

## *Reactors, Cores & Reactor Vessels*

---

### *Function*

Regardless of type, a nuclear reactor has 3 major functions:

- to produce the heat and transfer that heat to the coolant,
- to maintain a pressure boundary (so the coolant is not lost), and
- to provide a structure to hold the fuel.

The reactor is being treated separately from the reactor coolant system. In a reactor, the term **Core** is used to refer to that area where the fuel is located.

### *Design and Flow Paths*

Reactor vessels, used in light and heavy water reactors, come in 4 major shapes or designs:

- Horizontal cylindrical vessel with flat ends and horizontally mounted tubes passing through reactor. Designed for about 1800 to 2000 pounds per square inch pressure.

This is the design used in the heavy water moderated designs, as the CANDU. The cylindrical vessel is a welded design. The 300-380 tubes passing through the reactor are designed to hold the small fuel assemblies. The coolant flows around fuel assemblies, picks up the heat, and transfers it from the reactor. These tubes are normally at about 310C. Each coolant tube is located within a concentric outer tube. The 8-9 mm gap between the 2 tubes is filled with a slow purge of carbon dioxide gas. The moderator outside the outer tube is maintained at about 60-70C.

In this design, heavy water is used as both the coolant and the moderator.

This design is illustrated in the [CANDU](#) section of the site. Several pages on this site illustrate the features of this design - [CANDU overview](#), [candu1](#), [candu2](#), [candu-rx](#).

- Vertical cylindrical vessel with hemispherical top and bottom heads. Internal Core Barrel. Designed for about 2700 to 3000 pounds per square inch pressure.

This is the design used in the pressurized water reactor designs ([PWR](#) and [VVER](#)). Inside the reactor vessel is another vessel called the core barrel. The core barrel sits on a ledge within the reactor vessel. Water enters from the side of the reactor vessel, travels downward in the space between the reactor vessel and the core barrel, then flows upward through holes in the core barrel. The [Westinghouse reactor vessel](#) illustration shows the relative positions and lengths of fuel assemblies, core barrel, upper head.

The fuel assemblies are typically about 12 feet (4 meters) long. The water flows upwards along the fuel rods in the fuel assemblies and remove the heat. The water then passes out of the reactor vessel through holes in the side.

The water used in this design usually contains boric acid. The boron-10 in the boric acid can absorb neutrons and prevent the neutrons from entering the fuel and causing fission. The boron, in this case, is used to control the distribution of the power produced in the reactor.

- Vertical cylindrical vessel with hemispherical top and bottom heads. Internal Core Barrel. Designed for about 1500 pounds per square inch pressure.

This is the design used in the boiling water reactor. The design is somewhat similar to the previous vertical design. A major difference is that there are jet pumps mounted in the area between the core barrel and the reactor vessel. These promote flow through the reactor. The water flows to the bottom of the core barrel, flows upward through the flow distribution holes, then upwards along and past the fuel assemblies and rods.

Another difference in this design is that boiling is allowed to occur and the water gets converted to steam. The steam-water mixture then goes to the upper area of the reactor where water is removed from the steam. The General Electric reactor vessel illustration shows the relative positions and lengths of fuel assemblies, core barrel, upper head.

- Vertical cylindrical vessel with flat top and bottom heads and vertically mounted pressure tubes passing through reactor. Designed for about 1500 pounds per square inch pressure.

This is the design used in the RBMK reactor. 1600+ pressure tubes hold the fuel assemblies. Water flows upward past the fuel rods removing the heat. Boiling occurs in the upper area of the reactor.

Graphite is used as the moderator in this reactor vessel.

Reactors used in the gas cooled and metal cooled reactor designs will be discussed in a future revision.

### ***Methods of Controlling the Fission Process***

The fission process is controlled in the following ways:

- Control rods which insert to stop the fission process
- Neutron poison rods which shape the power in the reactor over the lifetime cycle
- Burnable neutron poison materials interspersed in the fuel rods to shape the power in the reactor over the lifetime cycle.

---

Copyright © 1996-2006. [The Virtual Nuclear Tourist](http://www.nucleartourist.com). All rights reserved. Revised: January 6, 2006.