LEADIR –PS100

Something Old – Something New

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By

Ralph S. Hart

Engineering Manager

Northern Nuclear Industries Incorporated

LEADIR –PS100

Something Old – Something New

LEADIR-PS is an acronym for:

LEAD-cooled Integral Reactor - Passively Safe.

Something Old: Graphite moderator, TRISO fuel and Lead coolant, all with significant reactor operating experience.

Something New: the novel combination of proven elements in an advanced thermal reactor.

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LEADIR-PS100 has an output of 100 MW_{th}

- Initial market focus is the Canadian Arctic and Western Canadian Oil sands.
- The small LEADIR-PS100s, while meeting market demands, will serve as demonstration pants.
- The creep, crawl, walk, run approach is adopted.
- Future LEADIR-PS reactors may have larger capacity, higher temperature capability, operate on a Thorium fuel cycle.

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LEADIR-PS Design Requirements

Comprehensive design requirements focused on safety, economics and minimizing development were defined which resulted in high level requirements including:

1. Production on a modern assembly line.
2. Capable of remote unattended operation, with 3000MW_{th} minimum operated from a central facility.
3. Have maintenance and refuelling services provided by specialized crews deployed from central locations.
4. Have security and surveillance provided by existing or modestly enhanced organizations.
5. Facilitate siting within conventional facilities in populated areas (below large parking garages, etc.).

Why LEADIR-PS?

- An integral pool reactor employing a high boiling point coolant is necessary to meet the design requirements.
- Extensive studies of most prior reactors including the HTGR, the MSRE, and Hallam were completed.
- MSRs can potentially meet requirements but they have challenges requiring extensive development.
- The integration of Hallam and HTGR technologies utilizing ^{208}Pb coolant offers a viable **near term** energy solution requiring minimal development.

Coolant Selection

- Acceptable coolants identified are molten salt, lead (^{208}Pb), and ^{208}Pb-bismuth eutectic with melting points of 354 ^{o}C, 327 ^{o}C and 125 ^{o}C respectively.
- Bismuth is corrosive and yields Polonium, a neutron and alpha emitter, when in a high neutron flux.
- Bismuth, ^{208}Pb and molten salt have acceptably low thermal neutron capture cross-sections.
- ^{208}Pb does not react with water, graphite or air.
- ^{208}Pb avoids a requirement for an intermediate circuit

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LEAD Coolant

- Lead utilized in Russian Fast Breeders and Lead-Bismuth in Russian Alfa Class submarine reactors.
- ^{208}Pb has a very high boiling point (1750 ^{o}C).
- ^{208}Pb has excellent thermo-hydraulic characteristics, including high heat capacity.
- Lead is plentiful and low cost.
- Prior to use in LEADIR-PS100,
  - The lead is purified
  - The ^{208}Pb isotope is separated, and
  - The ^{208}Pb is conditioned to LEADIR-PS requirements

Graphite Moderator

- Has a long history in reactor operation (MAGNOX, AGR, HTGR, RBMK, more).
- Has a strong negative reactivity temperature coefficient.
- Is an excellent and efficient moderator.
- Has a very high temperature capability.
- Has a high Heat Capacity.
- No reaction with ^{208}Pb at high temperature.

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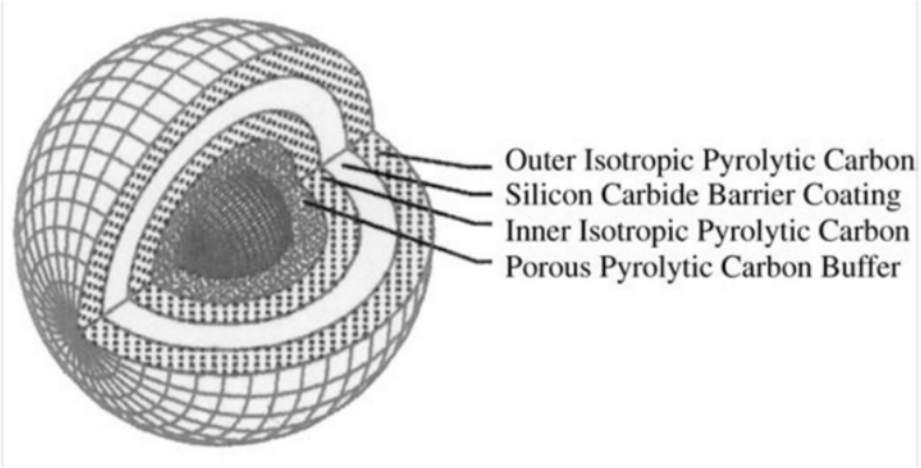
TRISO Fuel



- Dragon Project technology advanced by Germany and US.
- Main benefit is the retention of fission gas and radionuclides within the Silicon Carbide layer.
- Maintains containment integrity to above 1600 ^{o}C
- Currently produced by Japan and China.

