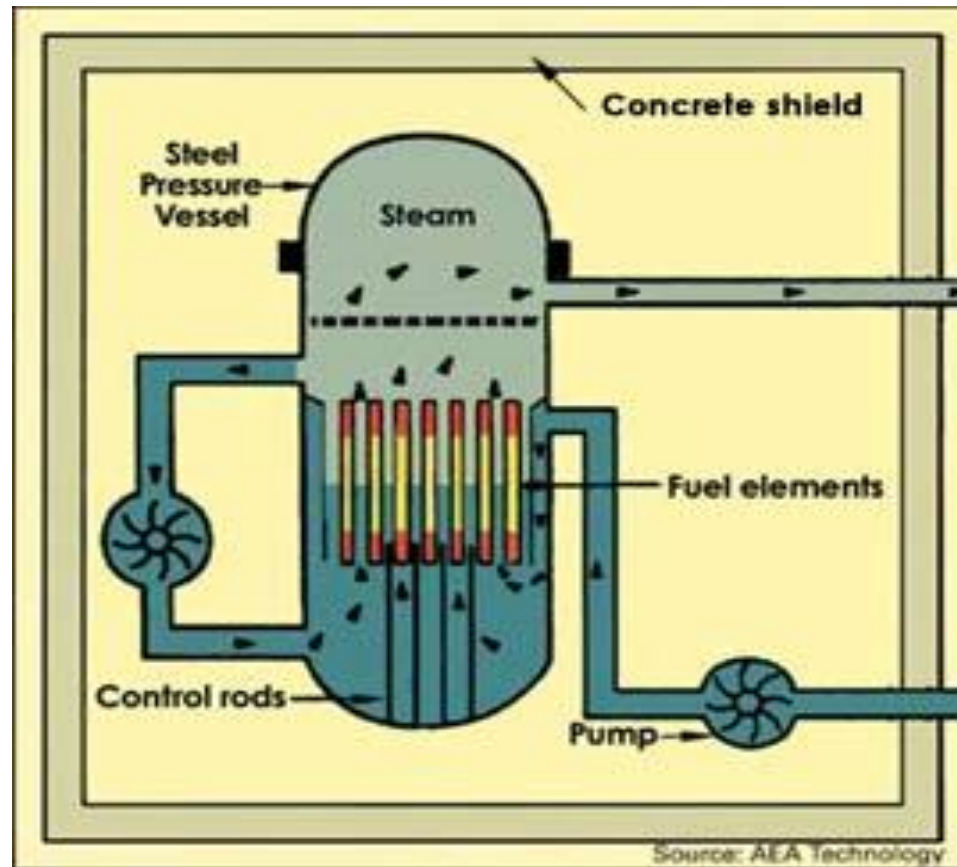
- As far as the coolant is concerned, the types of reactors are:
 - Pressurized Light Water Reactor
 - Boling Water Reactor
 - Pressurized Heavy Water Reactor
 - Liquid Metal Reactor
 - Gas Cooled Reactor

Light Water Reactor (Pressurized)



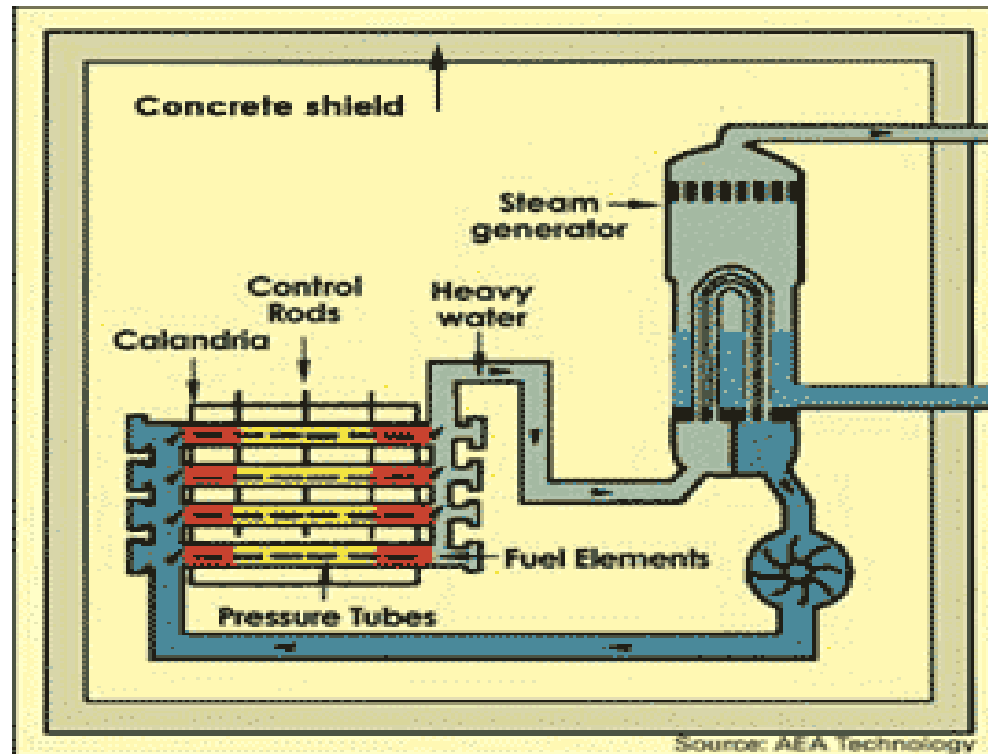
For a light water reactor with an output of 1,000 megawatts, the core would contain about 75 tonnes of uranium enclosed in approximately 200 fuel assemblies

