Australian Government

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ANSTO Synroc Wasteforms and processing technology for the immobilization of Mo-99 production wastes

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ANSTO Synroc

Science. Ingenuity. Sustainability.

Vision

Be the worlds number one solution provider for the immobilisation and termination of intractable nuclear wastes.

Synroc

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ANSTO Synroc Capability

ANSTO Synroc is expert in developing technology solutions for intractable nuclear wastes

Ability to develop solutions that range from wasteform design and validation through to process conceptualization, design and demonstration testing, storage, transport, and final disposal

A multidisciplinary team which uses a systems integration and risk mitigation approach to develop tailored solutions

Laboratory to pilot scale engineering including integration, automation, and high-fidelity surrogate testing for active environment

Active handling at an industrially relevant scale

Outline

- Brief overview of ANSTO Synroc
- NECSA collaboration
- ANM and the SyMo Facility

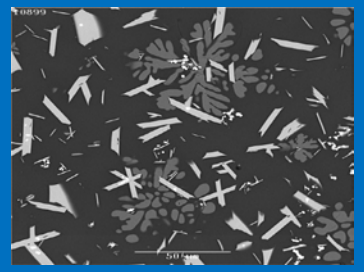
Candidate Waste Forms

Ceramic

- HLW / ILW
- Lattice substitution
- 10^{-5} g/m²/d

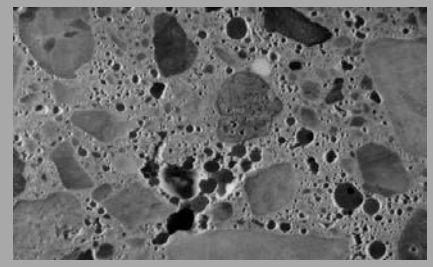
Glass

- HLW / ILW
- Glass network incorporation
- 10^{-3} g/m²/d



Glass Ceramic

- HLW / ILW
- Composite glass-ceramic
- Elements targeted to either ceramic or glass
- 10^{-3} -10^{-5} g/m²/d



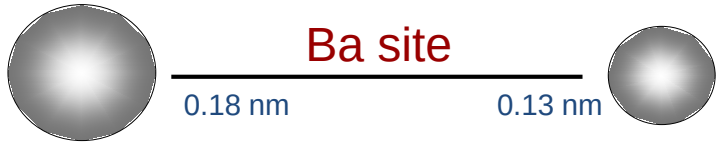
Cement

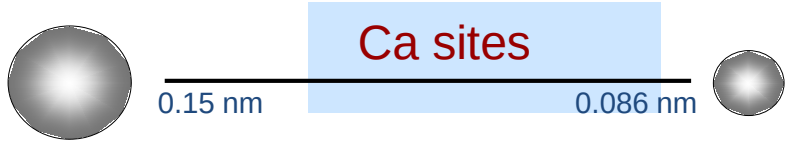
- LLW
- Continuous porosity
- Diffusion release
- Waste ions located in pore water

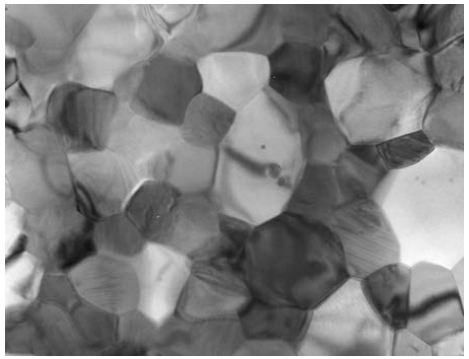
- Mix the waste with selected additives to make solid material that is relatively insoluble in water
- Major HLW waste forms that can immobilise the full range of FPs + actinides are glass, synroc, and glass-ceramics
- Long-lived in Nature
- Cementitious products for less active wastes

ANSTO Synroc Waste Form Development

- Radionuclides enter into solid solution in the mineral phases as a result of appropriate formulation design and processing conditions







