A Conceptual Mobile Control Panel for SRWMF at Point Lepreau Site

M. Jamieson[1] and A. Fathimani[2]
[1] Atomic Energy Canada Limited, Sheridan Park, Mississauga, Ontario, Canada
[2] Atomic Energy Canada Limited, Sheridan Park, Mississauga, Ontario, Canada

Abstract

Phase III of the Solid Radioactive Waste Management Facility (SRWMF) at PLGS is being constructed to store Levels I, II and III radioactive waste material resulting from Retubing and Refurbishment work planned to be undertaken in 2008. A large volume of Level III waste will be generated, requiring specialized handling equipment, including a mobile control panel, to allow for safe and efficient storing of Retube waste.

The scheduled loading cycle requires that this control panel will be operated 24 hours a day, seven days a week, in all but the most adverse weather conditions where personnel safety would be compromised. To achieve this, the control panel must be highly rugged, highly reliable, easy to operate and service, and easy to relocate.

This paper will focus on the conceptual design, functionality, reliability, serviceability, ruggedness, safety, and human factors elements required for safe loading and retrieval of the level III waste.

1. Background

1.1. Facility background

The new Phase III SRWMF facility will consist of five reinforced-concrete silo-like Retube Canisters, 23 ft (6.8m) tall and 31 ft (9.5m) in diameter, each containing seven storage cylinders. Each of these storage cylinders contains three guide tubes, and each guide tube accepts waste containers stacked on top of each other in a vertical fashion. Refer to figure 1 for a diagram describing each Retube Canister.

Waste containers will be loaded into the canisters from the top, using a hoist to gently lower each container from a transport flask into one of the 21 guide tubes per canister. In order to coordinate this activity, the top of each canister is designed for operators to walk around on and it is up here that the mobile control panel will be placed to coordinate the loading or unloading of the waste containers into this storage facility.