Boiling Water Reactors



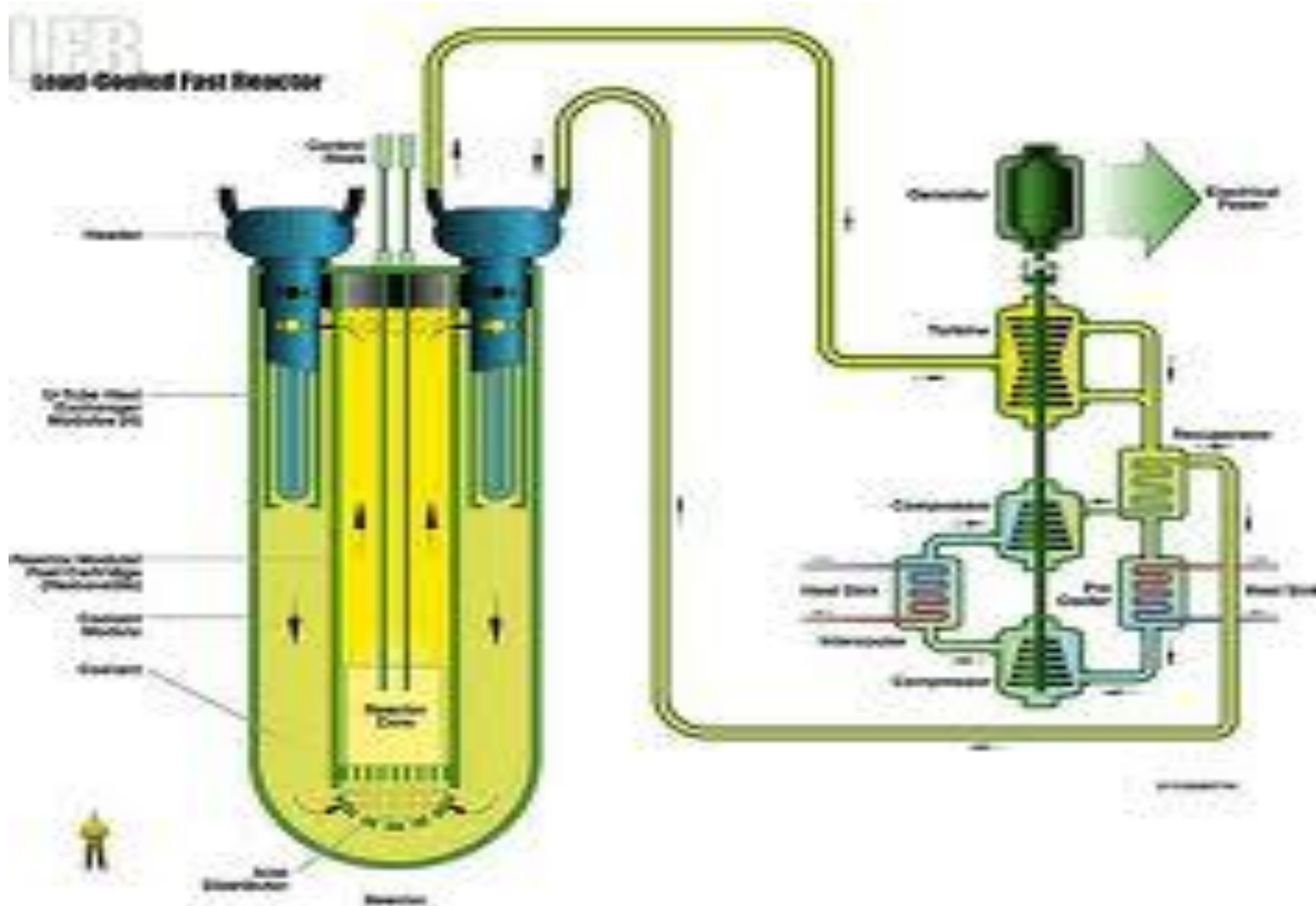
- **Boiling Water Reactors (BWR)** heat water in the core and allow it to boil into steam. The steam goes directly to the turbine outside the reactor

Pressurized Heavy Water Reactor

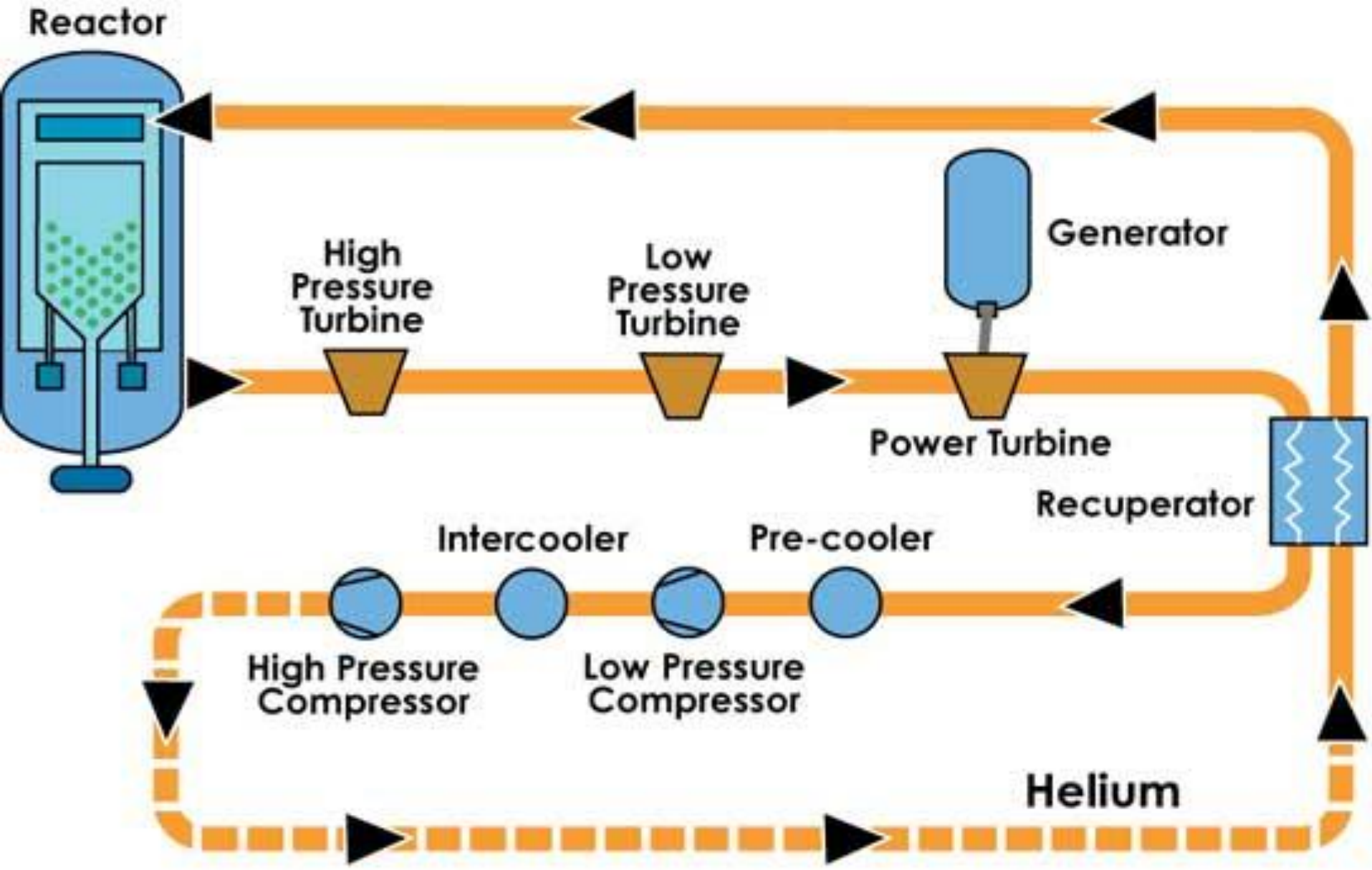


- Fuel assemblies are placed horizontally in a tank. Heavy water coolant is pumped through tubes containing the fuel assemblies to pick up the heat generated from the nuclear reaction. The coolant then moves to the steam generators to produce steam from ordinary water and back to the reactor.

