DESIGN CONSIDERATIONS FOR HIGH-PERFORMANCE RESEARCH REACTORS

N.P.G. DE LORENZO

delorenzo@invap.com.ar

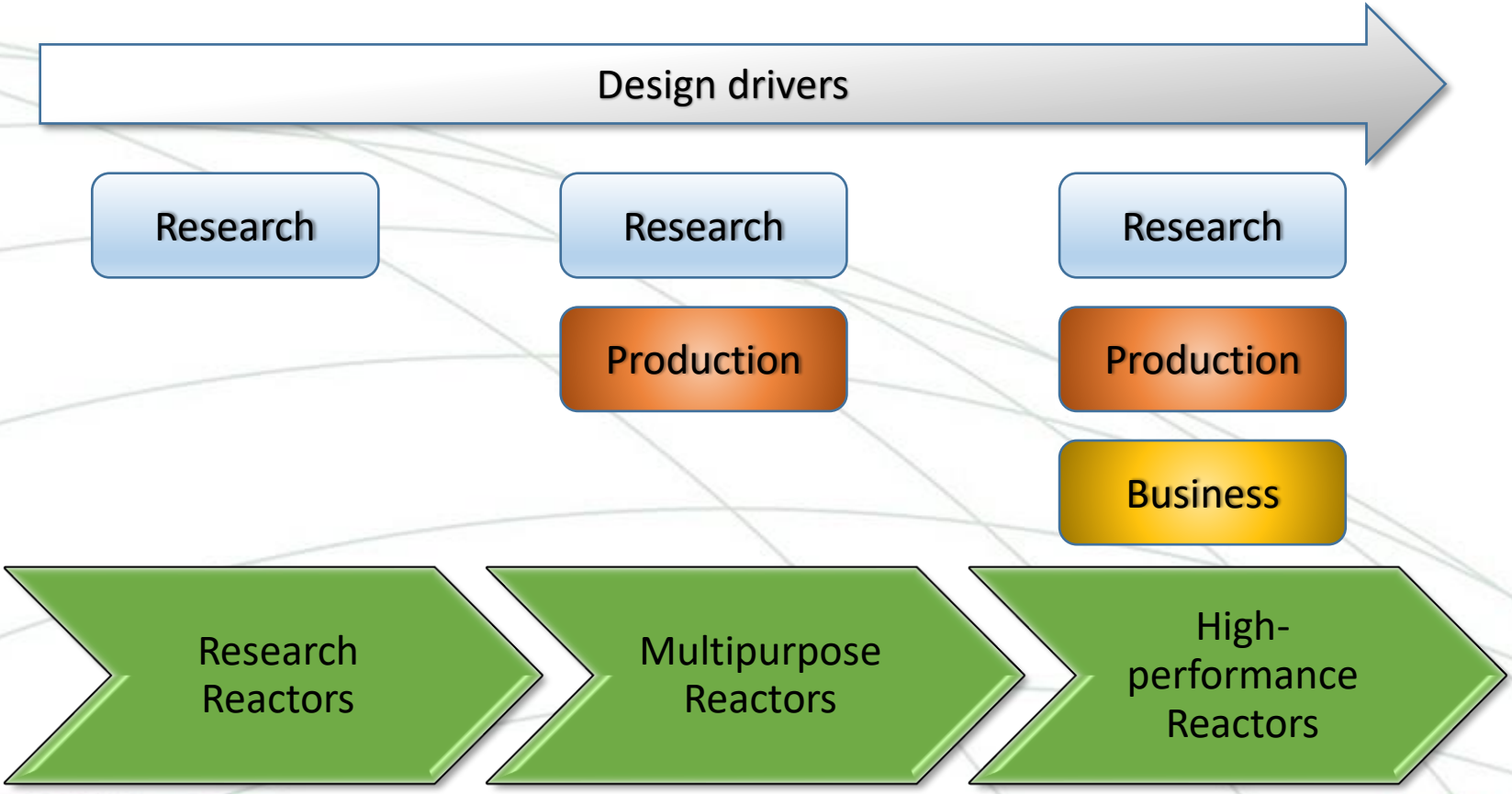
Nuclear Projects Department, INVAP

Luis Piedrabuena 4950, R8400 Bariloche - Argentina

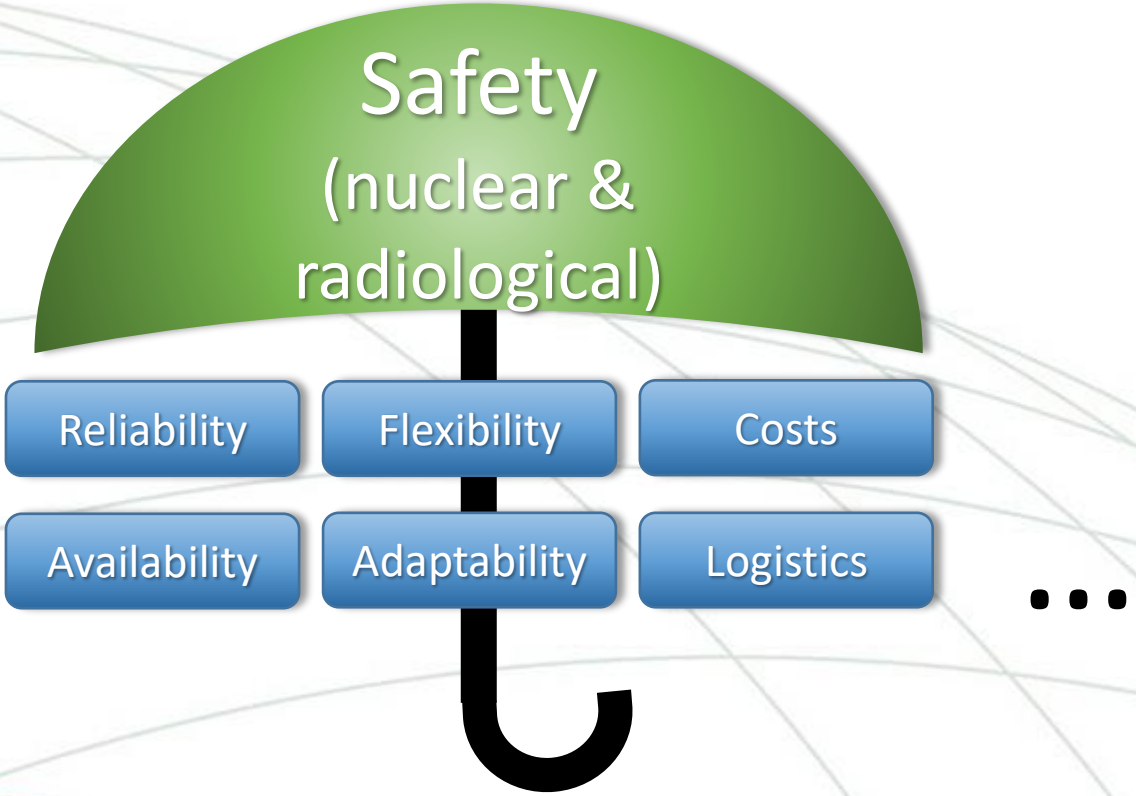
TRTR-IGORR Conference
June 2023

INVAP

Introduction



Focal areas revisited in the design



Issues on nuclear safety

- Increasing probability of some Postulated Initiating Events (PIEs):
  - Frequent modifications on the core's reactivity:
    - Targets loading/unloading
    - In-pile experiments modifying fuel/moderator ratio
  - Frequent changes in the cooling regimes:
    - Irradiation rigs loading/unloading disturbing the core cooling
    - Variable configuration of irradiation positions redistributing the total cooling flow
    - Cooling of targets after irradiation
- Introduction of new PIEs:
  - Mainly new *internal* PIEs
  - Several of them associated to the transport of heavy containers inside the facility

Issues on radiological safety

- Additional doses on the staff due to the increased number of targets being handled.
- New manoeuvres requiring the proximity of the operator:
  - Closure of transport packages (bolting, sealing, etc).
  - Testing and clearance (radiological and security).
  - Final packaging and labelling.
- Accumulation of loaded containers in storage awaiting for the transport vehicle.
- Contamination introduced by the empty casks coming from the clients' facilities (contamination surveys are commonly installed in the exit but not in the access to the facility).