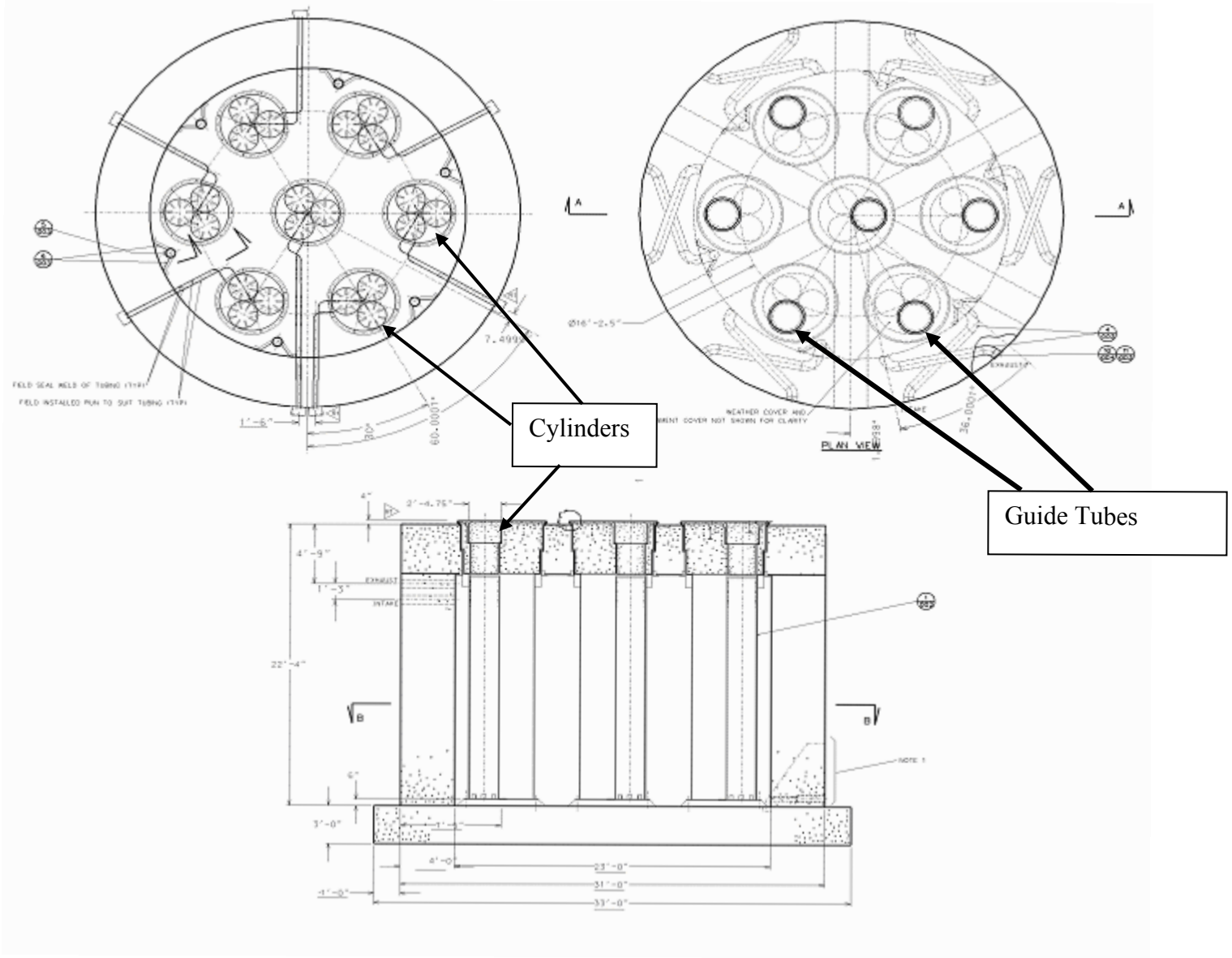

Figure 1: A retube canister.

1.2. Loading and unloading of the Waste Containers

Although the scope of this paper is to discuss the Mobile Control Panel (MCP) it is necessary to understand the waste loading and unloading process before one can appreciate the requirements for the Mobile Control Panel

The waste containers will be inside shielded Waste Transfer Flasks (WTF) and will be robotically filled with waste material near the reactor calandria. When the container is full, the WTF is checked for contamination, decontaminated if necessary, and then placed on a flatbed truck for transit to the SRWMF.

Prior to the flatbed truck arriving at the SRWMF facility, a Loading Interface Device (LID) is aligned over the correct guide tube to accommodate the WTF so that its waste container can be safely lowered into the Guide Tube. An overhead crane will carry the Container Loading Hoist (CLH) in preparation for hoisting the WTF to the top of the Retube Canister.

With the arrival of the flatbed truck, the overhead crane will move into position and lower the CLH down to the target WTF. Once the CLH has been securely fastened to the WTF, the assembly will be hoisted up to the top of the Retube Canister, and placed on top of the LID. It will be at this point, that the Mobile Control Panel is to be connected to the LID for control of the loading and unloading process. Refer to Figure 2 for a pictorial view of how this will happen.

