

THE SNS CRYOGENIC MODERATOR SYSTEM UPGRADE FOR THE HYDROGEN GAS MANAGEMENT SYSTEM

J.A.Proulx# Oak Ridge, TN 37831, U.S.A.

Abstract

The target moderator is a series of three cryogenic loops comprised of a circulator, accumulator, helium heat exchanger, and interconnecting cryogenic piping. Without the moderator accelerator beam power on target cannot exceed 65Kw. Hydrogen gas is supplied to the target moderator system using a vendor supplied gas management system (GMS) that utilizes proprietary control software. The upgrade is needed for control logic changes, reliability, a desire to increase maintainability, and to provide an intrinsically safe barrier to the hydrogen cabinet. This paper provides an overview of the commercial off-the-shelf (COTS) hardware to be used in the hydrogen GMS. Details of the design and challenges of an approach that will maintain the original logic for continued use of the cabinet until the new logic is tested, proven, and accepted will be covered in this paper.

INTRODUCTION

The hydrogen gas cabinet is comprised of four individual cabinets containing three cylinders each for a total of twelve cylinders. This provides a sufficient volume of hydrogen required for the target moderator. (Figure 1, 2, and 3) The safety features built into the cabinet include an oxygen monitor, hydrogen detector, venting system, excess flow protection, and door locks.



Figure 1



Figure 2



Figure 3

The controls enclosure (Figure 4) can be seen mounted on top of the gas cabinet and (Figure 5) provides a look inside the controls enclosure. This enclosure does not provide minimum recommended spacing for the installed equipment and does not meet the criteria for explosive gas handling equipment.



Figure 4



Figure 5

The target moderator also includes a helium GMS, warm compressor, cold box, and hydrogen circulator. Ethernet is used for inter PLC communications. Figure 6 shows the compressor room communications back bone hub located inside the warm compressor control enclosure.



Figure 6

The CMS communication network using EtherNet/IP [4] culminates to the Experimental Physics and Industrial Control System (EPICS). The three PLC systems in the compressor room are Allen Bradley MicroLogix processors and do not communicate directly with EPICS. The hydrogen circulator PLC sends and receives data with the hydrogen GMS PLC, the cold box PLC sends and receives data with the helium GMC PLC and the warm compressor PLC using message commands within the respective PLC code. The hydrogen circulator PLC and cold box PLC then communicate data between each other to exchange required information for system operations. The hydrogen circulator PLC and cold box PLC are Allen-Bradley ControlLogix5000 PLC [3] and meet the SNS Integrated Control System standard. Because of the nature of the vendor supplied hydrogen GMS cabinet it is not feasible to make required changes to the control logic. The existing code was written for configurability as an OEM would be expected to do for cost savings. In order to make a MicroLogix PLC configurable to this level a form of indirect addressing was employed. As an example, the first digital input module (I:0) data is copied to binary word B10:0, this is then copied to B40:0, and then to the PLC data transfer word N100:10. The entire program has similar copies of data which make it nearly impossible to follow and maintain the logic.

At SNS major equipment is started with local controls. The hydrogen GMS local operator control can be said to be confusing and barely sufficient at best. With the use of system procedures and the nature of the control system, there is high probability of an operation being done out of step, or in the wrong mode. If a hardware item does not perform correctly the entire process must be reset and restarted which can cause delays to accelerator beam operations.

NEW DESIGN FOR HYDROGEN GMS

A new PLC program with an operator interface was setup as a simulation for the CMS personnel to test and verify the new design meets their requirements. The new PLC program and operator interface passed all tests the CMS personnel conducted and they gave approval to proceed with further development that will eventually become the new standard for CMS/GMS operation. The new PLC program (code) is also a proof of concept of a novel and innovative method for producing accurate code in a fraction of time typically employed by base line programmers. The new code will reside in a standalone processor that will take control of the existing I/O currently controlling the hydrogen gas cabinet. This control can be easily turned off to allow the vendor's supplied system to run as it exists today. The new processor also has the capability to replace the helium gas cabinet controls as well as the controls for the warm helium compressor.

The first steps for bringing the new system to operational status is the fabrication of a new controls enclosure that will house the new PLC processor, operator

interface, associated power supplies, and a new managed Cisco series Ethernet switch. This new switch will add maintainability, reliability, allow for future expansion, and is the standard for SNS.

The most challenging aspect of this upgrade will be mapping the new PLC to/from PLC and PLC to/from EPICS data paths (Figure 7) so that no change to the EPICS controls screens will be required. However, the CMS personnel requested a new control screen for both the hydrogen and helium GMS. The new control screen shall mimic the local control screen with limited available controls that are needed for remote operation. (Figure 8) is the existing EPICS control screen and (Figure 9) will be the new EPICS screen for the CMS hydrogen GMS.