Liquid Metal Cooled Reactors

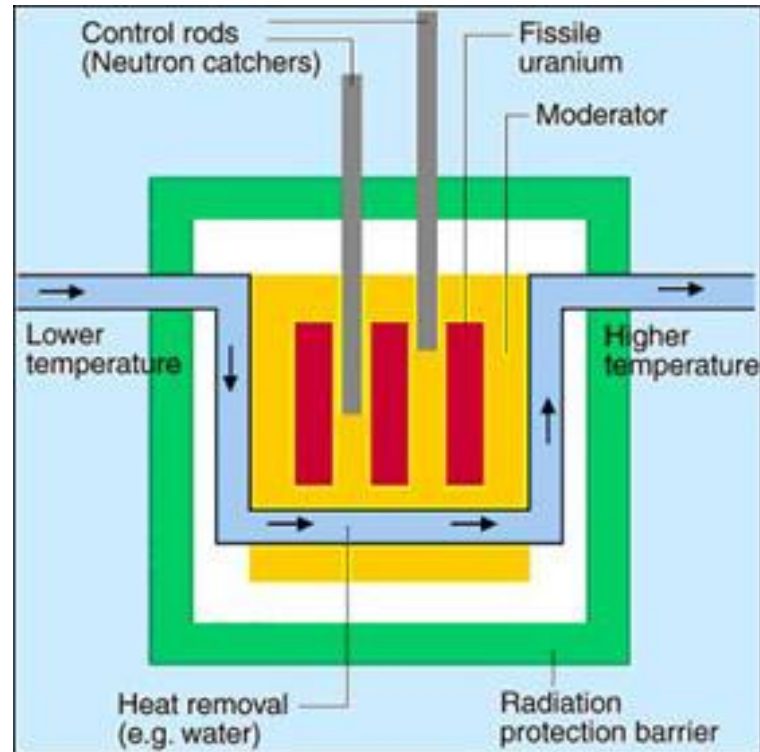


Gas Cooled Reactors



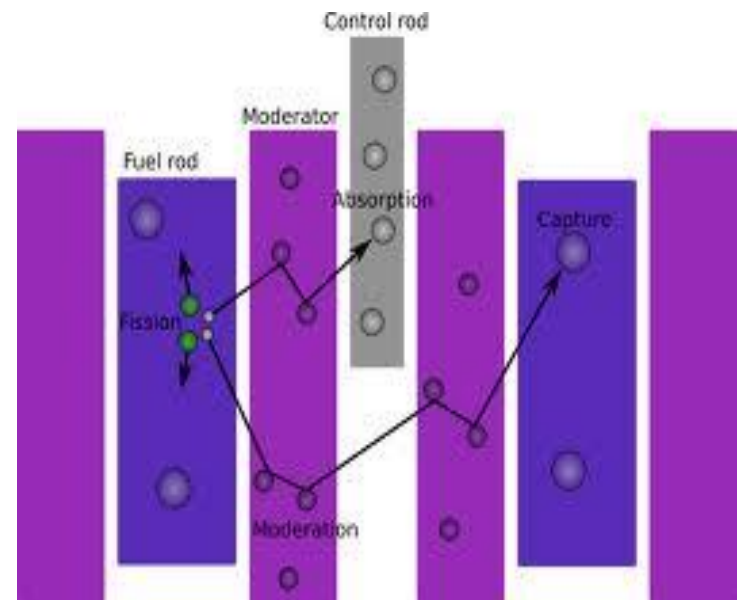
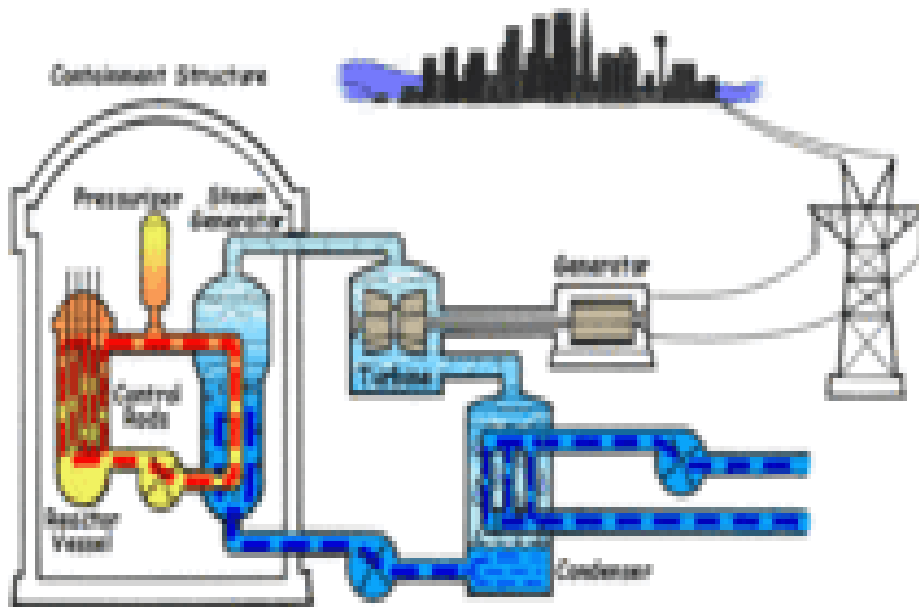
Types of Reactors (Operation)

- For the mode of operation, two types of reactors exist:
 - Thermalized reactors
 - Fast Reactors



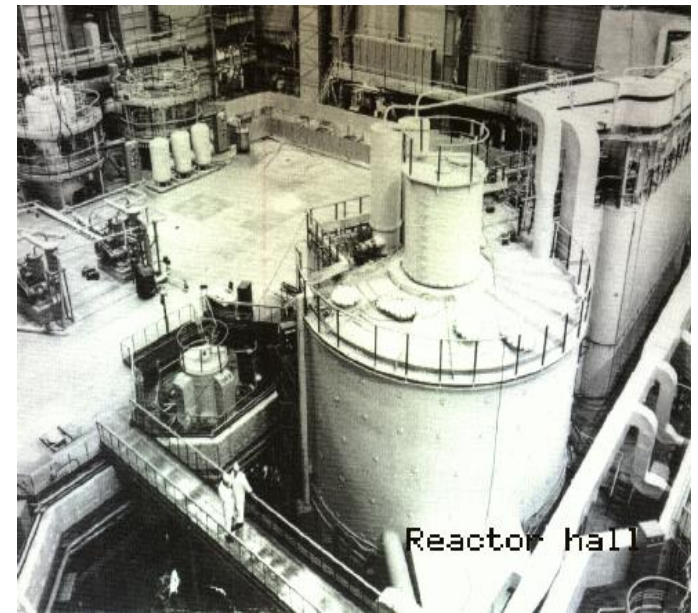
Thermal Nuclear Reactors

- These are the standard reactors that are used with thermalized neutrons. There must be a moderator for this type of nuclear reactor to work.
- Most nuclear power plant reactors are thermal reactors and use a neutron moderator to slow neutrons until they approach the average kinetic energy of the surrounding particles, that is, to reduce the speed of the neutrons to low velocity thermal neutrons.