Zirconolite
Pyrochlore
Perovskite
Hollandite

3+ *Actinides* *4+*

ANSTO Synroc – HIPing

Benefits from HIP route:

- Minimal emissions from high temperature densification
- Significant waste volume reduction (impact on long term storage)
- High density with minimal temperature (grain size)
- Versatile - Capable of producing a wide range of waste forms
- No contact between waste and process equipment – No melter required

ANSTO Synroc – CAN Design

- Integrated HIP CAN Design
  - Storage / final disposal
  - Waste form
  - HIP process

ANSTO Synroc – NECSA Project

Source Funding

- Funded by the U.S. Department of Energy's (DOE) National Nuclear Security Administration (NNSA)

Project AIM

- Demonstrate to existing Mo-99 stakeholders (producers and regulators) that there are technically viable and economically feasible means of addressing global challenges associated with wastes derived from Mo-99 production
- Address the waste treatment objectives of the Mo-99 producers
- Address NNSA's non-proliferation objectives

ANSTO Synroc – NECSA Project

Task	Deliverable	Completion
1	Feasibility review of immobilization and disposal of generated waste streams	August 2014
2	Consolidated demonstration report on encapsulation technologies using surrogate residue	April 2018
3	Assessment report on selection of encapsulation technologies	
4	Consolidated demonstration report on down-selected technologies with radioactive residue	
5	Integrated view and cost analysis report	
6	**Final report**	

ANSTO Synroc – NECSA Project

Task 1. Feasibility review (Desktop Study)

- Identification and description of all waste streams resulting from fission Mo-99 production
- Nuclear waste form candidates for the immobilization of waste streams from fission-based Mo-99 production
- Proposed generic waste acceptance criteria for waste forms used to immobilize waste from Mo-99 production
- Preliminary screening and recommendations made for waste forms for various waste streams

ANSTO Synroc – NECSA Project

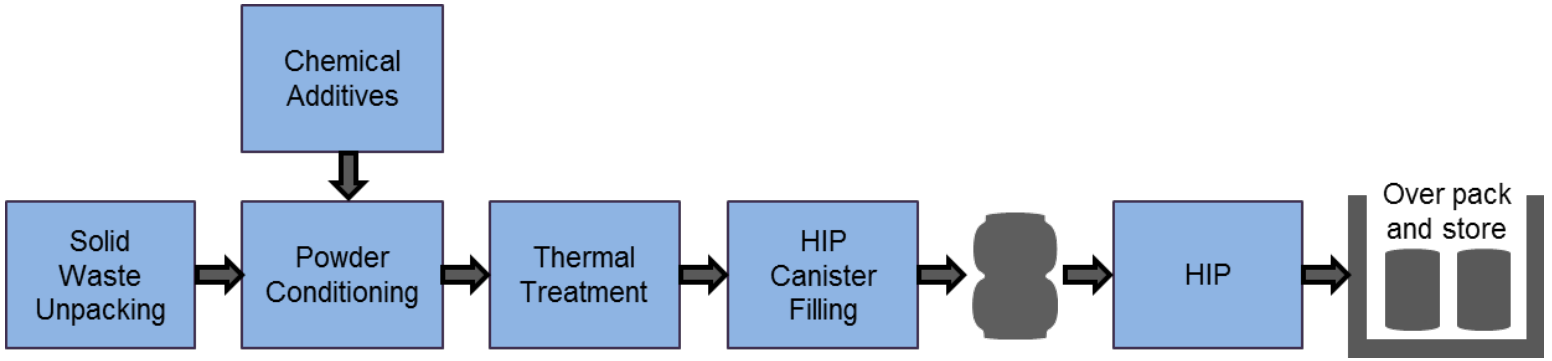
Task 2. Demonstration of Selected Technologies (surrogate material)

- A range of waste treatment technologies to immobilize the in -scope waste streams were prepared, characterised and evaluated against the pre-established performance criteria.
  - ~100 laboratory scale samples (~50 g scale)
  - ~20 larger scale samples (up to 6 kg)
  - A range of glass-ceramic and glass candidate wasteforms demonstrated to pass all performance requirements