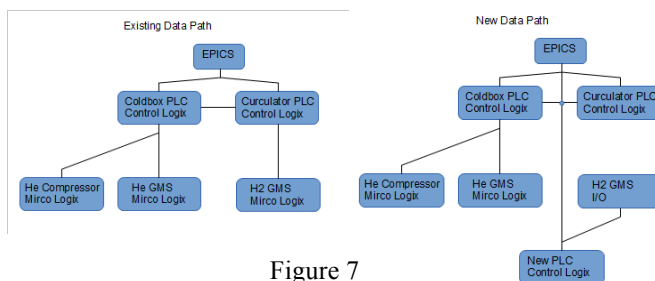


Figure 7

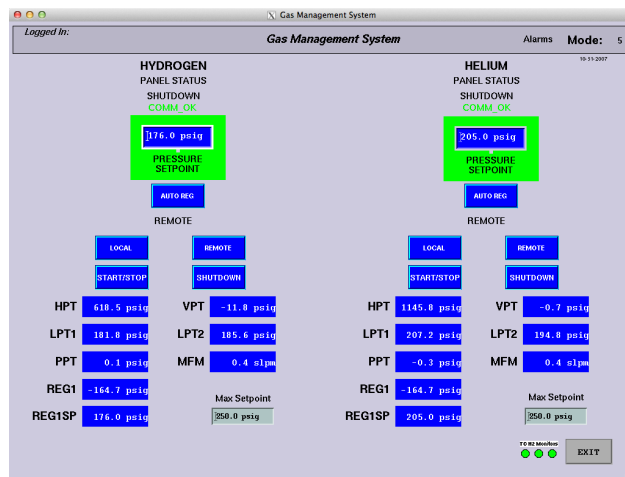


Figure 8

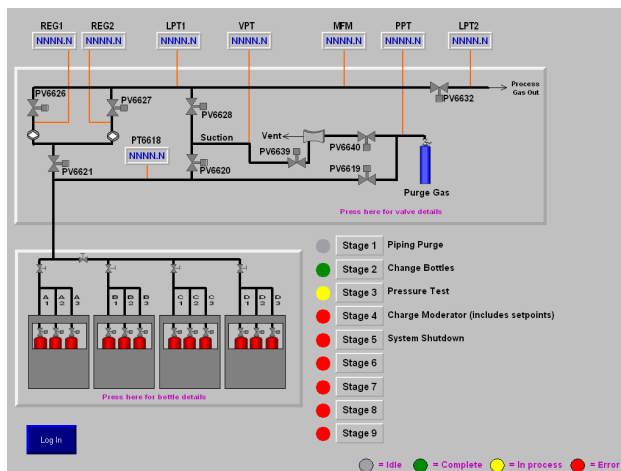


Figure 9 (local control screen)

The existing control screen will stay active for continued operation of the helium GMS until further development is completed.

The existing hydrogen GMS utilizes a custom hardware board to act as the intrinsically safe barrier for the hydrogen gas that is controlled by the MicroLogix processor. This approach effectively doubles the amount of hardware inside the small enclosure mounted on the gas cabinet. Although further development is required the plan is to use COTS safe barrier hardware that can interface directly with the Allen Bradley Control Logix PLC. This project is viewed as a much appreciated improvement to the system.

In addition to the improvements noted in this paper, this project will be used as a vehicle to:

1. Review the requirements of the system
2. Consolidate and update system documentation
3. Review and update system drawings
4. Identify required spare components
5. Improve communications network
6. Thoroughly test system operation

CONCLUSION

The new GMS code will provide an excellent standard to SNS which is easy to understand, developed using existing software tools with minimal development time, and expandable for possible future moderator gas management systems. The Ethernet managed switch and new data paths will add a degree of reliability and ability for future development of the CMS. New COTS hardware will be more efficient on size, function, and provide an explosive gas barrier with known specifications.

REFERENCES

- [1] Allen Crabtree, "SPECIFICATION FOR HYDROGEN GAS CABINET", Publication 106020200-EQ-0003-R01, October 18, 2005
- [2] Allen Crabtree, "Hydrogen Moderator System Functional System Description", Publication 106020200-TD-0001-R00, June 30, 2003
- [3] Rockwell Automation, "ControlLogix Controllers Selection Guide", Publication 1756-SG001I-EN-P, November 2006
- [4] K. U. Kasemir, "Interfacing the ControlLogix PLC over EtherNet/IP", ICALEPCS'01