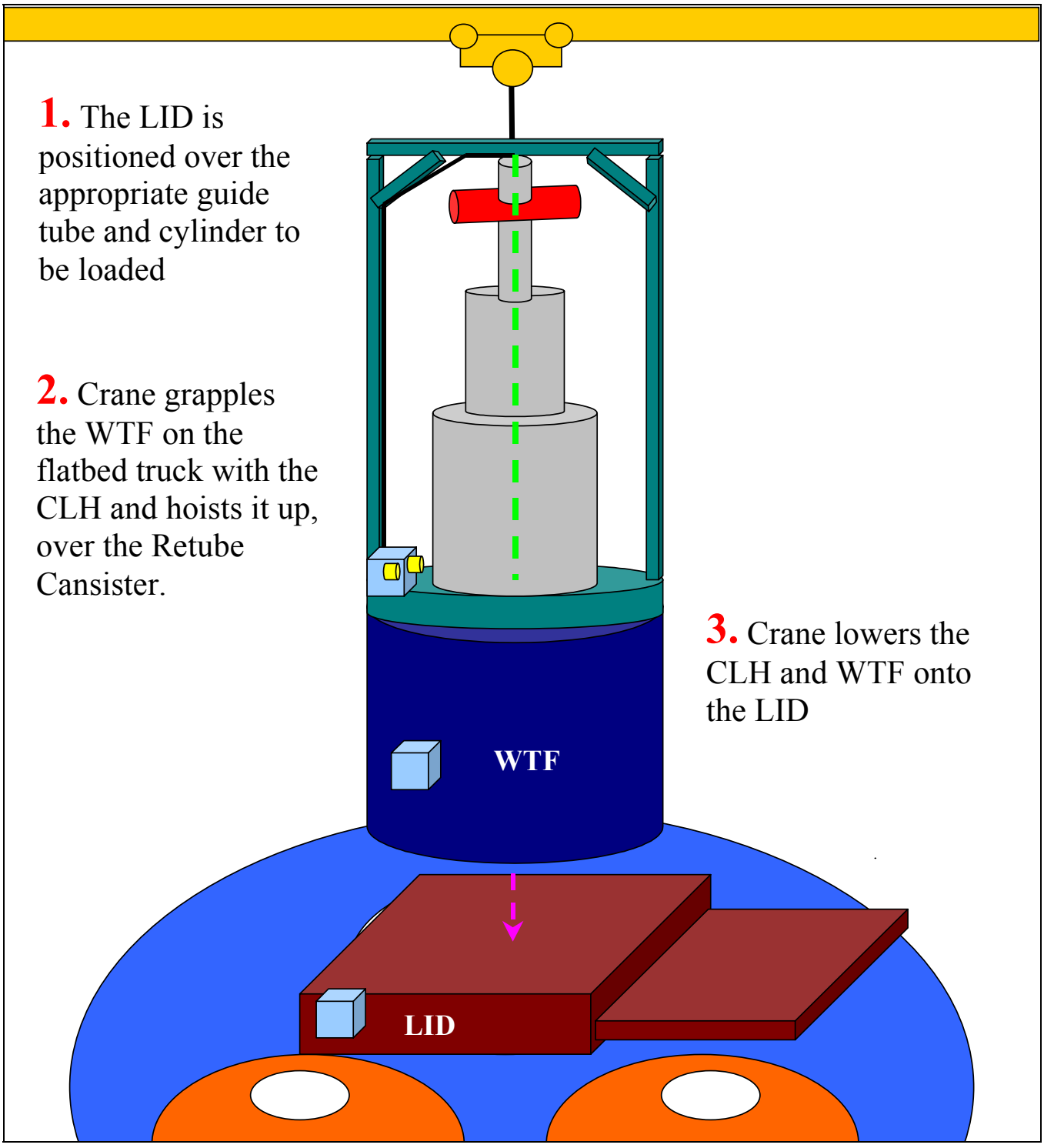

Figure 2 a: The process of lowering the WTF+CLH onto the LID

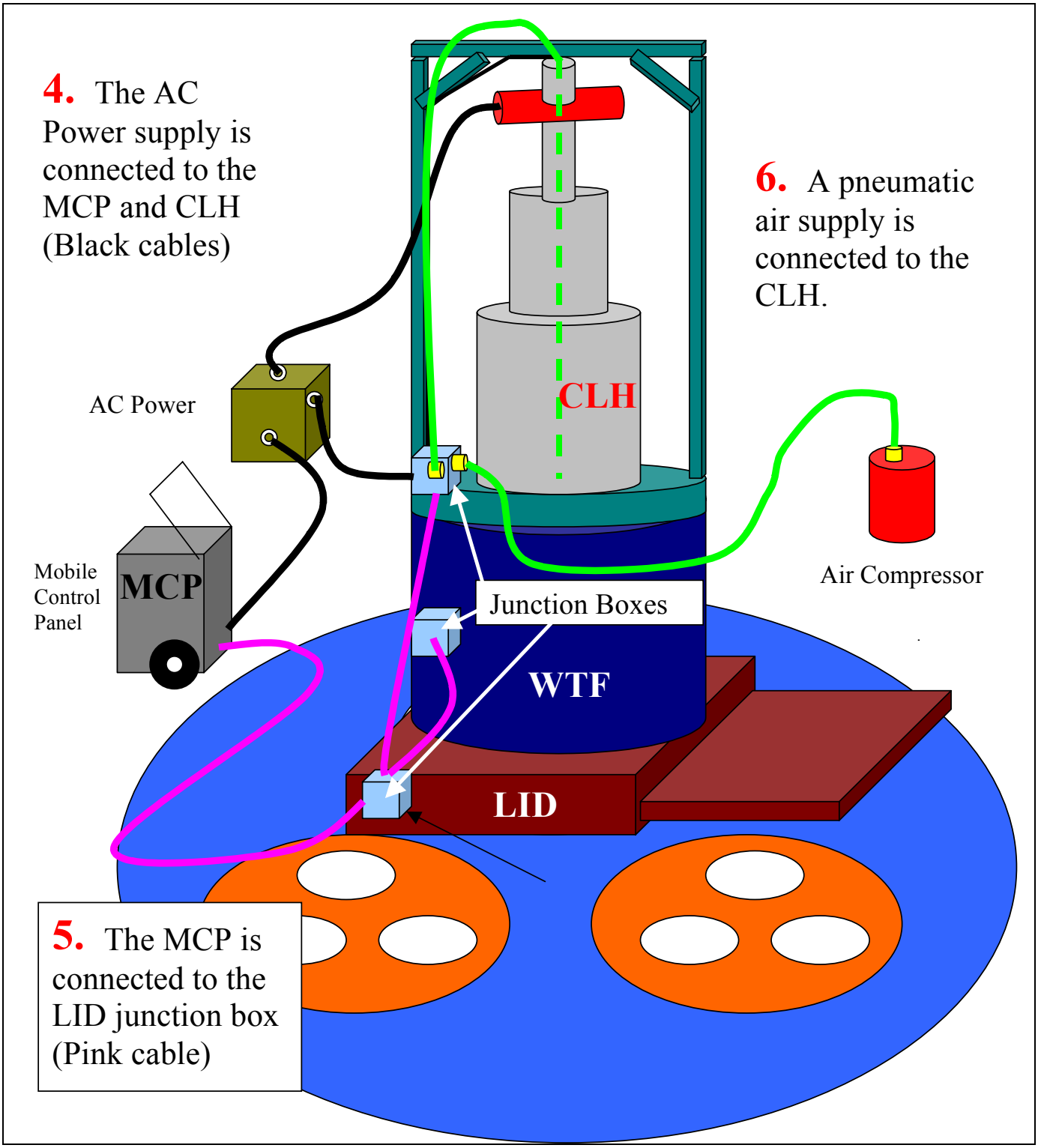

Figure 2b: Connecting the MCP to the LID

LID – The Loading Interface Device is designed to sit directly on top of the storage cylinder in the Retube Canister and accurately position the waste transfer flask over the storage cylinder guide tube opening, while providing additional shielding to eliminate radiation exposure to individuals operating the LID and WTF.

The LID will consist of a cylindrical part, a lead filled gate, and shielded panels. The LID is designed to allow a waste container to pass through when its gate is open, and to provide shielding when the gate is closed. The gate is driven open or closed using an electric drill to operate the gate drive mechanism.

WTF – The Waste Transfer Flask is designed to protect a waste container during transport and to protect operators handling the flasks from the waste in the container. The WTF is essentially a container with lead filled gates on top and on the bottom. The top gate will open to allow the grapple from the CLH to descend into the flask so that it can grab the waste container either in the flask (loading), or inside the SRWMF (unloading). The bottom gate will open to allow a container to be transferred to or from the flask. The top gate is opened and closed manually, and the bottom gate is coupled to the LID gate for opening and closing.

CLH – The Container Loading Hoist sits on top of the Waste Transfer flask (which sits on top of the LID) and is used to transfer the waste container from the WTF to (or from) the Retube Canister's guide tube using its hoist. The CLH consists of a hoist, load cell, and grapple connected to the hoist's chain.

