AC 2011-1572: RFID BASED PERMITTED ENTRY SYSTEM

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RFID BASED PERMITTED ENTRY SYSTEM

Abstract: This paper addresses a very important safety related issue of sanitization of hazardous work area. The gas and oil industries have very dangerous work environments. Lack of, and deficiency in permit-to-work systems was cited as the largest single contributing factor in a Health Safety and Environment (HSE) survey. To help lessen this danger a permitting process has been developed within these industries that allow everyone to be aware of the scope of work that is being performed. By being informed, the amount of associated safety hazards, environmental, and personal damage are significantly reduced. However, many of these processes are still manual and paper based which introduces various opportunities for human error. Radio Frequency Identification (RFID) technology has made great advancements as of recently in the fields of both human and asset tracking. Therefore, this paper is the result of a directed project that attempted to improve upon these manual permitting processes by incorporating RFID technology. The result is a digital tracking permitting system that eliminates the need for large amounts of paper, provides centralized data access, and greatly reduces the opportunity for human error. This project not only allows a worker to more easily locate a permit, but also provides a visual representation of where the work associated with that permit is being performed.

Refinize company is likely to implement throughout its refinery organizations a standardized permit-to-work system, called the Control of Work (COW), utilizing RFID to track operator rounds. Operator rounds are instances where the unit operator physically enters the unit to take and record various measurements.

I. INTRODUCTION

A Health Safety and Environment (HSE) survey [9] found that a third of accidents in the chemical industry were maintenance-related. Lack of, and deficiency in permit-to-work systems was cited as the largest single contributing factor. One of the most well-known incidents occurred in 1988 at Piper-Alpha oil rig facility in the UK [15]. This incident resulted in 167 out of the 229 member crew being killed due to inadequate control of maintenance work. These people died because a maintenance crew was performing a routine maintenance job in a dangerous work environment with an inadequate method of communicating among staff. This and other events led to the development of safety management systems known as permit-to-work systems. This is a system of paperwork designed to promote communication between all parties affected by any maintenance procedure [4]. However, even with the adherence to these permit-to-work systems, the numbers of injuries in the oil and gas refining industry are still twice as large as those found in manufacturing as shown in Figure 1.

Refinize (a pseudonym) is a company that owns numerous oil refineries throughout the United States, Europe, Asia, and many other countries. Refinize experienced a tragic incident similar to that at Piper Alpha that also resulted in numerous fatalities. Furthermore, very similar to Piper Alpha's situation, an investigation determined that this incident was also due to a failure in their permit-to-work system.

To address this issue Refinize decided to instate a new standardized permit-to-work system that would be implemented throughout its entire refinery organizations. This standardization became known as Control of Work (COW).

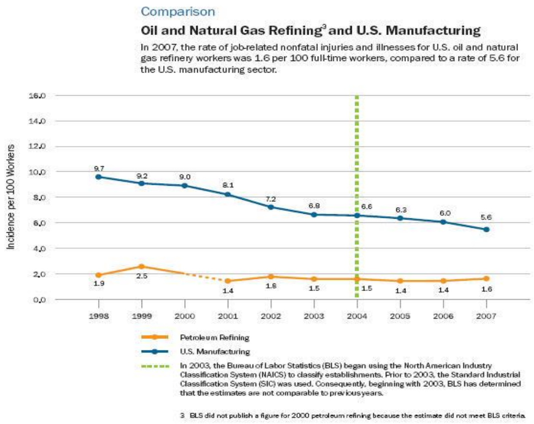

Figure 1 – Refining and Manufacturing Injury Comparisons

The COW process was intended to slow down the pace of maintenance work and ensure that all safety hazards and potential accidents are addressed and prevented before the start of the work [3]. This new system still incorporated the use of safe work permits and additionally made sure that every worker has access to these permits. This was accomplished by installing permit issue boards in every unit control room as shown in Figure 2. The permit issued rack provides a centralized location for each active paper permit package.

The COW process also entailed the installation a second permit rack, which would act as a central location to store permits when they are not active, incomplete, or awaiting verification. This board is shown in Figure 3.