ANSTO Synroc – NECSA Project

Task 3. Engineering feasibility of down-selected options

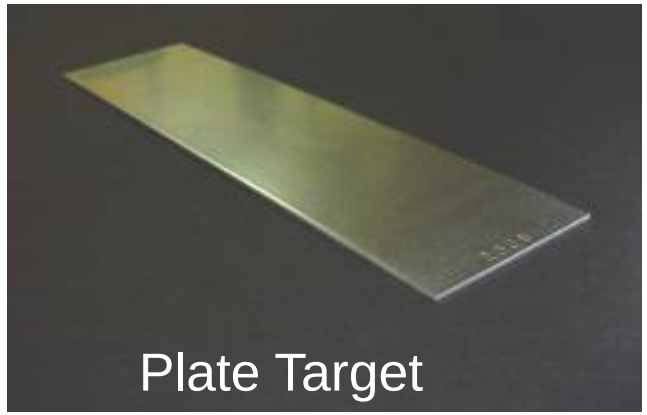
- Technological risk
- Industrial scalability, maturity (technology readiness) and deployment requirements
- Ability of technology to treat all wastes in question
- Criticality and proliferation issues
- Waste throughput and secondary waste streams generated

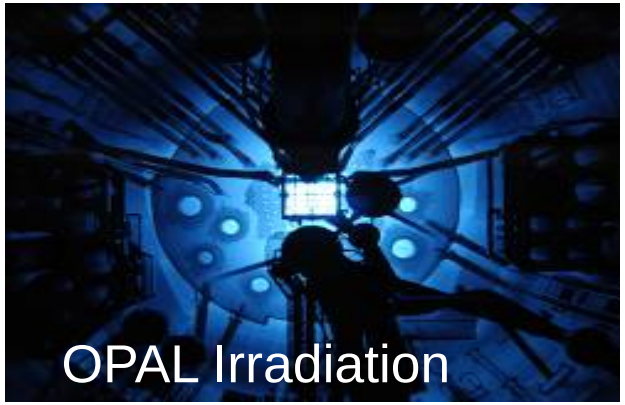


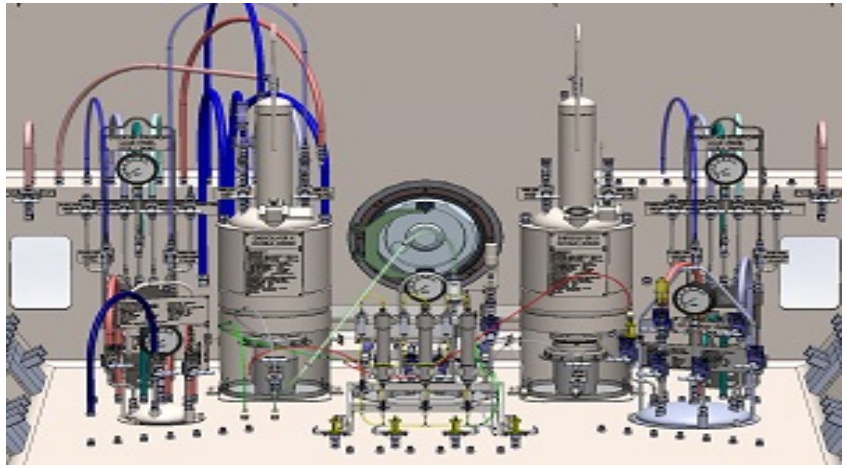
ANM and the SyMo Facility

https://www.watpac.com.au/project/ansto-nuclear-medicine-facility/

ANM Production Cycle





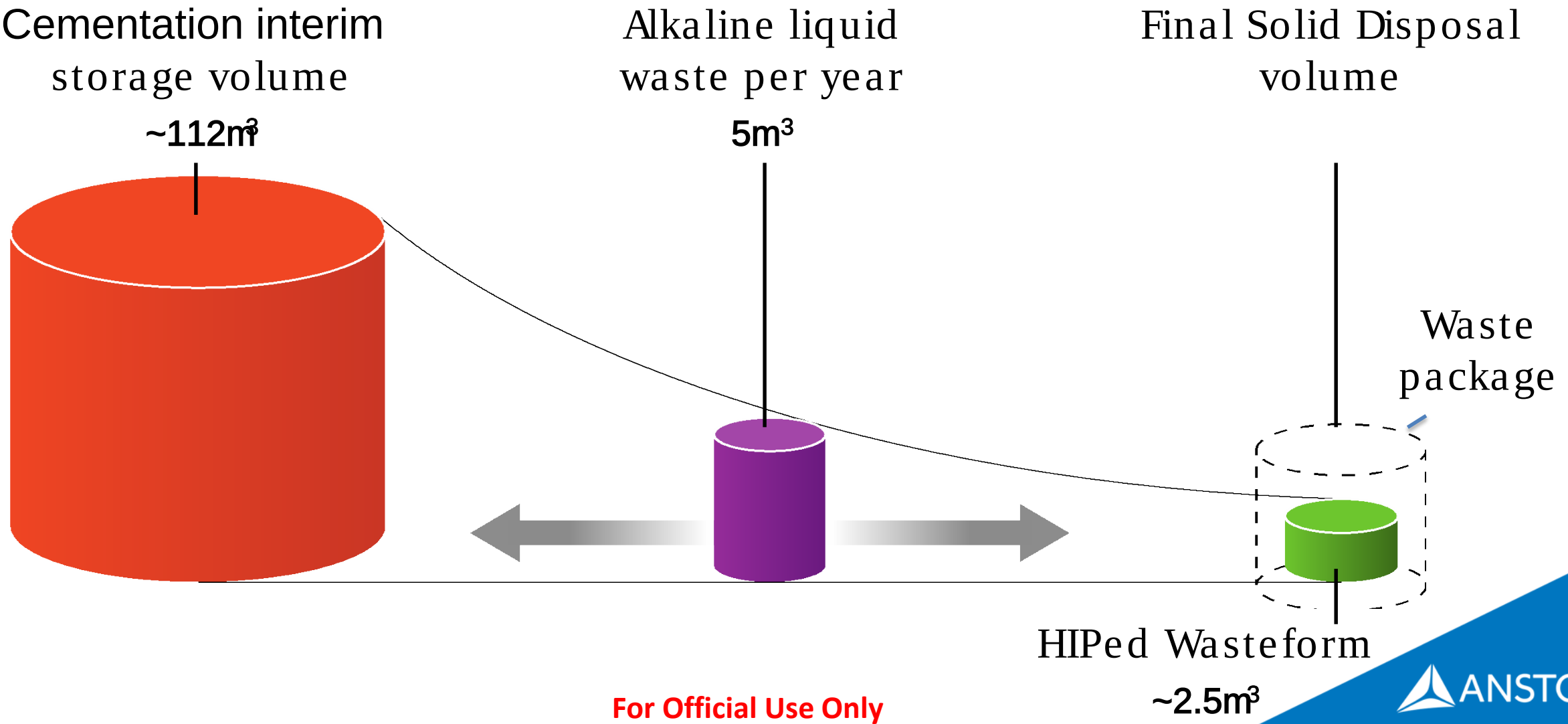


Dissolution, Filtration and Initial Ion-exchange Purification: ILLW

Synroc Intermediate Level Liquid Waste Treatment Plant (SyMo Facility)

