Small Modular Reactors (SMRs)

Frontier technology corp.

Small modular reactors (SMRs) are an emerging nuclear technology with the potential to revolutionize access to clean energy. They are designed to have a smaller physical footprint and faster construction and installation than traditional nuclear plants. As a result, SMRs might be a viable solution for areas previously unable to support nuclear power.

At Frontier Technology Corporation we're excited about the opportunity SMRs bring to expand access to nuclear energy, and pleased to be a supplier of the neutron source start-up rods and shielding walls these modern reactors rely on.

What is SMR technology?

Small modular reactors operate on the same principle of nuclear fission as traditional nuclear reactors. The primary differences are their output, size, and method of construction, for example:

Power output: up to 300 MW(e) of power (less than half the amount from traditional reactors)

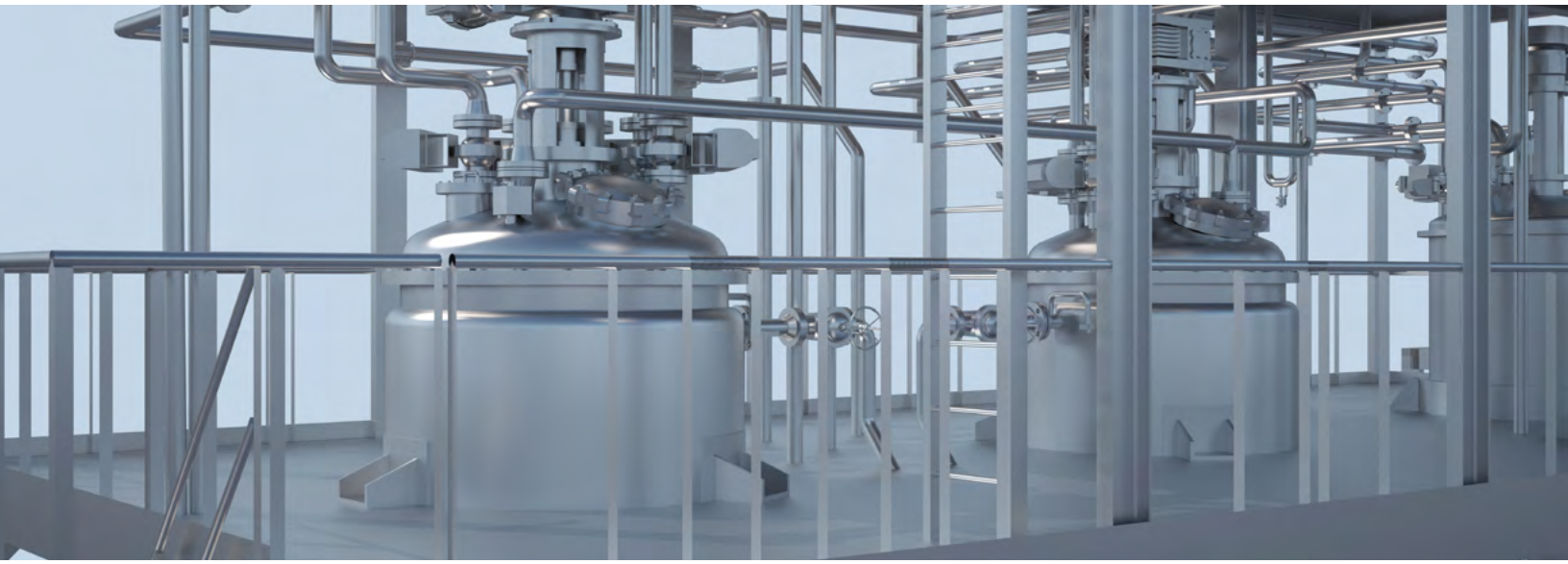
Size: ¼ or even less of the size of a traditional reactor

Method of Construction: same general components as in traditional reactors (i.e., reactor core, steam generator, coolant water, turbine, etc.) but constructed offsite as a complete unit to deliver and install rather than from-scratch construction onsite

How do small modular reactors work?

