

BUILDING A PROCESS CONTROL LABORATORY FOR ENGINEERING AND ENGINEERING TECHNOLOGY

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Abstract

In 2006 a Honeywell TDC 3000 distributed control system (DCS) was donated to McNeese State University by Bassell corporation. Subsequently, the process engineering laboratory was completely remodeled and new process equipment was purchased. Additionally, an Emerson Delta-V DCS was brought into the lab. Later, an outdoor model plant was built to allow for operator training and to enhance the laboratory experiences for students in the various engineering and engineering technology programs. This paper describes the work that was done to wire the lab, and configure and connect the process equipment to the DCS systems.

1. Renovation

Renovation is the up and coming trend at McNeese State University. The nursing building is one of the latest and greatest complete renovations. The Shearman Fine Arts building has been close to follow in McNeese's makeover. The engineering building, Drew Hall, may not be receiving a new facility or upscale add on like Shearman, but the Engineering and Engineering Technology Labs are incurring a drastic dress-up. .

McNeese is developing a small scale plant to educate and train the students at McNeese in a more hands-on way. Although the labs are not in complete working order as far as what's ultimately intended, they have experienced a major upgrade. The chemical engineering lab has been completely overhauled with new equipment, new floors, and fresh paint to the walls. Figure 1 shows a picture of the back wall of the lab before this transformation.



Figure 1 – Old Lab

Before

The lab was decorated with concrete flooring and yellow walls, as seen in Figure 1. The lab looks very dull and gloomy. The offices inside the lab were very outdated, also with yellow paint on the walls. These rooms were very cluttered and non-functional when renovation began. Through two semesters, the lab and offices were given a facelift and cleaned from top to bottom. Equipment, furniture, and books from some of the offices were moved to the very back lab and some to a completely different lab for organizational purposes. The purpose of moving this around was to help these offices and the back lab become useful for professors and students during classes. The objective was to make all the resources that are available to McNeese available and in working order. With this goal in mind, the unorganized rooms had to be overhauled.

After

The flooring is now a bluish non-slick floor and the walls are now a light blue to match the new floors. Each office has been completely cleaned out including the lab in the very back. In the picture below, you can see the new floors and freshly painted light blue walls, along with the new equipment available in the lab. The lab looks totally different now and gives a sense of life and brightness (Figure 2). This is definitely what this lab needed to inspire students for a deeper desire of learning.



Figure 2 – New Lab

The pictures below were taken of the updated offices and lab in the back of the main lab. Figure 3 is the lab in the back of the main lab. When this project began, there was no room for walking in this lab. Now it is a fully functional lab.



Figure 3 – Rear Lab



Figure 4 – Gus Station



Figure 5 – Development Lab

Figure 4 is one of the new Global User Stations (GUS). This is the main Honeywell interface used to control processes and check points, status, etc. This station is where various functions and capabilities of Honeywell are learned. For example, building schematics using colors and shapes on the Honeywell is a useful procedure to commit to knowledge. Learning how to navigate through the system via tutorial books is the best way.

Figure 5 is a room/office that is now available inside the lab, used for developing experiments to be used in the outer lab.

2. Logging Equipment

Cleaning and updating the labs was not the most important focus for McNeese. The first project was logging various donated equipment for the Honeywell system. These different pieces of equipment for the Honeywell system were logged so McNeese would know what was available, for future reference. This equipment was also put into a particular location, which is on the shelves in the room where the Honeywell TDC 3000 cabinets are located. The location information was also logged into a spreadsheet for easier referencing as needed. Figure 6 shows the equipment sitting in its location on the labeled shelves.



Figure 7 – DCS Equipment Storage

Appendix 1 is a copy of the spreadsheet where all the equipment donated is logged. It is organized by using the model #, extension #, reference #, and assembly # located on the equipment. Their location and box # are also documented on this log.

3. Projects

Testing Modules

After logging this equipment, the input/output (I/O) modules were tested in the Honeywell TDC 3000 to see which slots were bad and which were good. There are four types of I/O modules: analog out (AO), analog in (AI), digital out (DO) and digital in (DI). Each module has multiple slots for connection to multiple field instruments. Some had bad pins, which rendered them not usable. The terminals with bad connections were noted, and skipped over during the wiring process. In all, there are 20 I/O modules connected to the Advanced Process Manager (APM) of the TDC 3000.

Citgo Petroleum Corp donated 400 feet of 36 instrument cable on a huge spool that was used to wire the Honeywell TDC 3000 to the equipment in the lab and also to the Honeywell TDC 2000 in another location. Below is a picture of the cable donated by Citgo with Dr. Griffith and a graduate student, Michael Pearce, who helped wire the TDC 3000.



Figure 8 – Instrument Wire

Mapping Diagram

The black cable contains 36 pairs of instrument wire. This wire was connected to grey marshalling strips (inside the Honeywell cabinets) that go out to the equipment in the lab for various experiments. The wires were then wired from the marshalling strips to field termination assemblies (FTA) for the I/O modules in the Honeywell TDC 3000. A mapping diagram of the wiring was documented and hung inside the Honeywell TDC 3000 cabinets for referencing purposes. A portion of this document is attached below (Figure 9). This shows the module number (so it can be located inside the cabinet), the type of module (AO, DI, etc.), and the slot number within the module. The mapping also shows which marshalling strip, or terminal, the wire goes to. The wire number, 1-36, corresponds to the numbered wires within the black cable. A space is left for a description of the instrument as well as a tag name.

