Canadian Nuclear Laboratories | Laboratoires Nucléaires Canadiens

ZED-2 Research Reactor

CNL's Zero Energy Deuterium (ZED-2) reactor is a versatile tank type, heavy water moderated low power research reactor that achieved first criticality in 1960. The variable pitch of the reactor and ease of access to the core, along with the reactor's associated counting facilities, make the reactor an ideal tool for performing reactor physics measurements and fuel studies. The clean, extremely low activity, moderator means that neutronic equipment calibrated in the reactor can be returned to the customer within a day of irradiation.

ZED-2 has been used to confirm the reactor physics design of all Canada's power reactors. The ZED-2 reactor was initially built to test the fuel arrangement of Canada's first nuclear power plant, the Nuclear Power Demonstration. ZED-2 has supported development of the CANDU® industry by testing a wide range of fuel bundle designs and fuel arrangements at low power, usually between 5 to 120 watts indicated power, under a variety of operating conditions and simulated accident scenarios.

The reactor consists of a large aluminum tank surrounded by a graphite reflector and concrete shielding. Fuel assemblies are hung in the calandria from steel beams with the fuel arranged in virtually any desired configuration. The assemblies are typically composed of stacks of five 50 cm long fuel bundles loaded into a sealed channel consisting of two concentric tubes. These tubes are designed to simulate the pressure and calandria tubes typical of a CANDU power reactor. The channels may be filled with "coolant" such as light-water, air, or heavy-water, in order to simulate the coolants and possible accident scenarios in a power reactor. Also available are seven hot channel sites able to operate at pressures up to 8.6 MPa and 300°C with either CO_2, D_2O, or H_2O coolants. The maximum power in ZED-2 corresponds to a neutron flux of approximately 1 x 10^9 neutrons per cm^2 per second in the centre of the core.

Over the years many experimental fuel types and designs have been tested in ZED-2 including natural uranium oxide bundles with a range of geometries, and various uranium metal, silicide and carbide bundles. Today ZED-2 supports the development of the Enhanced CANDU 6® (EC6) reactor and advanced fuel cycles. ZED-2 is also used for the development, characterization, and calibration of in-core and ex-core flux detectors for use in power reactors.

ZED-2 is operated by the R&D Facilities Operations Division with counting lab and reactor physics support provided by the Applied Physics Branch (APB) at CNL's Chalk River Laboratories. In addition to the hands-on operation of the facility, ZED-2 and APB professionals have extensive knowledge of reactor physics and are able to leverage complementary site facilities and existing expertise in this field to enhance any project.

ZED-2 is in the process of becoming a user facility and building collaborative ties with industry to provide research and development support and calibration services for radiation monitoring equipment; and with universities and research institutions to further advance nuclear data libraries, code validation, dosimetry applications, and fuel research . In addition, ZED-2 will continue to host Experimental Reactor Physics Schools for university students to experience reactor physics research in the field.

AN EXAMPLE ZED-2 MEASUREMENT: THE FLUX MAP

A flux map measurement is used to reconstruct the relative neutron field at various locations across the core. To do this, thin metal foils approximately 1 cm in diameter are suspended in the reactor between the fuel assemblies. The reactor is operated at high power, typically 100 W, for approximately an hour to irradiate the foils. These foils are then removed from the reactor and the activity of the foils is measured using sodium iodide detectors. The activity of each foil is proportional to the neutron field it was exposed to, and so the list of foil locations and activities can be used to reconstruct the shape of the neutron field in the core, referred to as the "buckling". Foils of different materials are sensitive to neutrons of different energies, and so changes in energy distributions can also be determined if multiple foil types are used.

CURRENT AND FUTURE R&D PROGRAMS

Current programs in the ZED-2 Research Reactor include providing high quality measurements of criticality and flux to support Canada's involvement with the OECD NEA International Reactor Physics Experiments Evaluation Project and International Criticality Safety Benchmark Evaluation Project. In addition, the reactor is currently being used to calibrate self-powered flux detectors for power stations around the world.

Future work in the ZED-2 is likely to include thorium fuel measurements in support of the Thorium CANDU Reactor initiatives, additional lattice physics measurements for the EC6 reactors, additional self-powered flux detector calibrations, and strengthening collaborations with industry academics.