Fast Reactors

- Fast Reactor is a nuclear reactor in which fission is caused mainly by fast neutrons.
- Such a reactor needs no neutron moderator, but must use fuel that is relatively rich in fissile material when compared to that required for a thermal reactor.
- A fast neutron reactor can reduce the total radiotoxicity of nuclear waste, and dramatically reduce the waste's lifetime
- They don't use water and they usually use liquid metal as coolant (such as liquid sodium), since we don't want moderator capability in the coolant.
- Sustaining a fission chain reaction with fast neutrons means using relatively highly enriched uranium or plutonium

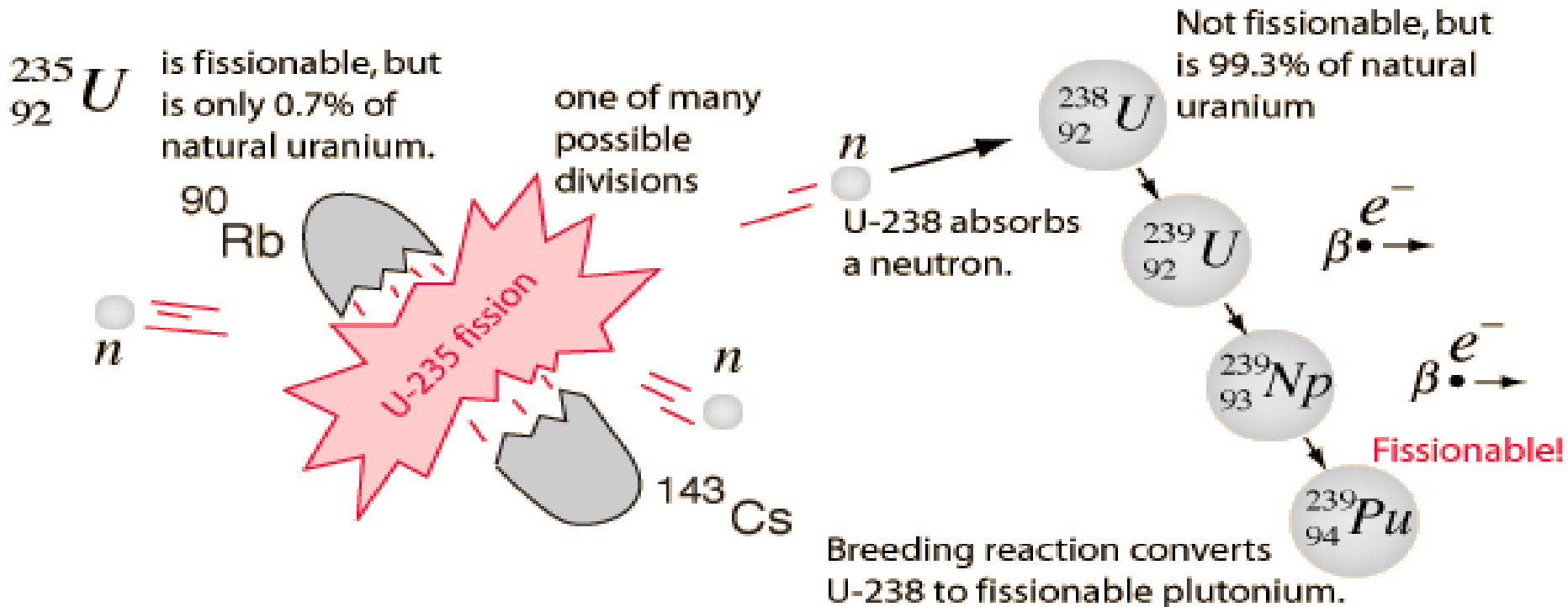


Types of Reactors (Purpose)

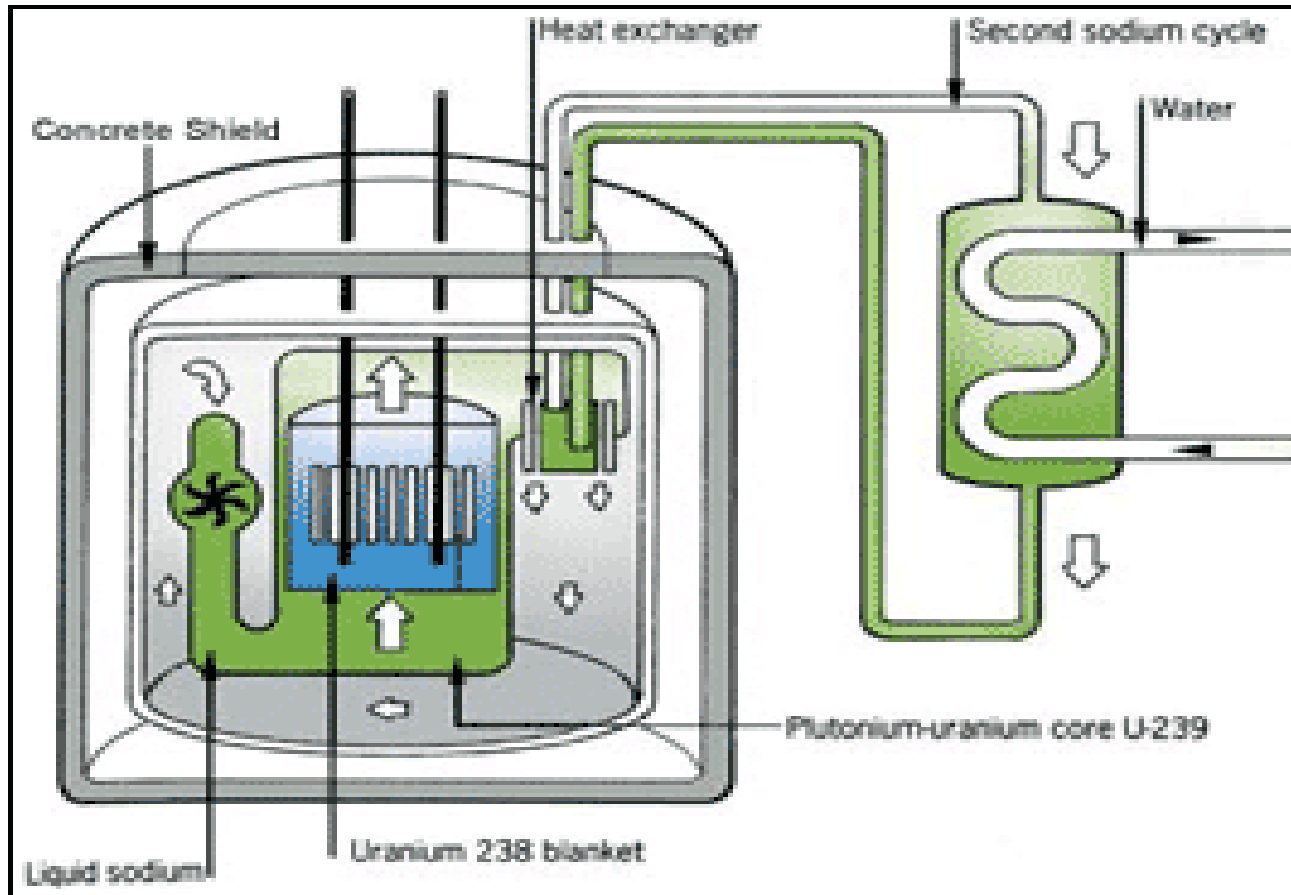
- Types of reactors purpose wise are
 - Power Production Reactors
 - Conversion / Breeder Reactors
 - Research Reactors
 - Propulsion Reactors