Figure 2 – Permits Issued Rack

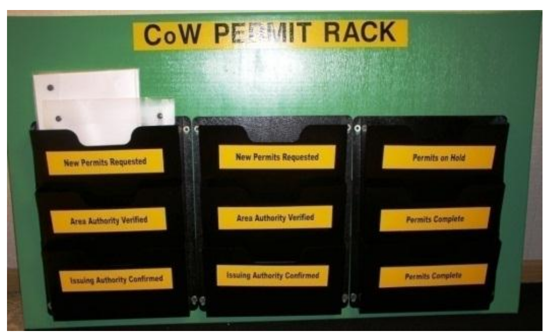

Figure 3 – COW Permit Rack [8]

The new COW process not only allows a worker to more easily locate a permit, but also provides a visual representation of where the work associated with that permit is being performed. This is accomplished through the use of unit plot-plan diagrams and magnetic icons (see Figure 4). The plot plan diagrams are dry erase boards that incorporate circles and squares as representations of the various drums and vessels on the process units. The placements of these figures are also representative of their physical locations on the actual units.

The magnetic icons are labeled with numbers that represent the active permits in the permit rack slots in Figure 2. The chief operator is responsible for placing the corresponding magnets on the plot plan when a permit goes active as shown in Figure 5.

II. OBJECTIVE

A refinery's new control of work process (COW) is a manual process that is wasteful and allows for errors. The process also involves huge amounts of paperwork. Furthermore, although it does provide a centralized location for paper permits, there is no centralized database for maintaining equipment records and maintenance schedules.

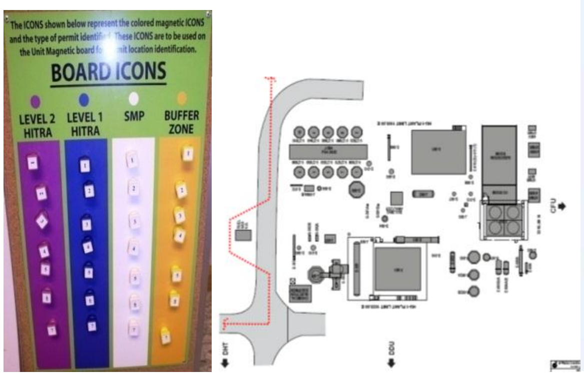

Figure 4 – Sample Plot Plan, and Board Icons

Figure 5 – COW Chief at Work

III. PROPOSED SOLUTION

Utilize RFID technology in a fully integrated computerized permitting systems to streamline the process of equipment maintenance management in an big enterprise such as the oil refinery. This process includes determining what maintenance has recently occurred, needs to occur, and is currently occurring on a live refinery process unit.

3.1 EXISTING METHOD AND ITS DEFICIENCIES

One such system is Petrotechcic's Sentinel Pro software which is currently being implemented on several units at one refinery in Texas [13] as a stand-alone electronic system.

In the existing COW process, RFID technology is utilized to track operator rounds. Operator rounds are instances where the unit operator physically enters the unit to take and record various measurements. This is accomplished by utilizing handheld RFID readers to enter the data into a database. Every temperature, pressure, etc., that an operator records during their rounds has an associated instrument that is affixed with an RFID tag in which the operator scans and enters information into [17].

We propose to use the same idea for equipment maintenance and tracking [11]. This paper describes a new RFID enabled COW work process through a series of five steps (hence forth referred to as phases).

3.2 Enhancements in COW

The numerous improvements in the COW process are listed below:

1. Provides a single signature page as the permit to work, saves (up to 25 pages in the existing method.
2. The permits are combined with maintenance history for each piece of equipment.
3. Eliminated the need to go to separate locations/programs to obtain device history, hazards, and equipment locations.
4. Ability to identify when a permit is active and the scope of what that permit entails.
5. Provided a real-time view of when a work crew is authorized to access a unit and whether or not they are currently outside working on that unit.
6. Provided easier access to a permit, and eliminated the need to search through a file folder for a particular active permit.

3.3 METHODS

3.3.1 Establishment of a new equipment database

A. Create new Equipment Identifiers.
All maintenance equipment are affixed with a small passive RFID tag. This equipment includes items such as meters, gauges, valves, pumps, rotating equipment, motors, lights, and other misc items.