The grapple is able to grab a waste container inside the WTF using a fail-safe, pneumatically operated, mechanism that requires pressurized air to release it. The hoist motor, chain, and grapple are supported by a load cell which will be used to monitor the weight of the waste container to ensure that the CLH is hoisting the container before the WTF gates open.

1.3. Operating environment

The MCP will be used outdoors on top of the Retube Canisters as part of a 24 hour a day, seven day a week operation, and must be able to operate in all Point Lepreau weather conditions, except the most extreme conditions that threaten personnel safety. Although there will be a movable roof which will cover the Canister being loaded, the control panel is designed to withstand the environmental extremes encountered in New Brunswick such as snow, rain, sun, cold, humidity, salty air, etc.

1.4. Mobile Control Panel

The MCP provides the benefit of improved safety and increased container loading/ unloading efficiency. Safety is improved by the control panel monitoring and displaying the state of the flask gate positions, load cell measurement, and grapple position status, ensuring that everything is nominal before attempting to perform an operation. The MCP will step the operator through the process, and ensure that controls are interlocked to limit the possibility of a step being performed out of sequence. Further, the interlocking will make it next to impossible to accidentally drop a container.

Container Loading/Unloading throughput is improved by automatically performing checks which an operator would normally have to perform via visual inspection, and provides audible announcements when certain tasks complete (eliminating idle time and extra walking).

This prototype control panel is currently being built for use at Point Lepreau's SRWMF facility and it is anticipated that it will be used at other facilities in the future. As a result, best engineering practices are used to ensure that the MCP will operate problem free as long as currently possible with today's technology.