Breeder Reactors

- Under appropriate operating conditions, the neutrons given off by fission reactions can "breed" more fuel from otherwise non-fissionable isotopes.
- non-fissionable uranium-238 is 140 times more abundant than the fissionable U-235 and can be efficiently converted into Pu-239 by the neutrons from a fission chain reaction.



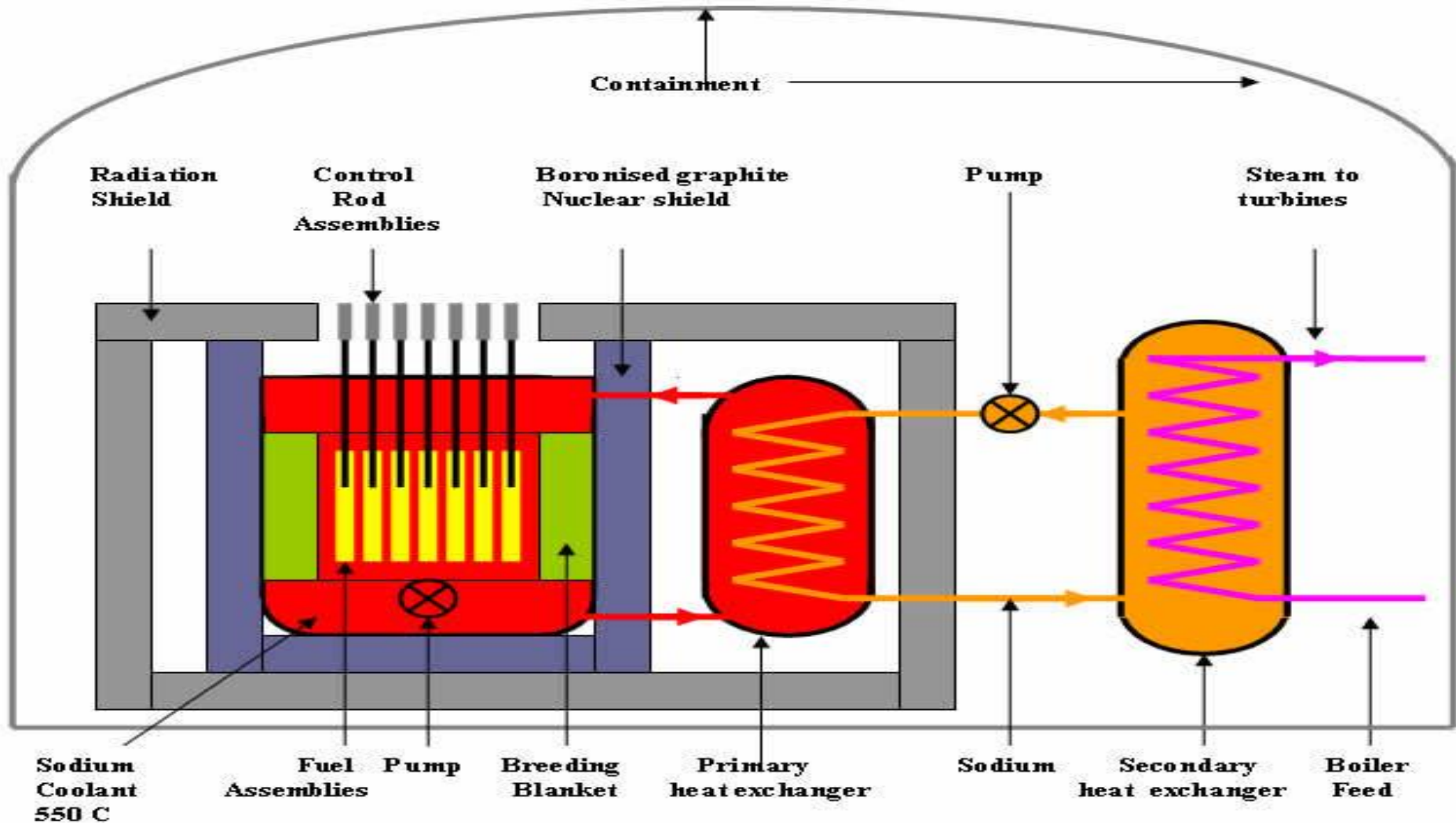
Breeder Reactors



- These reactors have a core of plutonium surrounded by rods of U-238. The U-238 nuclei absorb neutrons from the core and are transformed into plutonium (P-239). For every four atoms of plutonium that are used up in the core of the breeder, five new plutonium atoms are made from the U-238. Therefore, they "breed" plutonium. Fast breeder reactors work at such a high temperature that they need a special coolant such as liquid sodium.