Issues on “abilities”

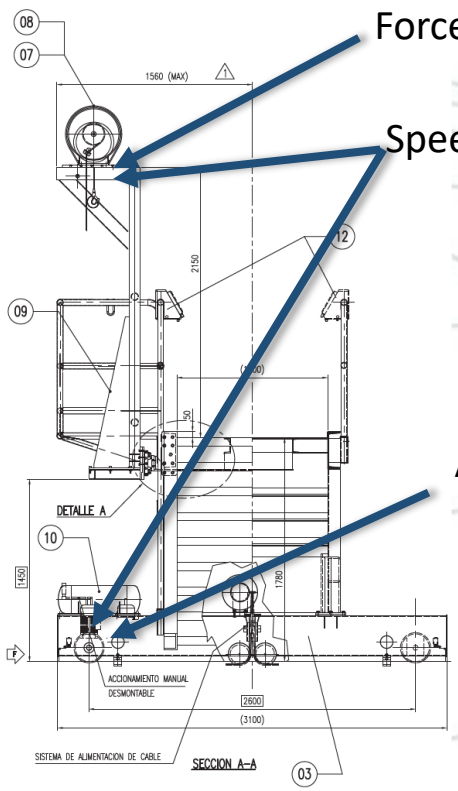
- Reliability and availability are to be extended to the SSCs related with the logistic chain such as:
  - Truck access gate (bottle neck in the production)
  - Lifting/transport devices
- Flexibility: the facility shall be able to adjust the production levels to the market’s demand with marginal impact in the quality and cost of the products.
- Adaptability: the facility shall be able to develop and elaborate new products including the preparation of targets for irradiation and the post-irradiation processes.

Issues on production costs

- Fuel supply and staffing are important factors to be considered.
- Additional costs attributable to the higher production rates should be controlled and potentially covered by the revenues.
- Market prices are influenced by the availability of other facilities.
- Logistics costs are dependable on the engineering solutions implemented which are influenced by the consumers interfaces.