B. Create an Equipment Database based on RFID tags.
Every device on a vessel is assigned an RFID tag ID that is based on the vessel number and the device number. For example:

E808-FT118 (A flow transmitter located on vessel E808)
E808-CV118 (A control valve located on vessel E808)
C102-MT218 (A motor associated with vessel C102)
C102-TT218 (A temperature transmitter for vessel C102)

Each of these RFID tag IDs will contain the maintenance history for that specific piece of equipment such as:

a) When was the device last worked on and why
b) Who performed this work
c) Current status
d) Serial # and Configuration Data
e) Location (i.e. if scaffolding is needed to reach it)
f) Procedures for calibrating/maintaining it
g) Associated permits that are needed to work on it
h) Associated hazards

3.3.2 Eliminating Paper Permits and Enhancing Permit Tracking Board

A. Establishing a second RFID database.
Each magnetic icon was replaced by a passive RFID tag, shaped as a credit card, key fob, or id badge. These tags were used to represent an active permit location, and whether or not a work crew is currently out in the field at that location. For simplicity, this project will represent only ten of the thirty plus available permitting slots shown on the Permits

Issued Rack in figure 4. These tags were labeled as RFID tag 1, RFID tag 2 …etc, and are assigned according to the equipment work order number.

B. Enhanced Monitoring and Tracking

When a maintenance worker is ready to start working or their daily schedule, he first reports to the unit's Chief Operator. The Chief Operator is the single point of accountability for all activity that occurs on their assigned unit. He tracks who is currently on the unit, work that is being performed on and surrounding the unit, the status of the unit processes, and controlling and maintaining simultaneous operations.

If the first item on the worker's schedule is E808-FT118. The Chief Operator (after he decides that the unit conditions are safe), will log into the COW system, assign E808-FT118 to RFID tag 1, activate the tag by scanning it at RFID reader 1, and give it the associated tag (the key fob) to the worker. A RFID reader is located at the entrances to the unit and the worker now has a tag (similar to an access badge) that will track when they enter and exit the unit.

When the Chief Operator activates the tag, it appears as a yellow box on a computer screen version of the plot plan diagram shown in Appendix B. The box is located next to the vessel or location of the tag. In this case, it appeared next to vessel E808. When the worker scans the access pass at Reader 2, which is located in the field near the entrance to the unit, the yellow box turns green to indicate that someone is in the field working at that location.

If the worker was to leave the unit (by scanning the access card again) to get a part or take a break, the box turns yellow again. This acts an indicator to show that even though the worker is not in the field, their permit is still active. When the worker finally finishes their job for the day, he returns the tag to the Chief Operator. When the Chief is satisfied that the job is complete, he then deactivates the card and the yellow box disappears from the digital plot plan display.

Additionally, the yellow box links to the equipment database. This way, anyone can click the yellow box and view the associated permit as opposed to searching through the permit folders.

3.3.3 Equipment Updating

Another advantage of RFID is the ability to write data to a tag [12]. Data on a RFID tag can also entail dynamic enabling, for example, allowing a complete usage history to be embedded in the RFID tag on a pipe [12]. In this case, the maintenance worker would also have a handheld RFID tag reader similar to the ones used by operations. When the work is complete, or cannot be completed, the maintenance worker would scan the RFID tag located on the equipment. When scanned, the tag would automatically be updated by the worker. Because each piece of equipment has its own RFID tag ID attached to it, its history can be obtained in the office from a computer by accessing the database, or by an operator or technician out in the field though the use of the handheld. This is an added benefit when an emergency occurs because the latest equipment information is now readily available in the field.

IV. SOFTWARE DESIGN

A new digital user interface (see Form 1- Appendix B) replaced the plot plan diagram and folder boards as shown in Figures 1-3. This interface was developed through the use of Visual Basic programming software. The new scheduling and record databases are represented as Microsoft Excel files. These files have taken the place of the paper permits (see Appendix A), thus eliminating the need to print the entire permit. An overview of the software programming is demonstrated in the flow charts in Appendices C-E.