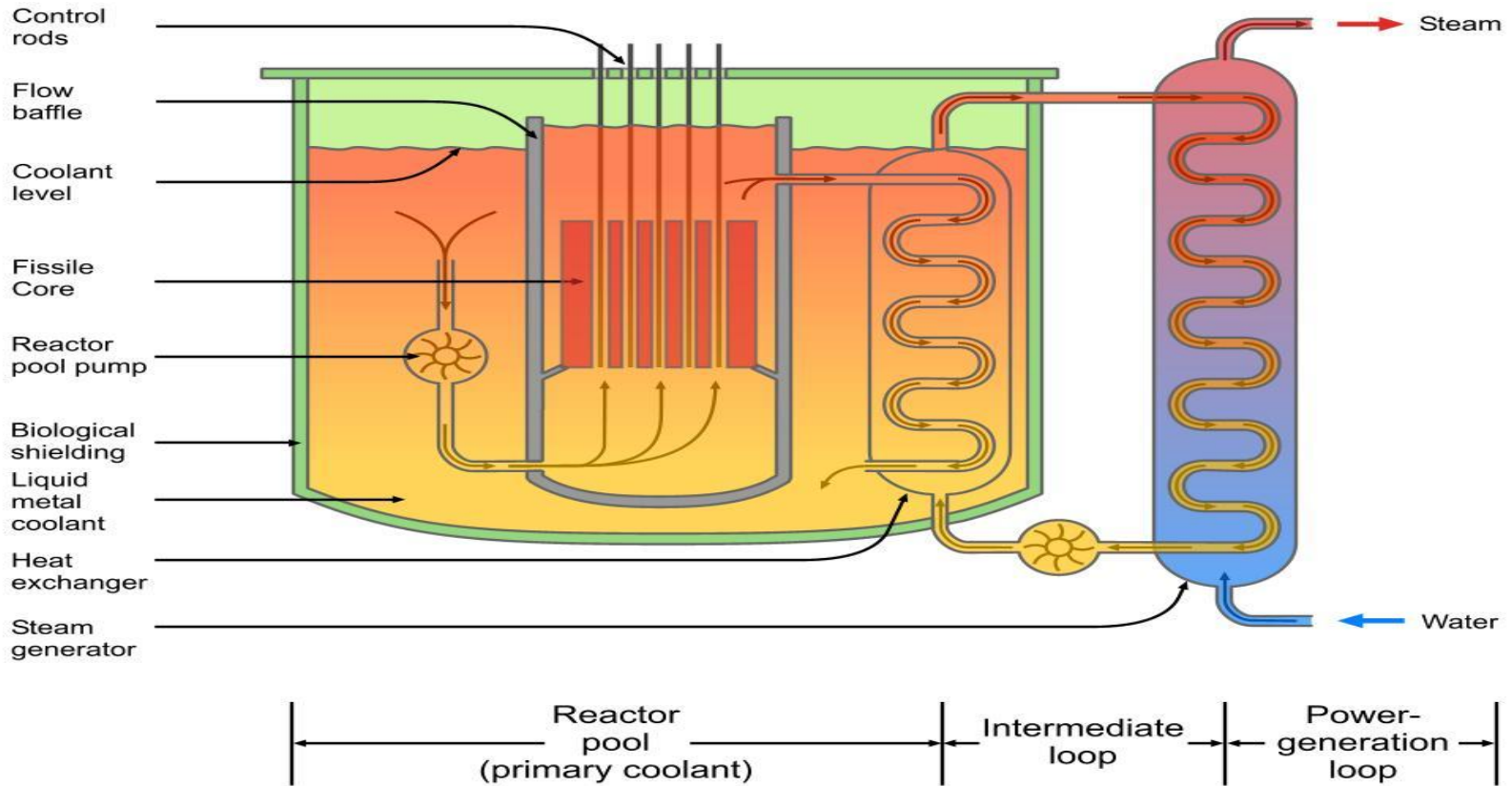
Another Example of Breeder Reactor

Fast Nuclear Reactor



Fast Breeder Reactor with Liquid Metal Cooling

Liquid Metal cooled Fast Breeder Reactors (LMFBR) "Pool" Design



Research Reactor

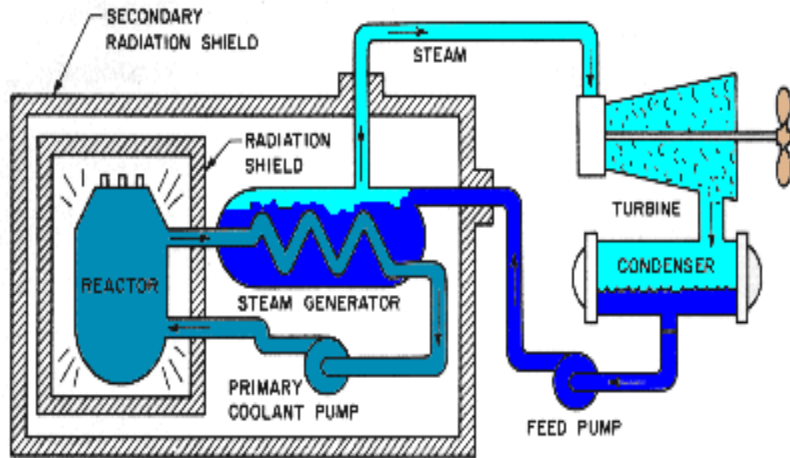
- **Research reactors** are nuclear reactors that serve primarily as a neutron source. They are also called **non-power reactors**, in contrast to power reactors that are used for electricity production, heat generation, or maritime propulsion.
- The neutrons produced by a research reactor are used for neutron scattering, non-destructive testing, analysis and testing of materials, production of radioisotopes, research and public outreach and education. Research reactors that produce radioisotopes for medical or industrial use are sometimes called **isotope reactors**



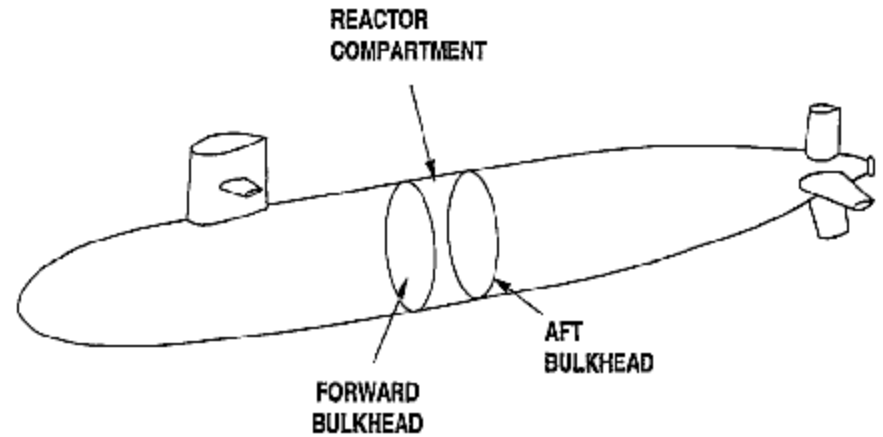
Propulsion Reactors

- Nuclear propulsion reactors are used by craft for power. The most common form is naval propulsion where nuclear reactors are used in Submarines, aircraft carriers and large ships
- The majority of marine reactors are of the pressurized water type, although the US and Soviet navies have designed warships powered with liquid metal cooled reactors.. Nuclear reactors require no oxygen for combustion and emit no exhaust gas.
- The fuel in a seagoing reactor is typically more highly enriched (i.e., contains a higher concentration of U^{235} vs. U^{238}) than that used in a land-based nuclear power plant.
- They only produce in hundreds of megawatt rangee.
- The steam can be used for propulsion as well as for electricity production.
- There is research on nuclear propelled rockets where hydrogen is heated and expelled from rocket for high speeds.