2.0. Overview of the MCP Conceptual Design

2.1. Requirements

The requirements for this control panel are derived from functional, mechanical, electrical, environmental, and service considerations

The primary functional requirement is to provide interlocking of controls, and to semi-automate the loading and unloading process described above. The control panel will display the status of the LID, WTF, and CLH and is programmed to lead the operators through the loading/unloading process, indicating when to open and close gates, when to initiate the hoist and grapple, etc…

Secondarily, the control panel shall house all electronic circuitry necessary for automation and to ensure safety, and the control panel shall provide the necessary human interface to achieve efficient and safe automation of the loading and unloading process.

Since the hoist moves slowly, it is anticipated that the operators may become distracted at times and may be confused where they are in the loading sequence. The control panel indicates the current status, and what step should be performed next.

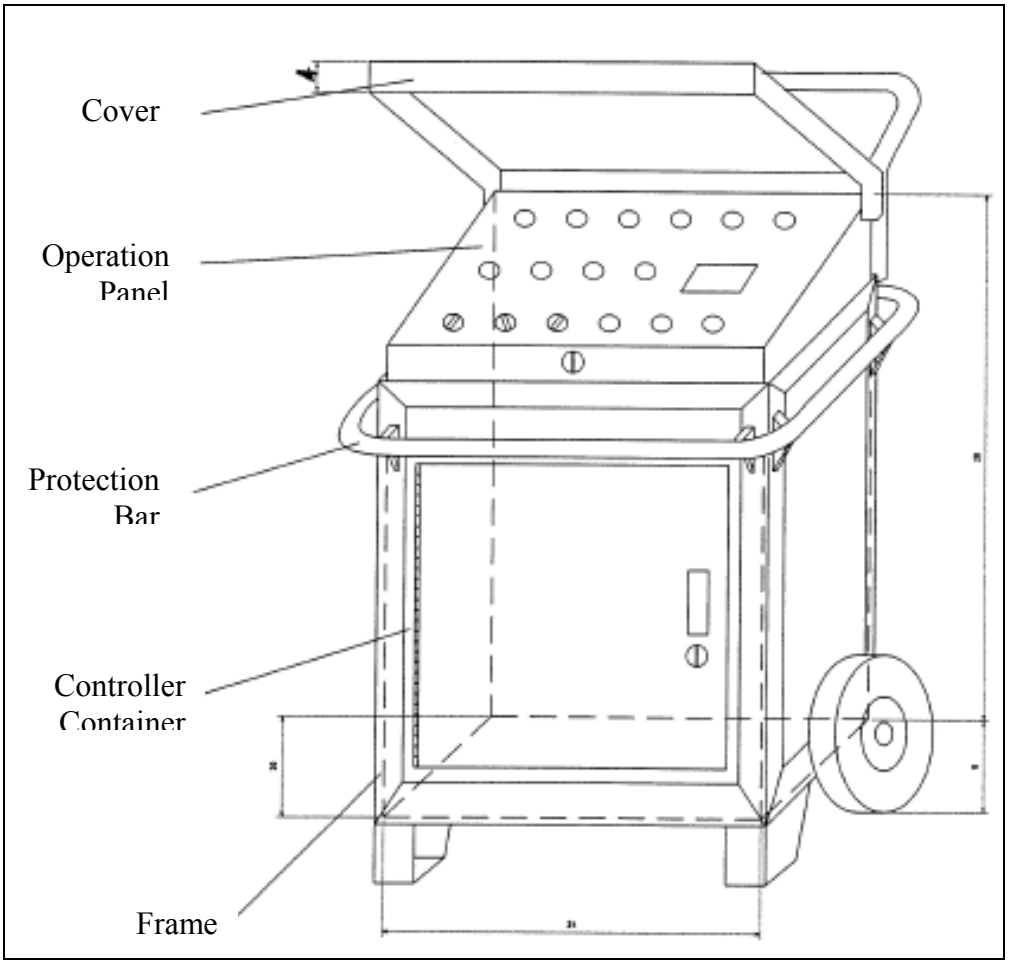

Figure 3 – a conceptual view of the mobile control panel (MCP)

Mechanically, this control panel needs to be robust, mobile, able to remain in a stationary state while being used, and tall enough to manipulate easily while standing. The mobility of the panel is a critical requirement since it will need to be manoeuvred around by hand on top of the canisters and will also have to be repeatedly hoisted, by crane, from ground to canister, and vis-a-versa. To achieve these requirements, the control panel will have wheels to allow easy movement on a flat surface and shall have a built in sling for hoisting. Handles shall be present to aid in wheeling it around, and to protect the panel from bumps.

