Deliverable C – Design Criteria

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Abstract

This report builds on the previous analysis of client constraints by defining the design criteria for the device. It outlines key considerations such as material selection, weight, cost, and dimensions, ensuring the design meets functional and safety requirements. Additionally, commercially available models are evaluated for their effectiveness, highlighting areas for improvement. This analysis establishes a foundation for optimizing the device while maintaining feasibility and compliance with industry standards.

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1-Introduction

In engineering design, establishing clear criteria based on the needs of the client is essential for having a final product that is optimized and effective. This report focuses on the design criteria received based on the client meeting with CNL and on benchmarking products that have similar objectives and setting target specs, which will guide the development of a successful product. Benchmarking allows the project to have realistic yet competitive target specifications that meet the level of quality of already existing designs in the industry. This process involves analyzing existing designs, identifying the pros and cons of each design, and determining what aspect needs to be different in the new design. This approach ensures a final design that meets both the technical and practical needs of the client while maintaining efficiency, feasibility, and innovation.

2-Design Criteria

To meet the client's needs for this project, we must satisfy the following requirements in order of importance.

#	Need	Design Criteria
1	Must be Safe (Safety)	Device must have **rounded edges, protective casing, and shielding** to prevent operator exposure to radioactive materials. Must comply with **radiation safety standards (IAEA Guidelines)**.
2	Must have a long reach (Function)	Device must extend to **15 feet (4.57 meters)** without compromising structural integrity. Telescopic or modular sections preferred for ease of storage and transport.
3	Must provide secure sample containment (Safety & Functionality)	The sample must be **automatically sealed in a secure, contamination-free container** before removal to avoid direct operator contact.
4	Must include a failsafe system (Function)	Must incorporate a **mechanical failsafe or retrieval mechanism** to prevent getting stuck inside the pipe. A **backup manual extraction system** must be included.
5	Must provide operator feedback (Safety & Usability)	Must include **real-time status indicators** (LEDs, sound, or vibration alerts) to inform operators of: **Power status, sampling progress, system errors**.

6	Must be compact (Function)	Must fit within a **4-inch (10 cm) diameter pipe**, ensuring **low profile for easy insertion and extraction**.
7	Must be lightweight (Function)	Mass should not exceed 5 kg (~11 **lbs)** to ensure portability. Material choice: **Aluminum or composite materials** for an optimal strength-to-weight ratio.
8	Must be cheap (Cost)	Target price: **Under $100** per unit, with leeway for specialized materials if justified. Must use **off-the-shelf components** where possible to minimize costs.

3-Technical Benchmarking

Product	Strengths	Weaknesses	User Perception
CIGAR Tool (Channel Inspection and Gauging Apparatus for Reactors)	Provides precise sampling and inspection capabilities for nuclear reactor components.	High cost, complexity, and lack of modularity, making it unsuitable for low-budget applications.	Considered reliable for large-scale operations but impractical for field use due to its complex design.
SLAR Tool (Spacer Location and Repositioning Tool)	Effectively retrieves debris and samples while reducing direct operator interaction.	Expensive, requires extensive training, and is not optimized for confined spaces.	Valued for its precision but criticized for being difficult to transport and use in varied environments.
SP16 Groundwater Sampler	Efficiently collects samples from various depths, demonstrating versatility.	Designed for liquid sampling rather than solid material extraction.	Recognized for its ease of use but not applicable for nuclear fuel pipe sampling.
Vacuum-Based Sampling Devices	Non-contact methods reduce contamination risks and radiation exposure.	Requires significant power, may compromise sample integrity, and can be expensive.	Appreciated for safety but often regarded as inefficient for small-scale sampling.

4-Conclusions

The client provided many details, valuable information, insights, and knowledge about the project during the first meeting. This has allowed us to draft a list of needs and design criteria along with them. As for the relevant importance of these design criteria, the primary function of entering the fuel pipe and retrieving the sample takes precedence. Following that is the cost of the device. Finally, the safety fe

atures and precautions which ensure that the operation process goes along smoothly, along with the safety precautions of the operators. These criteria were directly derived from the needs of the client expressed during the meeting. The now developed design criteria were expanded upon from the initial needs list erected in part B, and from this point onwards we can refer to this list and the technical benchmarking done for the already existing options. Overall, this list of criteria is a key part of the design process allowing us to address every point the client mentioned and will be used to create an ideal product.

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