Like traditional nuclear reactors, SMRs use energy generated through nuclear fission to produce power for a variety of applications. There is no definitive, standard design for the size and shape of an SMR, and the details vary among the different reactors currently under development; however, they typically contain the same types of components. The components are arranged in a vertical stack, housed in a cylindrical structure, and the unit can be installed above ground or partially buried. From the bottom to the top, SMR components include:

- **Reactor core** - contains fuel (such as low-enriched Uranium-235)
  - Start-up rods - inserted along with fuel in the core to begin the nuclear chain reaction, later removed
- **Control rods** - to manage heat generated by fission in the core and to absorb additional neutrons released during fission
- **Coolant water/steam generator** - light water circulates to cool the reactor and moves heat away, then enters a steam generator
- **Turbine** - powered by the steam and generates electricity
- **Pressurizer** - maintains proper pressure of the coolant water so it does not boil away



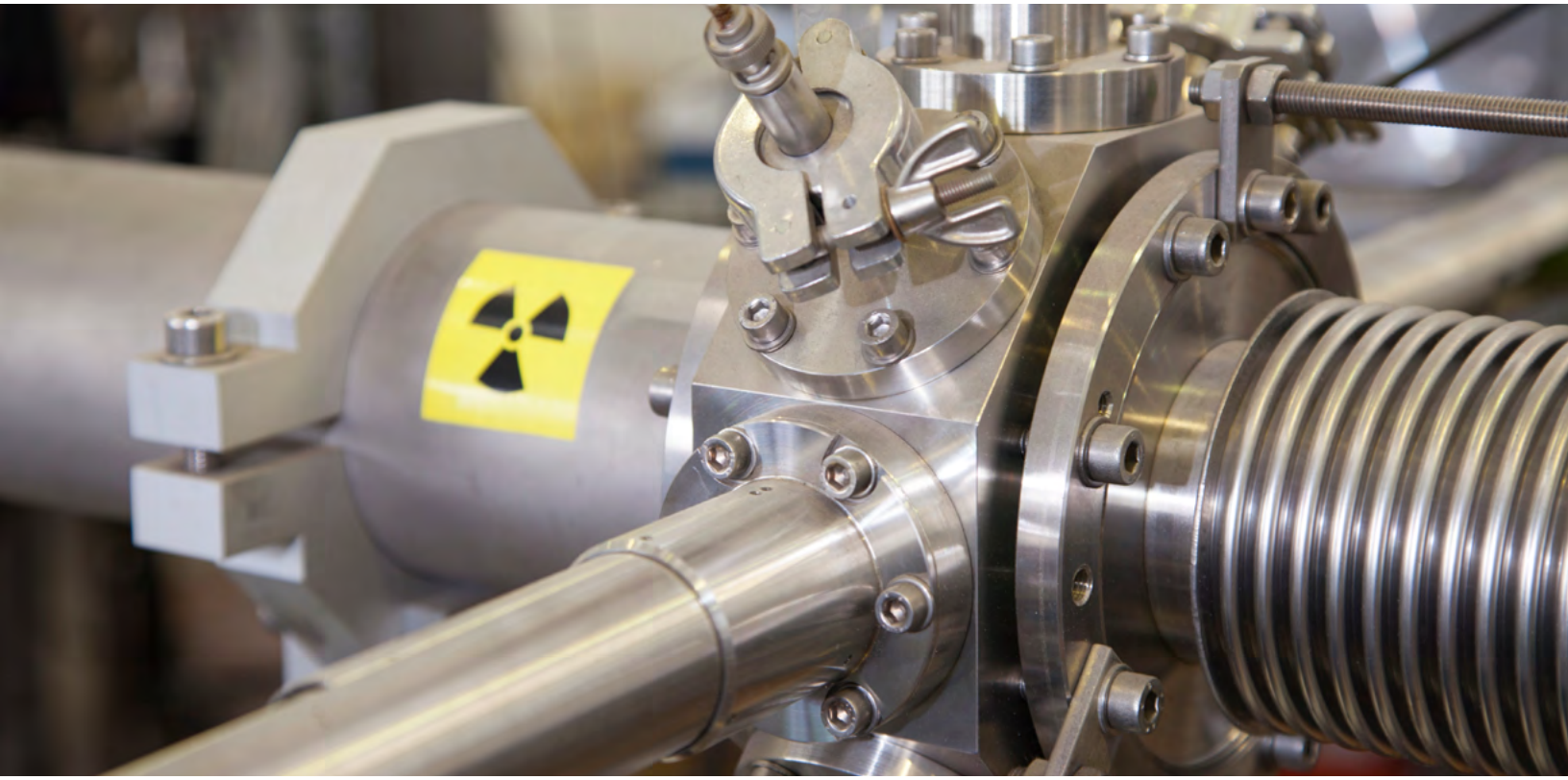
For safety and to protect people, buildings, and equipment around it, the reactor core must be surrounded by shielding walls that are both durable and able to block neutrons from escaping. Unlike lead or other heavy metals, which do not block neutrons well, materials containing hydrogen are extremely effective at slowing and stopping neutrons. This is because a single hydrogen atom has the same atomic mass as a neutron; therefore, when they collide kinetic energy is transferred, slowing the neutron.

