The History of WR-1

1965 to 1985

Why, What, and When?

Setting the Scene

- 1945- ZEEP was started up at Chalk River as the first critical assembly outside the USA
- 1947-NRX was started up. Isotope production, material irradiation, neutron experimentation.
- 1952-NRU was started up. Plutonium production plus chores similar to NRX.
- 1962- NPD, Canada's first power reactor, was started up.

Why WNRE?

- AECL decided that future expansion would not take place at CRNL.
- AECL was in the throes of developing and assessing three competing CANDU Power Reactor concepts.
  - Heavy water moderated and cooled, pressure tube reactor.(NPD and Douglas Point)
  - Heavy water moderated, boiling light water cooled, pressure tube reactor(Gentilly 1)
  - Heavy water moderated , organic cooled, pressure tube reactor .(The future WR-1).

Why WNRE?

- A cabinet member of parliament from Manitoba convinced his colleagues that Manitoba was the logical place for AECL expansion.
- The chosen site had good quality and quantity cooling water and was appropriately isolated from populated areas.

WHY WR-1?

- Organic coolant was chosen that would operate at higher temperature and lower vapour pressure than water coolant.
- Lower pressure means thinner walled pressure tubes.
- Thinner walled pressure tubes means lower neutron capture.
- Lower neutron capture means higher neutron economy.

Why WR1?

- The American program was considering the development of reactors using an organic coolant.
- The Americans were interested in working with AECL in the design and construction of a prototype reactor.
- The Americans were operating a prototype pressure tube reactor at their reactor test site near Idaho Falls.
- The Americans had a Pressure Vessel Organic Cooled Reactor under construction at Piqua, Ohio.

Why WR-1?

- AECL was operating an organic cooled loop (X-7) in the NRX Reactor that was providing useful information re the irradiation of Uranium Carbide fuel and the decomposition rates of organic coolants.

Some of the ????

- Decomposition rate of the coolant.
- Fuel design.
- Flammable coolant.
- Can you operate a leak tight coolant system having many mechanical pipe joints and rotating pump seals.
- Would a leak result in unacceptable fires.
- Radiation fields resulting from fuel failures.

WR-1 Design

- CGE won the contract to design and build WR-1 for $14.5 Million.
- Del Tegart was assigned by AECL to oversee the design at CGE's Peterborough offices.
- Del enlisted Art Summach to assemble the initial operating crew at Chalk River who took responsibility for approving the design of the various reactor systems and wrote the Commissioning and Operating Manuals.

WR-1 Design

- The reactor was to be a vertical pressure tube reactor.
- 54 pressure tubes connected to 3 independent cooling systems.
- Each cooling system had its own pump, heat exchanger and purification system.
- Reactor power approx. 60MWth.

WR-1 Design

- Pressure tubes were to be installed in a relatively thin walled pressure vessel which would contain the heavy water moderator.
- Reactor reactivity and power to be controlled by varying the moderator level.
- Emergency shutdown to occur by rapidly dumping the moderator.

WR-1 Design

- Reactor coolant purification was accomplished via a side stream which passed coolant through columns containing Attapulgus Clay followed by a filter.
- Start-up coolant was to be an hydrogenated terphenyl supplied by Monsanto called HB-40.
- This coolant was liquid at room temperature to facilitate initial start-up and reduce the need for trace heating all lines.
- HB-40 was expected to have uneconomic coolant disintegration rates at full power and temperature.
- Plan was to replace the coolant after a successful start-up was accomplished with a coolant having lower decomposition rates which would result in it solidifying at room temperature.
- Initial operation with HB-40 indicated lower than expected decomposition rates so this change was never made.

WR-1 Design

- Uranium Carbide fuel was chosen which provided:
  - improved performance over UO2 fuel at high temperatures.
  - low release of fission products in case of fuel sheath failure.

WR-1 Design

- Coolant distillation system was to be supplied which would:
  - distill batch quantities of coolant to remove high boilers.
  - thereby maintain coolant high boiler levels at a low enough level to prevent freezing at room temperature.