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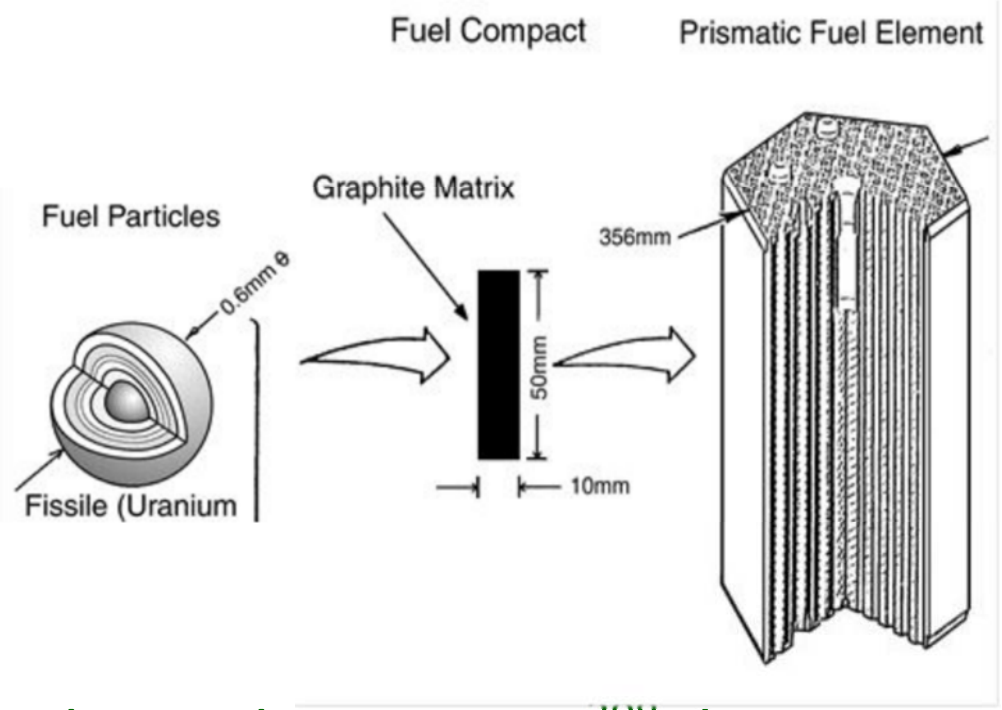
Reference Core

- Prismatic: Fuel blocks contain TRISO Fuel and Coolant passages.
- Axial and radial Graphite reflector blocks.



- Fuel and reflector blocks are buoyant in ^{208}Pb.
- Pebble Bed core has advantages for large LEADIR-PS reactors.