Water, naturally rich in hydrogen, is often used in shielding walls, either directly in an enclosure or mixed into concrete or in water-extended polymer (WEP). Boron, which readily absorbs neutrons, may also be added to water to increase shielding effectiveness.

Because SMR designs vary, it's important that shielding walls be made to fit each unique set of requirements. One-size-fits-all is simply not an option. Frontier is an expert manufacturer of custom walls and containers for neutron shielding in a range of applications, including SMRs.

The SMR start-up process

As in traditional reactors, fission in the reactor core of an SMR is driven by the nuclear chain reaction in which a neutron hits an atom and splits it in two and releases additional neutrons. The neutrons continue to hit and split atoms, creating a nuclear chain reaction.



However, simply placing a fuel source in the core does not spontaneously create this chain reaction - a plentiful source of neutrons must be included in the core along with the fuel to start it. One common neutron source is Californium-252 (Cf-252), a radioactive isotope of the element Californium, because it reliably emits large quantities of neutrons needed to generate the chain reaction.

Cf-252 neutron sources are assembled with great care to ensure efficacy and safety. A small piece of the isotope in wire form (up to 5 mg) is double-encapsulated and TIG welded in a capsule made from stainless steel or another alloy. A capsule is then inserted into a hollow steel rod. A secondary neutron source is often included in start up rods as a “back up,” commonly antimony-beryllium (SbBe) pellets.

A supplier like Frontier can provide these start up rods to meet the specifications required for SMR projects. Rod assemblies must meet several industry standards including regulations set by the Nuclear Regulatory Commission, ISO 2919, ASTM, and ANSI.

The start up rods are interspersed with fuel in the core to begin the start up process. Once the nuclear chain reaction is well underway, the start up rods can be removed and replaced with additional fuel.

SMR applications and advantages

Nuclear energy is unique because it requires no fossil fuels to generate power and is not reliant on weather conditions. Due to the smaller footprint and modular design of SMRs, developers and scientists anticipate a number of potential applications for nuclear energy from SMRs, such as:

- Electricity or hybrid energy (nuclear/electric)
- Steam production
- Small electrical markets/small grid areas
- Water Desalination plants
- Isolated or rural areas
- Industrial applications

SMRs offer a number of potential advantages over traditional nuclear and other power sources. Most SMRs feature passive safety systems that use thermoconvection to circulate light water and dissipate heat during operation and in the event of a shutdown. The flow of water is directed by gravity; therefore, less equipment must be kept on hand and maintained, and the amount of worker intervention is also reduced. SMRs also use less fuel, produce less power, and operate at lower pressures, which may lower overall operational risk.

Because they are modular, it's possible to install and bring a single SMR unit online and then add more over time, producing energy with the initial unit as the others are installed, kickstarting ROI. And with a smaller physical footprint, it's possible to bring nuclear energy to smaller geographic or even remote settings, growing production as demand increases.

Construction cost savings are also possible because each unit is built in a controlled factory setting following a standardized process, then delivered to the site ready for installation above or below ground. As a result units can be in place and brought online in a short time period with far less equipment and labor than in traditional nuclear plant sites.

What's the current status of SMRs?

As of early 2023 approximately 70 SMR projects are in various stages of development around the world including the United States, with one in Russia (the world's first floating nuclear power plant, on a barge) and one in China currently producing energy.

Experts note that work remains to be done in tandem with bringing new SMRs online. This includes ensuring nuclear regulations reflect the unique characteristics of SMR technology, obtaining design certifications for the Nuclear Regulatory Commission (for US projects), and monitoring real-world outcomes of SMR projects compared to research-based predictions. It's also critical that power grids are in place to connect markets to new SMR-based nuclear plants. And of course, planning for safe disposal and containment of nuclear waste from these plants is critical.

Clean energy for the future

Promising SMR developments appear to be a pathway to cleaner, reliable energy for the future. Frontier Technology Corporation is ready to be a part of it by offering Cf-252 neutron sources for reactor start up rods and custom neutron shielding walls and enclosures. With decades of experience manufacturing encapsulated Cf-252 neutron sources and shielding structures for a variety of industries like medical, oil and gas, sand and shale, coal, cement, minerals, and research, we can work with you toward safe and effective nuclear solutions.

About Us

Frontier Technology Corporation (FTC) is the world leader in Californium-252 neutron source manufacturing and design, and is the foremost expert in logistics and shipping of radioactive material. Founded in 1984 by Treva Janzow and the late Edward Janzow, Frontier Technology is located in Xenia, Ohio. Frontier Technology has over 40 years industry experience in providing the highest-quality neutron sources, PINS sources, nuclear start-up rods, TYPE-A shipping containers, WEP shielding, and antimony-beryllium pellets.

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