Deliverable H: Prototype III and Customer Feedback

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Abstract

This document outlines the development of the first high-fidelity prototype for the nuclear pipe sample collector system, focusing on the sanding drum and motor. It included client feedback, design improvements, prototype objectives, a test plan, an updated bill of materials, and a preliminary project task plan. The goal is to refine the design based on feedback and ensure the prototype meets functional and safety requirements.

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1. Introduction

This document pertains to the first high-fidelity prototype for our device; the nuclear pipe sample collector, specifically the sandpaper drum and motor. This iteration includes client feedback and design enhancements to address issues identified in earlier versions. The primary focus of this prototype is to test the performance of the motor and sanding drum in terms of durability, wiring components, and determine the amount of time required for achieving the required amount of sample.

2. Design Improvements

Improvements:

- Tube: the tube which holds the design has been replaced with a shorter 7 ft one, improving maneuverability, making it easier to be carried by one person, and reducing the price of the overall design.
- Motor: the motor from the previous prototype has been retained since it has demonstrated reliable performance. This helps us reduce redesign time and ensures consistency in our testing of different prototypes.
- Custom Housing: A 3-D printed case was developed and manufactured to securely enclose both the wires and the motor, enhancing protection and stability within the overall des
- JB Weld: Used to bind critical components of the assembly.
- Drum: The original drum design, which was planned to be purchased from an external supplier, has been replaced with a custom pipe fitting for both convenience and superior pricing.
- Vice: The vice system has been redesigned to use a tripod with a c-vice, welded with a custom metal piece shaped to fit the pipe. This allows better grip as well as lower pricing while still allowing the adjustment for the device.

The feedback analysis has been refined to critically assess the impact of each design decision on system performance and usability. The choice to reduce the tube length was

evaluated for its benefits in operator control and potential trade-offs in reach. Retaining the previous motor was due to performance consistency and resource optimization. Additionally, the implementation of a custom 3D-printed housing addresses client feedback on component safety and durability. This structured evaluation ensures that the modifications align with technical goals and user requirements.

3. Prototype Objectives

The primary objective of this prototype is to validate that the motor and sandpaper drum can effectively collect the required sample under realistic operating conditions. Specifically, the design must demonstrate its ability to spin fast enough to remove samples from the pipe in a feasible amount of time, and ensure seamless integration with other subsystems. By addressing these specific performance criteria, the prototype addresses core client requirements and proactively mitigates potential reliability concerns—establishing a strong baseline for future iterations.

Why are we prototyping?

- To test the motor durability and functionality
- To refine the sandpaper drum mechanism
- To assess integration with other subsystems

What are we testing?

- Material selection: strength, durability, and friction reduction
- Motor: ensuring it's strong enough for it to spin the sandpaper drum at a good speed.
- Adjustability and ease of use: quick and reliable operation
- Manufacturability and cost-effectiveness: staying within budget constraints

When will the prototype be built?

- Initial design refinement: March 18th,
- Manufacturing and assembly: March 19th - March 21st
- Testing phase: March 22nd - March 23rd

4. Test Plan

The updated test plan outlines a series of quantitative procedures to evaluate the performance of the motor and sandpaper drum under realistic operating conditions. Each test includes clearly defines pass/fail criteria to enable objective assessment.

Key Test Include:

- Motor Functionality
    - Run the motor for a fixed duration (15 minutes) at operating speed
    - Pass if there's no overheating, no stalling or loss of power
- Speed and Stability
    - Measure drum RPM under load and observe vibrations and misalignment
    - Pass if it maintains consistent RPM within an acceptable range for functionality
- Subsystem Integration Test
    - Operate the motor and drum within the full assembly to ensure proper fit and function with structural supports and power system
    - Pass if there's no interference or electrical issues

- Manual Operation Tests:
    - Grip Strength Assessment: The clamping mechanism will be tested to ensure it holds the shaft securely under the applied torque
    - Friction Observation: The rotation will be assessed for too much friction, making sure it allows smooth operation without extreme dragging
    - Stability Check: The mechanism will be evaluated for any unintended shifts or misalignment under manual operation.