Other necessary requirements to meet the robust and environmental conditions are specified for this panel. The panel needs to be designed to prevent ingress of rain ice and snow. The panel should also protect the electronics inside, and allow easy servicing.

Cables will be connected to this panel so that it can be powered and can interface with the LID, WTF, and CLH. The positioning of these cables needs to be such that the cables do not pose a hazard to the panel, or a trip hazard to the operators.

Electrically, the panel will be powered by a 120V AC source. The hoist will be self powered externally, but will be controlled and monitored by the control panel. Electrical reliability is of paramount importance and as such, components will be selected with this in

mind, conforming to CSA 22.1 and 22.2 safety standards. It is expected that this panel will operate flawlessly in an industrial environment for at least one year without maintenance to the electrical components. The anticipated lifespan of the panel will be much longer.

In order to automate the task described above, a programmable controller will be required to step the operator through the process and ensure that the necessary interlocks are in the appropriate conditions.

The environmental operating requirements for this panel are from –27°C to +40°C with relative humidity ranging from 5% to 98% RH. As such, internal components need to be selected to survive humidity, cold and heat, while external components need to also survive rain, snow, ice, wind, sun and salt. Mechanical ruggedness is a necessity since the components need to be usable in these extreme conditions.

Human Factors assumes that the operators are wearing thick gloves so pushbuttons are sized and placed accordingly. The display needs to be legible and clear. The labels need to be legible, and immune to fading, crumbling, cracking, or otherwise becoming illegible under the environmental conditions specified.

The enclosure for the electronics shall meet NEMA 4X standards, which means that the enclosure needs to be water tight, dust tight and corrosion resistant indoors and outdoors, and also ensures that the panel will be able to withstand hose-directed water used to clean it periodically and will be undamaged by ice-formation on the enclosure.

Finally, this panel needs to be serviceable. All components shall be easily accessed and easily replaced as needed.

2.2. Prototype Design to Date

The conceptual design meets almost all of the design requirements identified above. The prototype unit has the following features:

1) Standalone control panel with two wheels at the back
2) A wrap around handle to make it easy to manoeuvre the MCP and also provide protection from bumps.
3) A lid covers the top of the panel which can be lifted exposing the controls. The lid provides environmental and mechanical protection when the panel is not in use.
4) An access door on the front of the panel for maintenance
5) Connectors on the back for attaching the interface cables.
6) A sling, used for hoisting the unit, is slung under the panel and attached on the sides permanently allowing quick rigging and the added benefit of the sling not getting lost.
7) A Key is required to open the lid, turn the power on, and disengage the interlocks.
8) Critical indicator lights are hardwired, bypassing the PLC.
9) A graphical display is present to provide a simple, clean, intuitive interface to the operator.

The selected controller, is rated from 0°C to 50°C, so it needs to be supplemented with an electric heater in order to meet environmental requirements. Because of the need for heaters, a thermo-interlock will be provided which prevents the PLC from operating in sub-zero conditions. In addition, the controller will be equipped with quick-release screw terminals to allow for easy replacement of the controller if necessary.

Built-in diagnostics are provided to help quickly display problems when they arise – be it a failure of the control panel, or of the LID, WTF, or CLH. In addition, it is anticipated that any problems arising will likely be due to damaged cables, so all cables can be tested by looping the ends back and connecting them to built-in cable testers. These perform loop-back tests on all of the conductors to diagnose the cables.

To meet the human factors requirements, the panel is equipped with a graphical display that allows the panel to adapt to the type of operation being performed (loading or unloading). The panel will prompt the operator to perform each step, and will indicate any faults that occur during operation. Critical indicator lights for the gate positions are hardwired, allowing them to function even if the PLC is no longer functioning.

When operating in the semi-automatic and manual mode, interlocks prevent the operator from performing an operation which might result in the waste container being dropped or damaged. In addition, the MCP will perform limit checks to ensure that it is safe to move the grapple in the direction indicated.

3.0.Conclusion

It is anticipated that meeting all of the requirements presented in this paper will result in a control panel which increases safety, throughput, and eases the operator's burden.

Analyses have been performed on this MCP to ensure that it is impossible to accidentally drop a waste container through operator error or system failure.

Currently, two Mobile Control Panels have nearly completed design and fabrication and will soon be ready for factory acceptance testing and ultimately commissioning.

Acknowledgements

A special thanks to Tom Beese for providing a detailed review of this article.