WR-1 Design

- A ventilation stack and tank (stank) was provided to:
  - exhaust reactor and building ventilation air.
  - store cooling water to be used in the event of failure of the main cooling water system.

WR-1 Design

- An emergency coolant injection system was provide to:
  - contain 50,000 lbs. of reactor coolant.
  - inject this coolant into the primary cooling system in the event of a line break or large leak.

WR-1 Design

- The reactor building was a normal industrial type building designed to contain normal ventilation air.
- In the event of a severe internal pressurization the walls were designed to blow off rather than damage the support structure.

WR-1 Construction

- Construction began in 1963 and was completed in 1965, on time and at the original price.
- CGE was responsible for the reactor construction and Shawinigan Engineering for the building.

WR-1 Operation

- First critical achieved Nov.1 1965.
- Reached full power by January 1966

WR-1 Operation

- The reactor originally contained 2 independent coolant circuits (A and B) each containing 17 pressure tubes.
- AECL was responsible for operation of the A Circuit and an American consortium led by Atomics International provided staff to oversee the operation of B Circuit. (this continued for several years till the US Federal Budget cut all funding for organic reactor research.)

WR-1 Operation

- The “C” coolant circuit was constructed and put in service at a later date as well as two organic cooled loops and one light water cooled loop which were used primarily for fuel design experiments.

WR-1 Operation

- The reactor was successful in proving that the concept was a viable prospect for future power reactors and that the fuel and coolant could be operated at outlet coolant temperatures up to 450˚C.

Unusual Events

- Aside from the occasional fuel failures which were easily handled and did not severely contaminate the system, there were three major incidents worth mentioning.
    1. The failure of a large isolating valve on the cooling water line feeding the main Heat Exchanger for the "A" Circuit.
    2. The catastrophic failure of experimental fuel bundle 913.
    3. The failure of a tube in one of the main heat exchangers which resulted in the leakage of approx. 2000 litres of organic coolant into the Winnipeg River.

Unusual Events

- The failure of the cooling water valve resulted in the flooding of the lower level of the reactor building with Winnipeg River water up to a height of approximately 8 feet. Thankfully nobody was hurt even though the valve failed while being operated by one of our operations foremen.

Unusual Events

- The 913 experimental fuel bundle failed on reactor start-up after its installation.
- Released sufficient gamma emitting fission products into the coolant system to require the shutdown of the reactor for 6 weeks in order to remove the contaminants and / or allow them to decay to reduce the fields in the operating areas of the building to a suitable level.

Unusual Events

- The release of coolant into the Winnipeg River prompted immediate action to determine that the organic coolant concentration in the river water diminished to negligible levels in a short distance from the point of release as did the radiation contamination levels.

An Interesting Sideline

- The spent fuel from the reactor was originally sent to the US for extraction of the Plutonium.
- When this became politically incorrect, there was the need to find a way to store this fuel outside the reactor.
- This resulted in an experimental program to store irradiated fuel in canisters and resulted in the building and use of the first fuel storage canisters just to the east of the WR-1 building.

The Full Scale Prototype

- AECL designed a full scale organic cooled prototype power reactor for evaluation by Ontario Hydro as to whether they should change from building and operating PHWR reactors to an OCR (Organic Cooled Reactor).
- The design evaluation indicated that an OCR could be built for 10% less and with an annual operating cost of 10% less than the existing PHWR.

The Full Scale Prototype

- Ontario Hydro very seriously analyzed this prospect and concluded that the logistics associated with training operators and developing the resources to supply equipment and construct an OCR would likely result in additional costs exceeding the expected capital and operating cost savings.

Why Continue with WR-1?

- The experimental loops were providing valuable research material.
- Research into the Thorium Fuel Cycle was well underway and relying on experiments using the WR-1 core.

Why Shutdown WR-1?

- Nuclear Power programs were cutting back reducing the immediate need to develop an alternative fuel cycle using Thorium.
- ???