The most pertinent component involved integrating a graphical user interface with the RFID readers. In order to keep hardware cost to a minimum, two identical Phidget RFID readers were chosen. These readers contained a programmable on board LED, an external LED connection, and configurable +5V digital outputs. The readers also have an antenna which can be switch on and off through software programming. Additionally, the Phidget RFID manufacturer provides Application Programming Interfaces (API) for each Phidget device as exposed by the COM library. This library is compatible with various programming languages, including Visual Basic, and provides ease of use building blocks that provide Universal Serial Bus (USB) sensing and control communications between the Phidget RFID reader and user customized Visual Basic programming.

4.1 Software Functionality Testing Through Hardware Model

A mock model of the new COW system has been developed to test the functionality and feasibility of the project's proposed improvements (see Appendix B for system layout). This model included the RFID reader and RFID tags shown in Figure 5. The first item shown is a RFID tag reader that will be used for programming the tags, the second item is a passive RFID tag (in the shape of a credit card) that will took the place of the magnetic field location icons. The last item is a small, active RFID tag that would be attached to the various pieces of equipment.

4.2 Hardware Model Specification Sheet

a) Distance between control room and unit is 100ft.
b) The hardware model contains 10 vessels of the mock unit.
c) Each of the 10 vessels is represented on the plot plan.

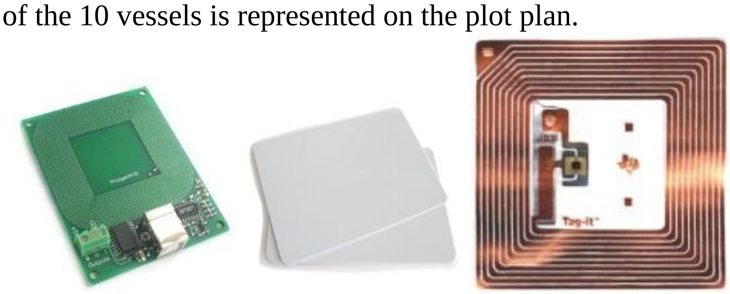

Figure 5 – Hardware

d) Each of the 10 vessels contains 10 pieces of equipment as defined in the equipment database such as: flow indicator, level indicator, temperature indicator, motor, pump, inlet valve, outlet valve, fan, heater, and pressure gauge.
e) There are 100 RFID tags to represent each piece of equipment.
f) 10 RFID tags are used to represent the control permitting slots.

g) Computer is used to represent the display screen, maintain the database and run the software.
h) 1- RFID reader
i) 1- RFID scanner

4.3 Assumptions

The planner is responsible for establishing which equipment is assigned to the daily schedule and is beyond the scope of this project. It is assumed that a schedule of work has already been developed, the maintenance worker has already received their schedule of work for the day, and the worker has already been trained on the new COW system. The new schedule will appear with the RFID tag number and a description of the work that needs to be accomplished such as:

Equipment	Description
1) E808-FT118 -	Needs to be replaced
2) C808-CV118 -	Troubleshoot, valve does not close

V. LIMITATIONS

5.1 Maintenance Scheduling

The scope of this project does not cover the priority in which work is assigned to the maintenance schedule, nor does it cover how the schedule is developed. The schedule may entail routine maintenance work, an abnormal equipment operating event, or an overall equipment failure that was discovered during operator rounds. The project, however, shows how this schedule and the equipment database are updated once they have been created.

5.2 Other Limitations

The proposed project demonstration model doesnot account for long distances between units and control room, and also does not account for the immense amount of tags that will be needed to actually implement it. It only shows a very small amount for demonstrative purposes. It, however, suggests additional products that can be used for long distance and still achieve the same suggested improvements.

VI. DATA COLLECTION/ ANALYSIS

The final hardware testing model is shown below in figure 7 and includes the following: RFID tags, a computer to run the software program, two Phidget RFID readers to simulate the reader in the control room (which allows the Chief Operator to control unit access) and the second reader located in the field (to monitor and track unit access).

In the original project proposal, the second RFID reader (located in the field) communicated wirelessly over a 100ft distance between its physical location and the system computer located in the control room (reference system diagram APPENDIX B). However, due to cost restraints, the wireless connection was eliminat- ed and replaced with a USB interface. It was then determined that the two readers function well in the same environment but need to have a distance of at least 20 inch between them to avoid communication interference. Since the ideal situation is for the second reader to be located in the field this is of little concern, except if the installation requires multiple entry/exit readers at the unit entrances.