~5000L/ yr of ILW to treat

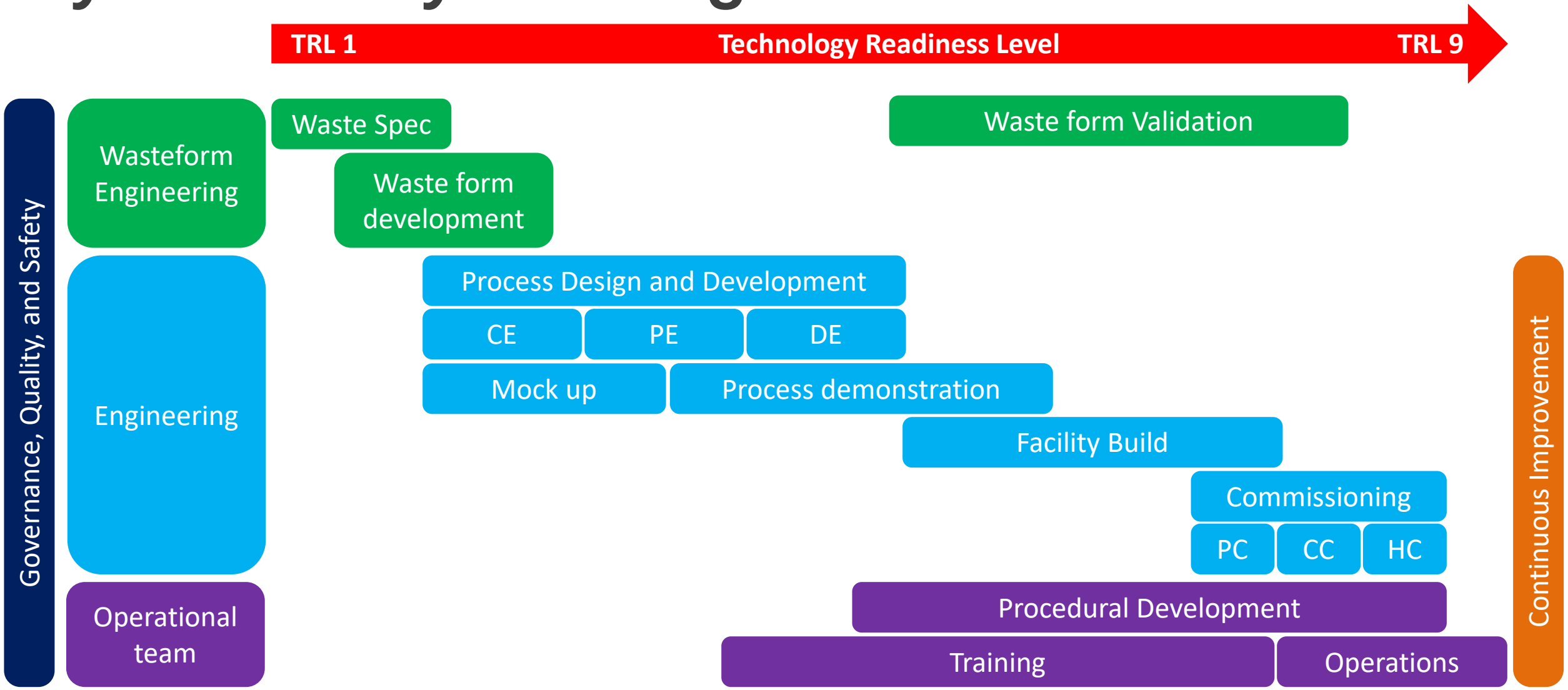
A Synroc Advantage



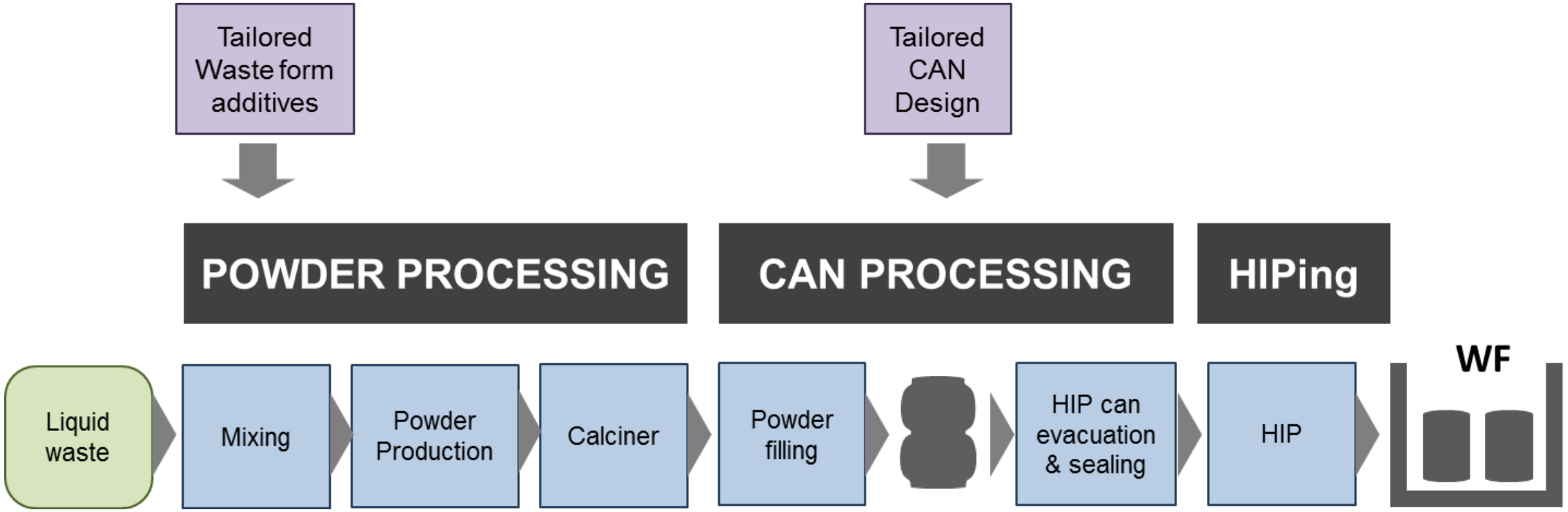
Evolution of ANSTO Synroc

- **For the delivery of a project such as the SyMo Facility ANSTO Synroc changed:**
  - A strong engineering focus
    - Risk based approach - identify, verify, mitigate, validate (safety in design)
    - Systems Engineering and Integration approach
    - Nuclearisation of proven process technologies
  - Process validation from waste through to wasteform
    - Demonstrate and validate prior to deployment within SyMo, i.e., Mock-up, Demonstrate, and Deploy technology
- **A significant objective of the Project**
  - Train and develop the next generation of young Nuclear Engineers within Australia

SyMo Facility - Design Process



Process Conceptualisation



ANSTO Synroc - Demonstration Plant

- Demonstrator at engineering scale equivalent to final plant with remote operation .
- Mitigate risks associated with **F.O.A.K** nuclear plant, e.g., process integration risk
- Powder processing - Test and validate inputs for the final plant design
- Critical CAN processing stages will be mocked-up as mechanical process steps to validate the design for the final plant
    - Operational window for process
    - Process performance
    - Product specification
    - Train plant operators and maintainers

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ANSTO Synroc - Demonstration Plant

ANSTO Synroc - Demonstration Plant

Conclusion

- Collaboration with Necsa (NNSA funded) to establish cost estimates for Mo-99 production wastes
- The 'SyMo' Facility (Synroc-Molybdenum) will operate a world first process line utilising a fully integrated HIP based technology
- Demonstration plant is key to increasing TRL for deployment
- Project status:
  - Demonstrator is in operational phase
  - Stakeholder engagement commenced for disposal (NRWMF)
  - Detailed engineering/ design of hot-cell structure and building
  - Construction commenced
  - Target- operational licence in 3 years

Acknowledgements

ANSTO Synroc Team

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- ANSTO Nuclear Medicine P/L
- Engineering & Capital Projects team
- Safety & Systems Reliability
- Waste Operations (Operational Readiness team)

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SyMo Facility status

Construction commenced: July 2018

ANSTO Synroc SyMo Facility design