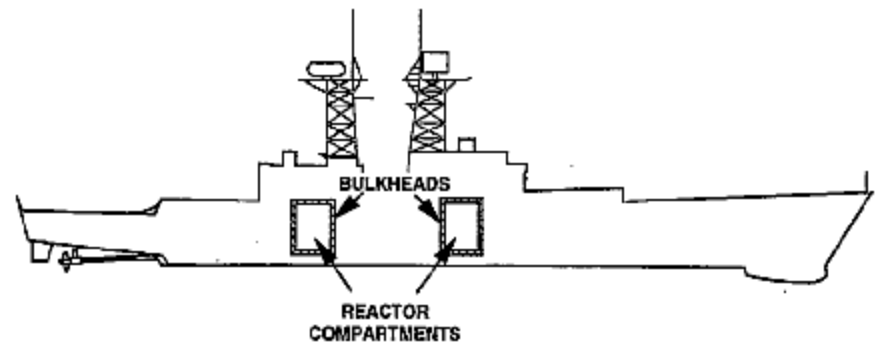
Propulsion Reactors



Pressurized Water Reactor



Typical Submarine Reactor Compartment Location

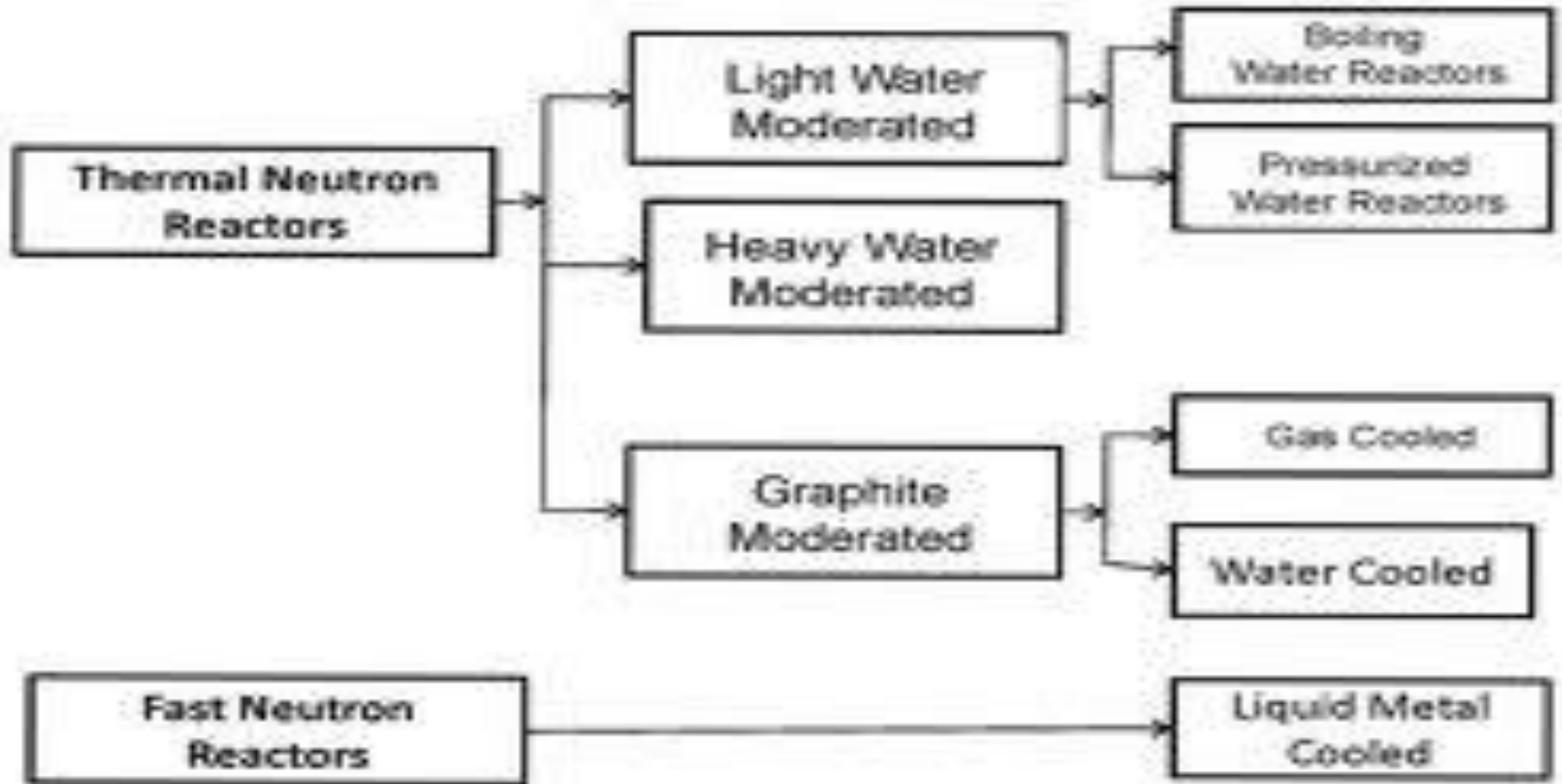


Typical Cruiser Reactor Compartment Location

Typical Characteristics of Nuclear Reactors

<u>Type of Reactor</u>	<u>Fuel Form</u>	<u>Coolant</u>	<u>Moderator</u>
BWR	Enriched Uranium Dioxide	Water	Water
PWR	Enriched Uranium Dioxide	Water	Water
PHWR (Candu)	Natural Uranium Dioxide	Heavy Water	Heavy Water
GCR	Natural Uranium	Carbon Dioxide	Graphite
AGR	Enriched Uranium Dioxide	Carbon Dioxide	Graphite
LWGR	Enriched Uranium Dioxide	Water	Graphite
FBR	Plutonium Oxide and Uranium Dioxide	Liquid Sodium	None