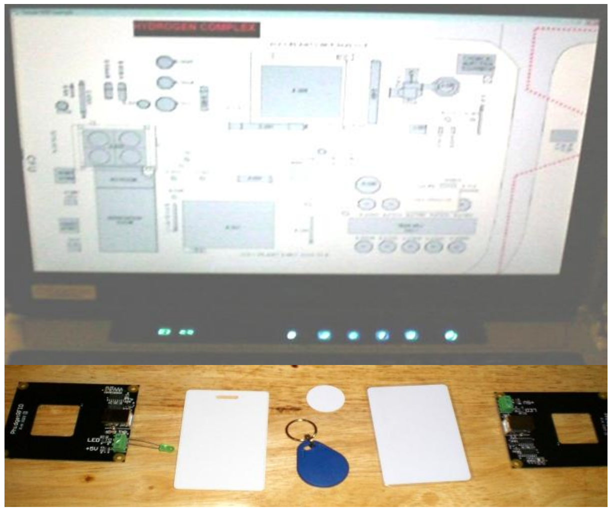

Figure 7 – Test Model Equipment

While simulating an actual permit being activated and a worker entering/exiting the unit, it was noted that there was only a lag time of approximately two seconds between the time that the tag was scanned and an update was cycled on the user interface. Further research could be conducted to determine how to eliminate this lag time, and whether or not it is significant to the user. If the lag time is significant, other industrial RFID readers are available, and may be suggested to greatly reduce this lag time.

The original design of the project, furthermore, required that the Chief Operator manually assign a key fob (or other type of access tags) to a specific slot (1-10 as shown on Form 2 Appendix C) when scanned. Testing of the hardware model illustrated that this step provided an increased opportunity for human error and was consequently altered. The new design allowed each key fob to be specifically assigned to a permit, which was predetermined by the scheduler. As a result, in the final design, when the Chief Operator conducts a scan of the tag at the reader he is only prompted whether or not to activate/deactivate the tag and its corresponding permit, and given the option to view the associated information in the equipment database.

VII. CONCLUSION

In conclusion, the mock hardware model functioned along with the developed Visual Basic software programming to provide a viable worker access tracking system combined with permitting database. This project demonstrates how RFID technology can easily be incorporated to enhance a paper based permit to work system currently operating at a refinery.

Figure 8 – Refinize's Monitored Unit Entrance/Exit and Badge Reader

Refinize is currently utilizing RFID technology to provide employee tracking throughout its entire facility to account for individuals in the event of an emergency. Figure 8 is a photo of an access point used by the refinery as an entrance way where employees badge in and out of the unit during a unit outage.

Refinize's security personal currently monitors these readers during an emergency evacuation. This same design can be implemented during normal unit operation and linked to a digital display as illustrated in this project. The same technology and equipment can be used on a much smaller scale to provide an even better account of personnel during not only an emergency but under normal operating conditions.

Because the company already has RFID readers at their disposal, the largest cost associated with implementing the changes entailed with this project would be the software installation, database development, and employee training. However, these costs would be far outweighed by the elimination of expenses such as paper, printer ink, paper storage, and human error. Another great return on the investment would be the ability to have real live feedback as to who is actually working on the unit, equipment history, associated hazards, and predicted schedules and updates.

As an added bonus, once this new system is implemented, further development of the equipment database could be initiated, where every piece of equipment is equipped with an RFID tag for ease of identification and locating. This would also allow the maintenance worker to update their equipment from the field and the computer.