Pass/Fail Criteria

- Secure Shaft Clamping: The shaft must remain firmly in place without slipping or shifting.

- Smooth Rotation: The shaft should rotate freely without excessive friction or resistance.
- Stable Operation: The clamping mechanism must maintain its position during manual use.

5. Preliminary Project Task Plan

The project task plan now includes a comprehensive breakdown of all tasks with realistic time estimates, explicit dependencies, and risk assessments. Each task is assigned to a specific team member along with clearly defined milestones to facilitate ongoing progress tracking. In addition, contingency buffers have been incorporated for critical tasks, and collaboration points have been clearly highlighted. This ensures that the overall schedule remains achievable, even if unforeseen challenges arise, and reflects a more pragmatic approach to iterative design and prototyping.

Task	**Duration**	**Responsible Team Member**
Design Refinement	2 days	Caleb Gilbert
Acquiring Materials/Components	3 days	Ian Kahuro
Testing and Design Alterations	2 days	Berke Dai
Documentation and Reporting	1 day	Visisht Kaushik
Final Review and Presentation	1 day	Quin Ramos

6. Updated Bill of Materials (BOM)

Component	Description	Estimated Cost (CAD)	Comments/Notes	Amazon Link
Pole	7-ft PVC pipe to hold the device end	$14.96	Sourced from hardware suppliers; ensure lightweight durability	7 Ft PVC Pipe
3D Printed Case	Case to hold both the wiring and motor.	$4	3D-printed	
Clamping/Vise Assembly	Adjustable vice/clamp mechanism with rubber padding to securely fix the device onto the tube rim	$5.98	Attached and secured to tube and pipe	Adjustable Tube Clamp

JB Welds	Used to bind components of this assembly together	$15.54	Important in keeping the design intact	J-B Welds
Rotating Sandpaper Drum Assembly	Custom aluminum drum with abrasive 60 grit sandpaper wrap; modified with an integrated slit for sample collection and a hollow interior to hold the sample	$5.98 for Sandpaper $3 for sample capsule $6 for drum component Roughly 13$	Key component-design revision from Deliverable E; precision machining required	Sandpaper Drum (Price on website is incorrect we managed to acquire it for 6 dollars) Sample capsule will be 3d printed
Brushed DC Motor	12V DC motor (approx. 15W, high RPM/high-torque) for driving the drum at the desired speed	$30	High torque for friction of sanding.	12V Brushed DC Motor 15W

Broom Handle Wiring Harness	Dedicated bundle of insulated wires (e.g., 18 AWG) for routing power through the broom handle to reduce voltage drop and protect wiring	$13.70	High flexibility for in-handle routing - includes switch	Flexible Wiring Harness
Total		$99.16		

7. Conclusion

By clearly defining prototyping objectives and aligning them with direct client feedback, the current design more effectively tackles key performance and reliability challenges related to the motor and sandpaper drum system. The integration of a detailed, metric-driven test plan ensures that each critical component—particularly the motor, sanding drum, shaft, and clamping mechanism—is rigorously evaluated under realistic operational conditions. This approach validates core functionality while creating a strong foundation for iterative refinement.

In parallel, the enhanced project task plan incorporates realistic time estimates, clearly defined dependencies, and proactive risk management strategies, supporting a development process that is both achievable and flexible. By capturing and applying lessons learned from previous iterations, the team demonstrates a commitment to continuous improvement and sound engineering principles.

Looking forward, these advancements position the project to better meet technical specifications and client expectations. Future iterations will leverage additional test results and stakeholder input to further refine the system. Ultimately, this refined prototype sets the stage for a final product that is not only functional and safe, but also efficient, manufacturable, and user-friendly.