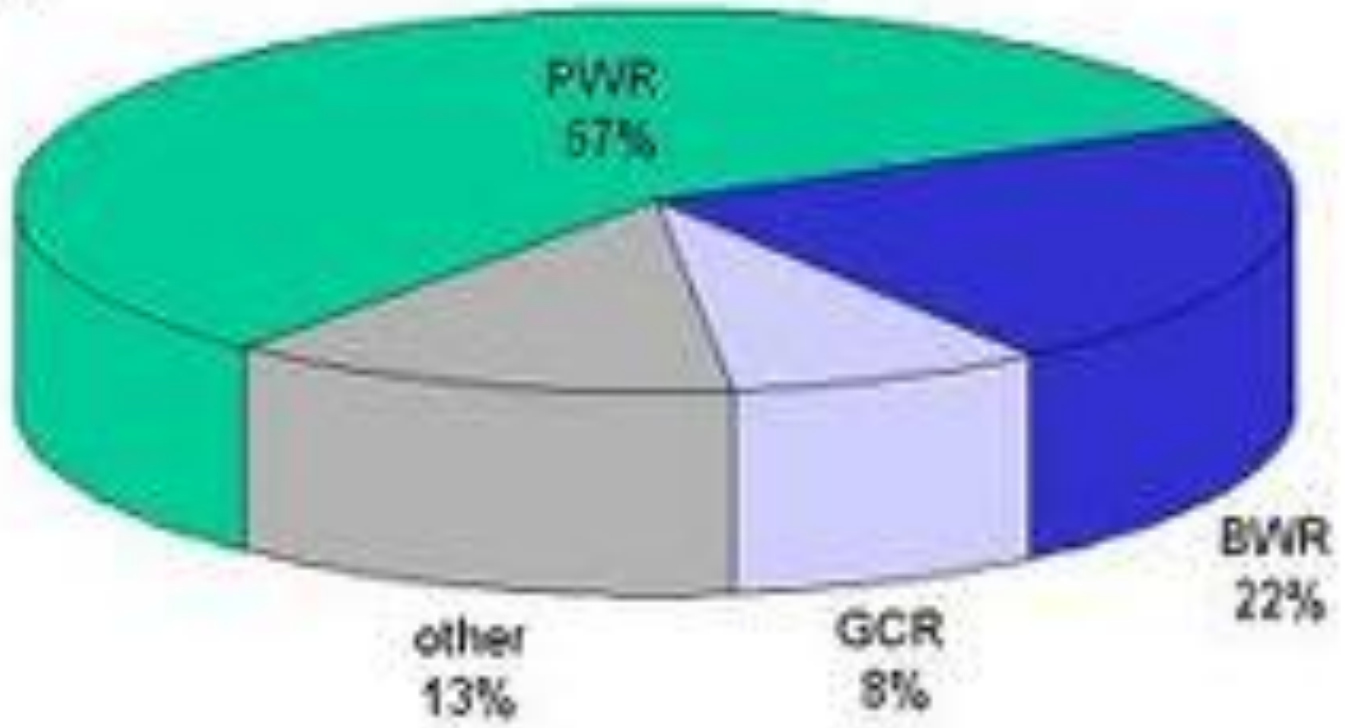
Operational Classification of Nuclear Reactors



Percentage of Nuclear Reactors

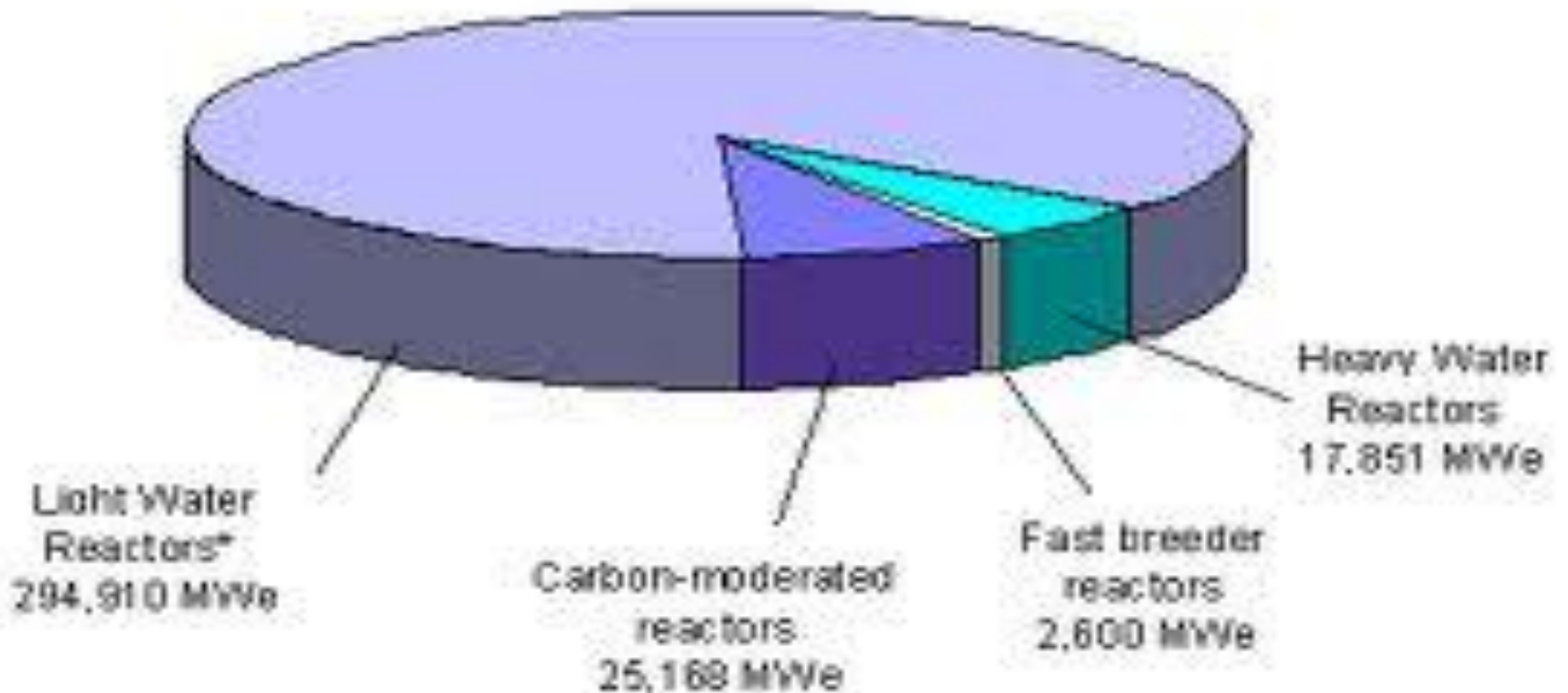
Types of NPP in the World

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Percentage of Electricity Production

Electricity Production Capacity of Various Reactors



Nuclear Reactor Saturation in the World

