UNC CHARLOTTE
The WILLIAM STATES LEE COLLEGE of ENGINEERING

UNC Charlotte College of Engineering Senior Design Program

Senior Design Project Description

Company Name	*Electric Power Research Institute (EPRI)*	**Date Submitted**	*4/25/2019*
Project Title	*Conceptual Design of Vacuum Boxes for Fuel Pool Liner Inspection* **EPRI_VAC**	**Planned Starting Semester**	*Fall 2019*

Personnel

Typical teams will have 4-6 students, with engineering disciplines assigned based on the anticipated Scope of the Project. 250 hours are expected per person. Complete the following table if this information is known, otherwise the Senior Design Committee will develop based on the project scope:

Discipline	**Number**	**Discipline**	**Number**
Mechanical	3	Electrical	2
Computer	2	Systems	1
Other ( )			

Project Overview:

Leakage from fuel pools is a common issue in the nuclear power industry, with some plants experiencing leakage since early in plant life. Plant owners need to identify and address leaks from their fuel pool liners but it is difficult to implement inspection tools due to the harsh radiation (expected at approximately 10,000 r/hr) and high temperature environment (up to 120ºF). Through another EPRI effort, the eddy current array (ECA) sensor was identified to inspect the seam and plug welds. However, vacuum and pressure boxes may be required to (i) verify the eddy current findings (complimentary method) and (ii) to perform stand-alone inspections in high radiation areas, hard-to-reach regions and corner welds.

Therefore, the goal of this project is to develop a minimum of two conceptual designs of a combination style vacuum and pressure box that will be remotely deployed to inspect seam, plug and corner welds. The box should be encoded for location tracking and pay loaded with a camera and lighting to access and navigate the region of inspection interest. This project will not fabricate any boxes but build 3D models and animations to demonstrate the feasibility and applicability of this inspection method and deployment.

Project Requirements:

This project would design a minimum of two combination style vacuum and pressure boxes (as identified by EPRI project managers) using 3D models that can be operated in dry and underwater environments. Special consideration must be given to the radiation environment that these boxes and associated components will be exposed to. Refer to the project overview section for radiation and temperature measurements. The requirements of this project will include:

- The modelled combination style vacuum and pressure box shall be capable of operating at up to 15 meters deep underwater and shall be watertight for all electrical and electronic components of the entire system. Therefore, it is required to consider cable and hose lengths of 25 meters. Radiation hardening to components that can be damaged must be considered.
- The combination box shall provide positive and negative pressure, respectively.
    - Positive pressure is applied pressure that can open leak paths that may have been previously clogged.
    - Negative pressure is when a vacuum is drawn.
- The system should be able to provide up to 20 psi of positive pressure and 10 psi of vacuum draw pressure. The variable pressure will be controlled by the operator through pressure gauges and valves from the operating station.
- In all cases, it is paramount to maintain a proper seal during an inspection to ensure optimal performance of the vacuum/pressure box testing
- Clear and see through windows should be incorporated in the final design. This provides a visual aid to ensure proper fit to the weldment was achieved and also to visually see any bubble formation from a leak.
- The final combination box should have the following maximum allowable dimension:
    - 6-inches wide, 6-inches high, and 20-inches long (length may be reduced to 16-inches based on proper seal fit and pressure calculations)
- The vacuum box shall be mounted to a ROV or designed as a ROV with swimming and floating capabilities in water and must able to swim from the pool surface to bottom of the pool and vice versa.
- The vacuum box shall have sufficient movement with free moving axis to navigate, forward (x), backward (-x), right shifting(y), left shifting (-y) directions and turning to get the camera, lighting, associated cables and hoses, and gauges to the desired test location. The vacuum box should also be able to climb vertical walls while providing ease of navigation features. The purpose of the camera and light is to show the location of the vacuum box underwater.
- The vacuum boxes shall be designed in such a way that no parts become loose and drop-off during its operation (foreign material exclusion – FME). All parts must be accounted for before the go into the pool and upon withdrawal. Importantly, the vacuum box shall be easily retracted when the power is lost.
- All power, required air and vacuum shall be supplied from an outside source, which will be typically operated from the work station and dry environment.
- The vacuum box design should include parts that are easily replaceable. Commercially available parts should be considered in the design. In some cases, parts need to be specifically machined. Identify all commercially available and machined parts in a table to be included in the final report. For commercially available parts, provide source and for machined parts, provide design drawings in AutoCAD
- Build 3D CAD modeling and generate movie clips showing the operability.
- Provide estimated manufacturing cost and bill of materials (BOM).

Expected Deliverables/Results:

- The deliverable will be a 3D CAD modeling files and animated movie clips
- Final Report- The final report should provide all details of the project. It should be written in a manner that will allow the next UNCC team or EPRI to use most of the research information and results to fabricate a final field deployable system. As a minimum, the final report should include following:
    - Scope-of-work
    - Objective
    - Research and development approach – All steps
    - Radiation and temperature consideration on the parts and overall design
    - Foreign material exclusion (FME)
    - In case of power or equipment failure, steps to retrieve vacuum box
    - Operation and maintenance procedure
    - Estimated manufacturing cost and bill of materials (BOM)
    - Identify all commercially available and machined parts in a table to be included in the final report. For commercially available parts, provide source and for machined parts, provide design drawings in AutoCAD
    - Identify challenges and gaps

Disposition of Deliverables at the End of the Project:

- Hand over all deliverables to the EPRI project manager

List here any specific skills, requirements, knowledge needed or suggested (If none please state none):

- 3D CAD (Solidworks, Inventor)
- Robotics – Have taken or will take in Fall 2019 ECGR 4161
- Mechanical
- Electrical
- Programmer