Engineering solutions

Reactivity control of irradiation facilities

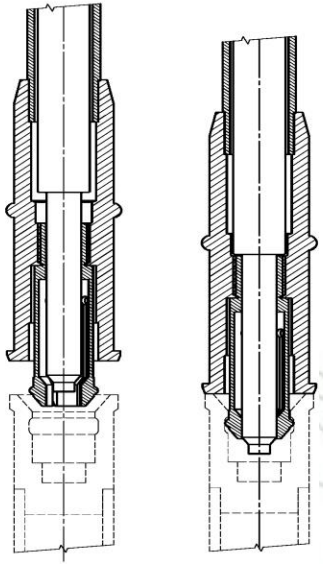


Force limiter

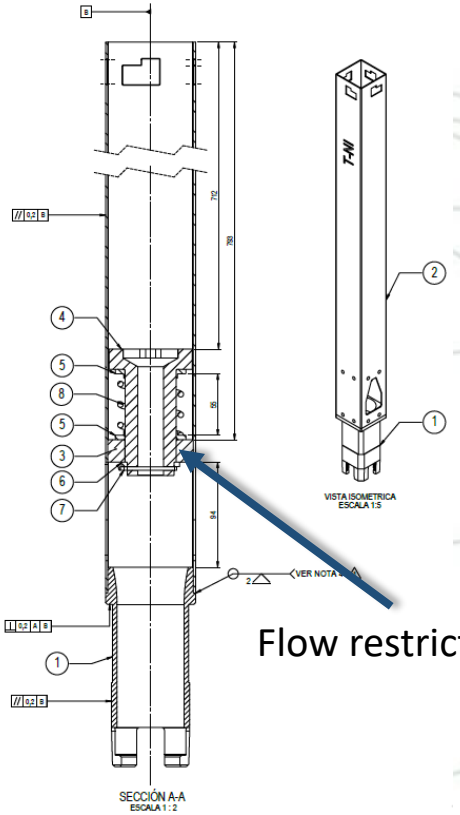
Speed limiter

Accurate positioning devices & sensors

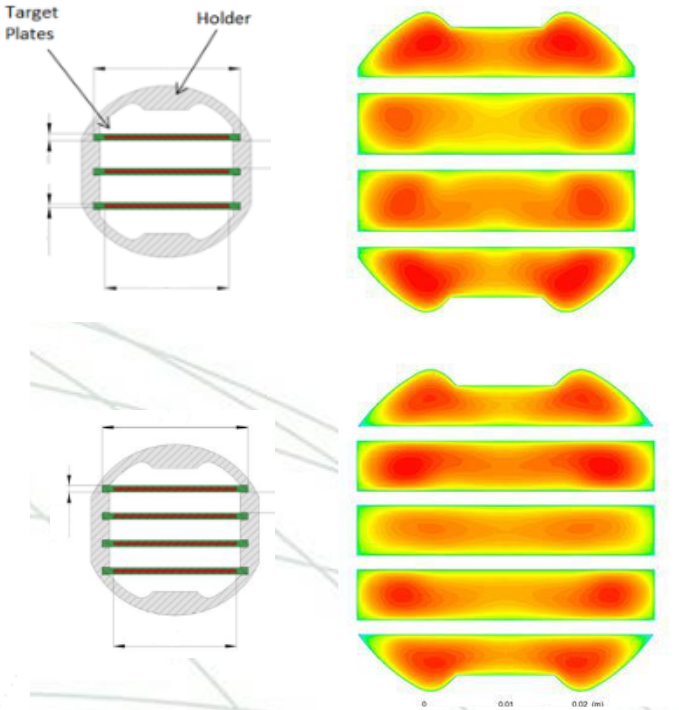
Lifting devices with safety lock



Cooling of targets and rigs



Flow restrictors



Variable number and types of targets

Transport casks related solutions

- Lifting devices featuring protective systems such as double breaks and cables in production areas.
- Additional protective structures for limiting the zones where the casks may drop or distributing the impact forces in larger areas and absorbing the energy of the impact.
- Reinforcement installed around sensitive SSCs.
- Reservation in the layout of dedicated areas where casks are loaded and handled.
- Dedicated transport devices (smaller intermediate transfer casks, transfer hot cells, pneumatic transport systems or conveyor belts)

Maintenance features

- Maintenance tasks can be facilitated by:
  - Shielding design ensuring the in-service accessibility to maintainable SSCs.
  - Modular system design for easy replacement in case of failure or for preventive maintenance.
  - Additional instrumentation for predictive maintenance.
  - Increased replacement scheme of SSCs before reaching its mean time between failure.

Radiological aspects

- Remote operations and automation in the dispatching of the loaded transport containers, for example:
  - Bolting the shielding lids
  - Testing airtightness and external contamination
  - Final packaging (shock absorbers, overpackaging, etc.) and labeling
- Hot cells design including robotics (MSMs).
- Layout contributing to the reduction of the staff exposure by providing proper separation between production streams thus preventing the doses from one line to operators working in another.

Flexibility considerations

- Flexible production volume:
  - Rigs managing different number and types of targets maintaining the neutronic and thermohydraulic characteristics (as previously seen).
  - Flux flatteners, dummy irradiation rigs, spectra conditioners, cooling flow regulators and other technical solutions available from Multipurpose Research Reactors' designs.
- Flexibility in the logistic chain:
  - Features for docking and handling transport containers of different types and sizes.
  - Storage areas dimensioned for storage of unused equipment.
  - Redundant lifting and transport devices for coping with peak production levels.

Adaptability considerations

- Reconfigurable irradiation positions in terms of volume and neutron spectra (including gamma contamination suppression).
- Configurable reflector positions preferable decoupled from the core in terms of neutronic parameters.
- Feasibility for redesigning and replacing core components in major scheduled overhauls.
- Feasibility for redesigning and replacing some SSCs by completely new ones designed specifically to future new requirements.
- Replaceable or adaptable hot cells for handling new processes (including radiochemistry).

Consideration on costs

- Improved fuel economy by defining an appropriate operation cycle length and discharge burnup compatible with the fuel design.
- Staffing of the production related activities (including hot cells' operations and other tasks requiring specific accreditations).
- Speeding up delivery times thus minimizing the radioactive decay of products.

Conclusions

- The concept of High-performance Reactors is reflected in projects currently being tendered and under design where a business case has been developed for establishing the technical specifications in a notional manner rather than fixing relevant parameters.
- From the designer's viewpoint these flexible technical specifications provide an excellent opportunity for engineering solutions such as the ones depicted in this presentation.
- Both, value engineering techniques and logistics considerations, are now to be also applied to the design of SSCs related with the processing of the production after its irradiation for ensuring the clients' satisfaction (and associated revenues) as well as maintaining the nuclear and radiological safety levels currently achieved by RRs and MPRs.

Thank you!

Questions to: delorenzo@invap.com.ar