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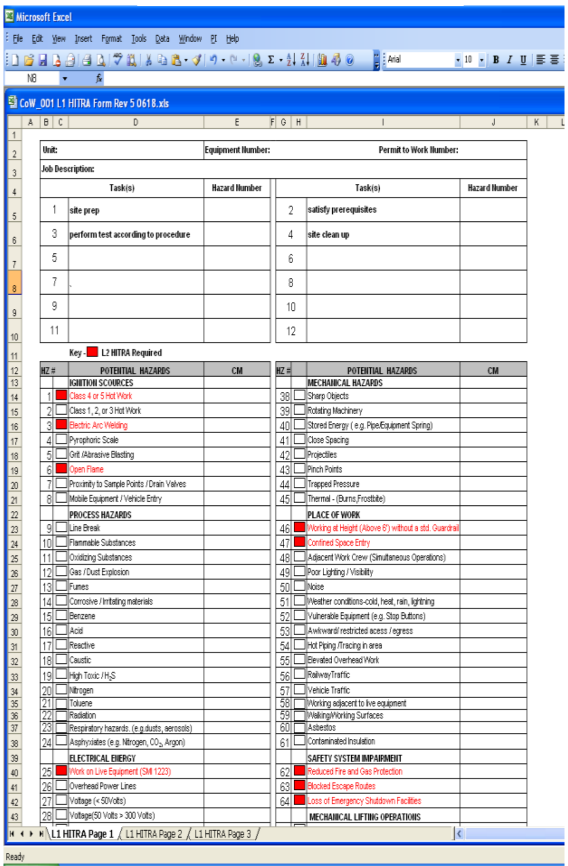
APPENDIX A



Microsoft Excel

CoW_001 L1 HITRA Form Rev 5 0618.xls

Unit:		Equipment Number:		Permit to Work Number:	
Job Description:					
	Task(s)	Hazard Number		Task(s)	Hazard Number
1	site prep		2	satisfy prerequisites	
3	perform test according to procedure		4	site clean up	
5			6		
7			8		
9			10		
11			12		

Key - ■ L2 HITRA Required

HZ #	POTENTIAL HAZARDS	CM	HZ #	POTENTIAL HAZARDS	CM
	IGNITION SCOURCES			MECHANICAL HAZARDS	
1	■ Class 4 or 5 Hot Work		38	Sharp Objects	
2	Class 1, 2, or 3 Hot Work		39	Rotating Machinery	
3	■ Electric Arc Welding		40	Stored Energy (e.g. Pipe/Equipment Spring)	
4	Pyrophoric Scale		41	Close Spacing	
5	Grit /Abrasive Blasting		42	Projectiles	
6	■ Open Flame		43	Pinch Points	
7	Proximity to Sample Points / Drain Valves		44	Trapped Pressure	
8	Mobile Equipment / Vehicle Entry		45	Thermal - (Burns,Frostbite)	
	PROCESS HAZARDS			PLACE OF WORK	
9	Line Break		46	■ Working at Height (Above 6') without a std. Guardrail	
10	Flammable Substances		47	■ Confined Space Entry	
11	Oxidizing Substances		48	Adjacent Work Crew (Simultaneous Operations)	
12	Gas / Dust Explosion		49	Poor Lighting / Visibility	
13	Fumes		50	Noise	
14	Corrosive / Irritating materials		51	Weather conditions-cold, heat, rain, lightning	
15	Benzene		52	Vulnerable Equipment (e.g. Stop Buttons)	
16	Acid		53	Awkward/ restricted acess / egress	
17	Reactive		54	Hot Piping /Tracing in area	
18	Caustic		55	Elevated Overhead Work	
19	High Toxic / H_2S		56	RailwayTraffic	
20	Nitrogen		57	Vehicle Traffic	
21	Toluene		58	Working adjacent to live equipment	
22	Radiation		59	Walking/Working Surfaces	
23	Respiratory hazards. (e.g.dusts, aerosols)		60	Asbestos	
24	Asphyxiates (e.g. Nitrogen, CO_2, Argon)		61	Contaminated Insulation	
	ELECTRICAL ENERGY			SAFETY SYSTEM IMPAIRMENT	
25	■ Work on Live Equipment (SMI 1223)		62	■ Reduced Fire and Gas Protection	
26	Overhead Power Lines		63	■ Blocked Escape Routes	
27	Voltage (< 50Volts)		64	■ Loss of Emergency Shutdown Facilities	
28	Voltage(50 Volts > 300 Volts)			MECHANICAL LIFTING OPERATIONS	