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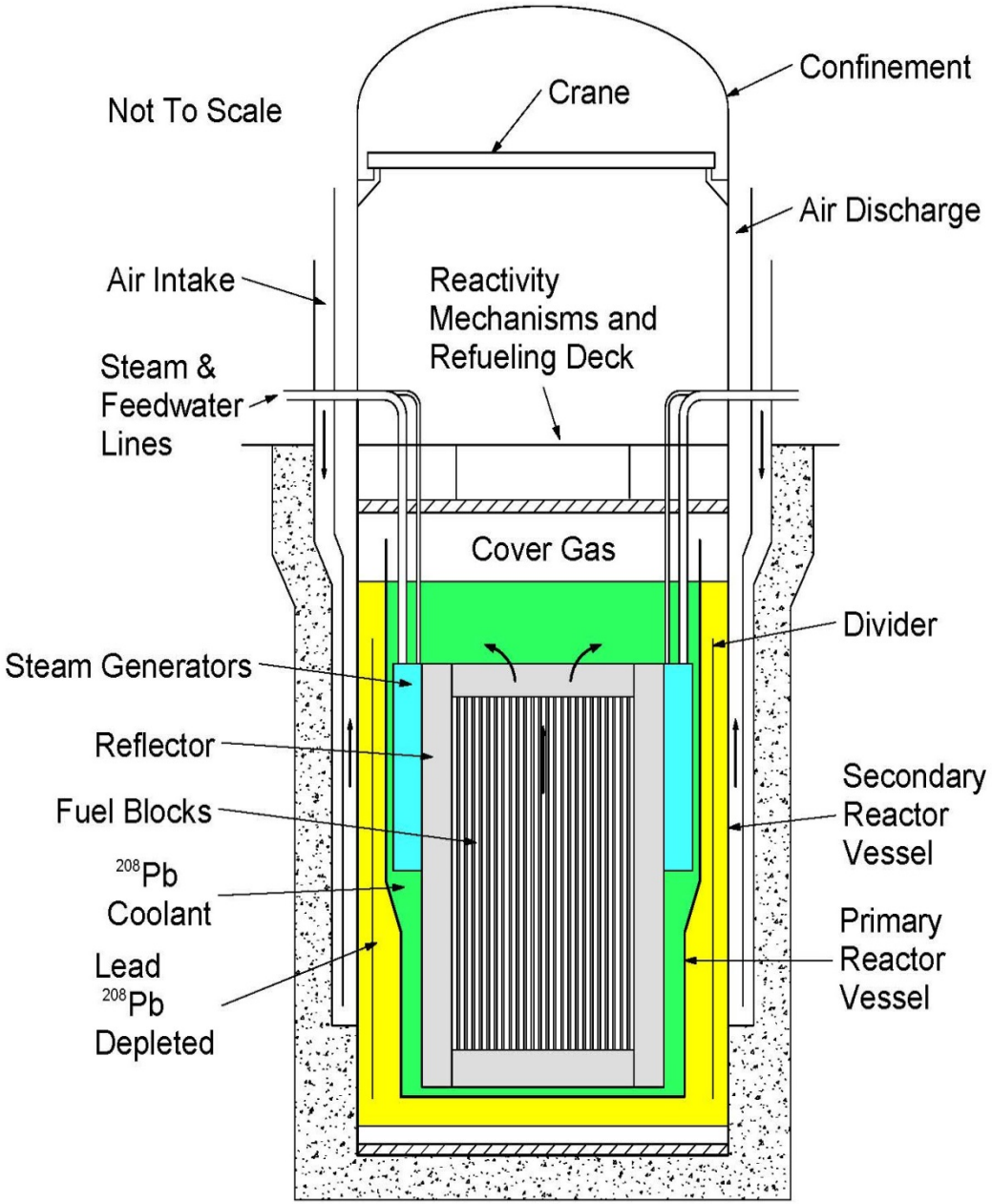
LEADIR-PS100 Reactor Configuration

Core Inlet - 360 °C

Core Outlet - 560 °C



Reactor Control and Shutdown

- Control rods & Shutdown Rods operate in the reflector.
- Control rod assemblies are driven in and out (electric stepping motors).
- Shutdown rods (SDRs) drop by gravity with initial spring assist (CANDU concept).
- Safety system initiation of SDRs is backed up by a passive initiation system.
- Shutdown via negative temperature reactivity coefficient as a last resort.

Safety Overview

- **Lead Coolant**: high temperature capability and no chemical reaction with graphite, water or air.
- **Graphite Moderator:** provides inherent shutdown capability and structural capability at high temperature.
- **TRISO Fuel:** Radionuclide retention at high temperature.
- **Integral Pool Configuration**: Avoids concerns over high energy pressure vessel/pipe rupture, simple, and relatively low cost .

Safety Overview Continued

- **Passive Shutdown System:** SDRs drop by gravity, passive backup initiation.
- **Assurance of core submergence:** The core remains submerged in lead even if both the primary and secondary reactor vessels fail.
- **Passive decay heat removal:** Assured for all credible events for an indefinite period of time.

Challenges

- Technical challenges can be met with reasonable effort and sound engineering.
- The difficult challenge is the Regulatory. Unless Regulatory bodies recognize and credit the features unique to small reactors such as LEADIR-PS100, commercialization will not be realized by any small reactor.
- Hence there must be a focus on communication with the Regulatory agencies (CNSC in Canada).

Summary

LEADIR-PS100 meets safety and economic design requirements and provides a near term nuclear solution to target market energy demands.

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Meeting tomorrow's energy needs.

Thank You