L1 HITRA Page 1 / L1 HITRA Page 2 / L1 HITRA Page 3

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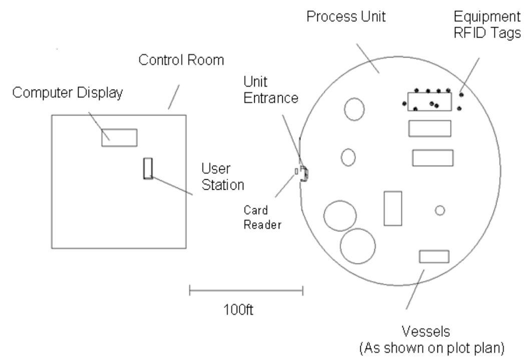
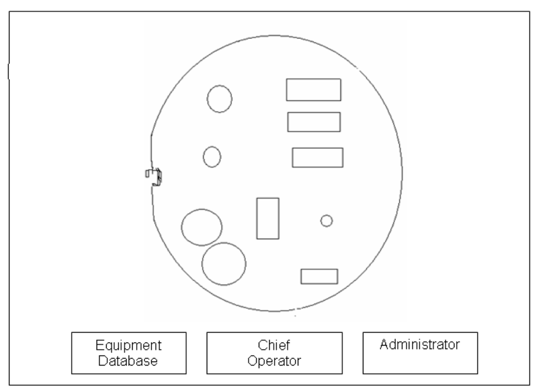
APPENDIX B

SYSTEM DIAGRAM

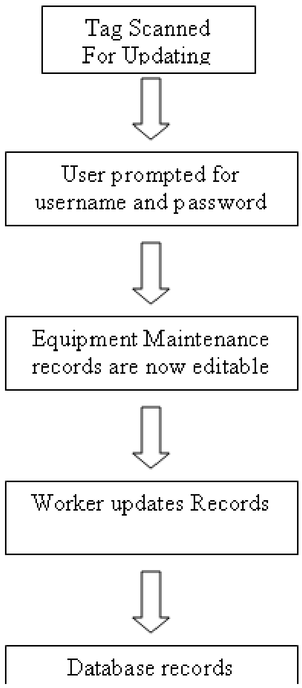


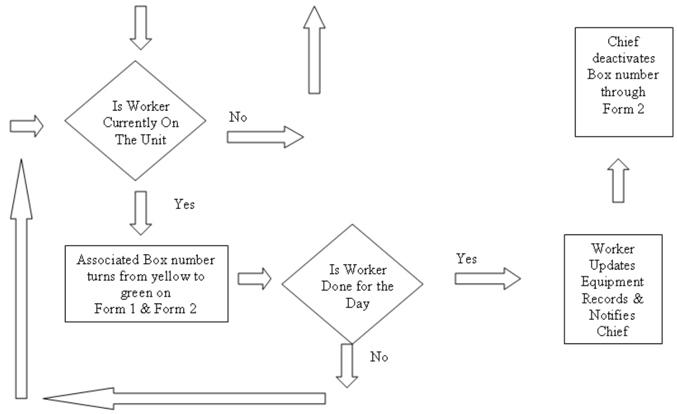
FORM 1 – Plot Plan Computer Display

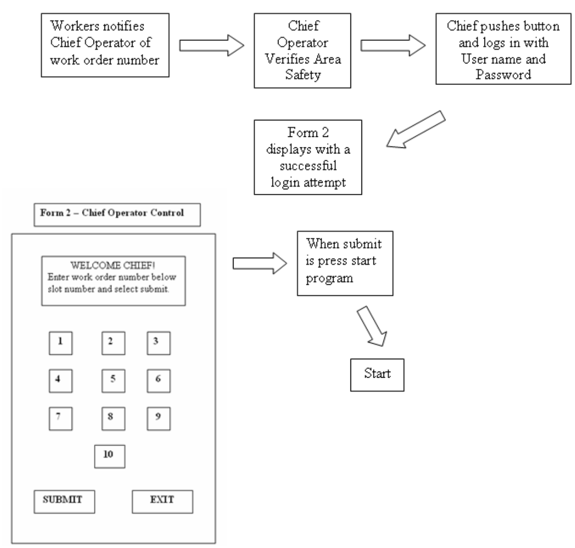


APPENDIX D

Equipment Updating







APPENDIX E