Module #	Type	Slot #	Terminal	Wire #	Instrument	Tag Name
1	Analog IN	1	A01/A02	A-1	Abs. Top T	TI_03
1	Analog IN	2	A03/A04	A-2	Abs. Bot. T	TI_04
1	Analog IN	3	A05/A06	A-3		
1	Analog IN	4	A07/A08	A-4		
1	Analog IN	5	A09/A10	A-5		
1	Analog IN	6	A11/A12	A-6		
1	Analog IN	7	A13/A14	A-7		
1	Analog IN	8	A15/A16	A-8		
...
2	Analog OUT	1	C11/C12	A-29	Var. Spd. Pump	VSP_01
2	Analog OUT	2	D01/D02	A-30	Var. Spd. Pump	VSP_02
2	Analog OUT	3	A61/A62	A-31		
2	Analog OUT	4	A63/A64	A-32		
2	Analog OUT	5	A65/A66	A-33		
2	Analog OUT	6	A67/A68	A-34		
2	Analog OUT	7	A69/A70	A-35		
2	Analog OUT	8	A71/A72	A-36		
3	Analog OUT	1	A73/A74	B-1		
3	Analog OUT	2	A75/A76	B-2		
3	Analog OUT	3	A77/A78	B-3		
3	Analog OUT	4	A79/A80	B-4		
3	Analog OUT	5	A81/A82	B-5		
3	Analog OUT	6	A83/A84	B-6		
3	Analog OUT	7	A85/A86	B-7		
3	Analog OUT	8	A87/A88	B-8		

Figure 9 – Mapping Diagram

The mapping diagram allows students to wire instruments from the field directly into the DCS modules without having to actually connect to the FTA cards. This is important because the terminals on the cards are worn, and frequent wiring and unwiring will continue to degrade them.

This wiring diagram is very useful when looking inside the cabinets, shown below. Figure 10 shows the inside of the cabinets. The huge black cable can be seen coming in the top of the cabinet. This cable is coming in from the equipment in the lab. The 36 wires within the cable are wired to the grey marshalling strips on the side of the cabinet. “Jumper” wires are wired from the orange terminals of the input/output modules to the grey marshalling strip.



Figure 10 – Wiring of Field Termination Assemblies



Figure 11 – Wiring Chart

Figure 10 is a picture of the wiring diagram posted inside the cabinet door. Once again, this is for referencing purposes.

Control Room

Figure 11 shows different views of McNeese's control room. Console furniture was donated by Trunkline LNG to support the computers connected to the Honeywell. More recently, an Emerson Delta-V DCS was acquired, and its terminals are housed within the control room as well. This control room simulates the operating environment in a refinery or chemical plant. There are three Honeywell systems or "GUS" stations in this room along with Delta-V terminals and PC workstations. The GUS stations are what the students use to control the experiment or "control the process" in refinery terms. Construction of the computer-instrument interface (building points and schematics) is also performed on these GUS stations.



Figure 11 – Control Room

Wiring of Lab Equipment

Initially, laboratory experiments were built from existing equipment and instruments. For example, variable speed pumps were used to pump hot and cold water into a mixing flask. A control loop for water temperature was configured with the TDC 3000. Later, more complex experiments having prewired instrumentation were purchased from Hampden Engineering. These experiments were designed to be connectible to a remote DCS computer, for remote automatic operation.

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The Hampden equipment includes a liquid-liquid extraction unit, a gas absorber, a pH control unit, and a multifunction heat exchanger system. The wiring and configuration of these systems has been the subject of laboratory classes in process control taken by both chemical and electrical engineering students. For example, the heat exchanger unit was fitted with a pneumatic control valve, and the experiment was modified from a *monitoring* of the effect of water flow on heat transfer, to a *control* experiment. A group of senior chemical engineering students connected the valve, provided for instrument air, connected the wires through the marshalling panels described above, and configured the appropriate control instrumentation points in the TDC 3000. Figure 12-15 show the heat exchanger unit, wiring in progress, the schematic used to operate the system, and process testing.

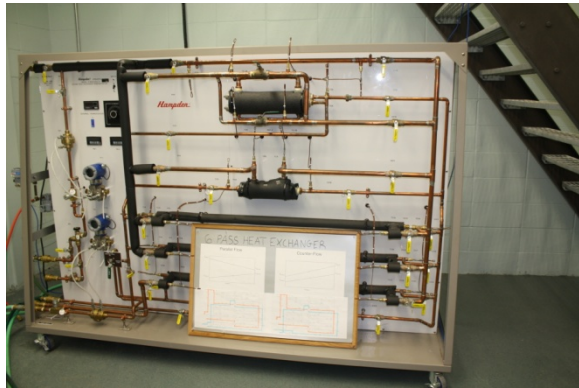


Figure 12 – Heat Exchanger System

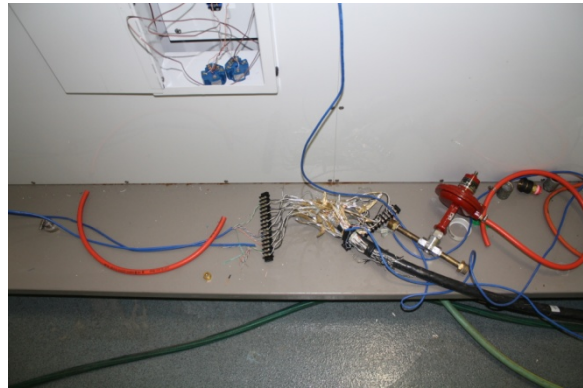


Figure 13 – Wiring HX to DCS

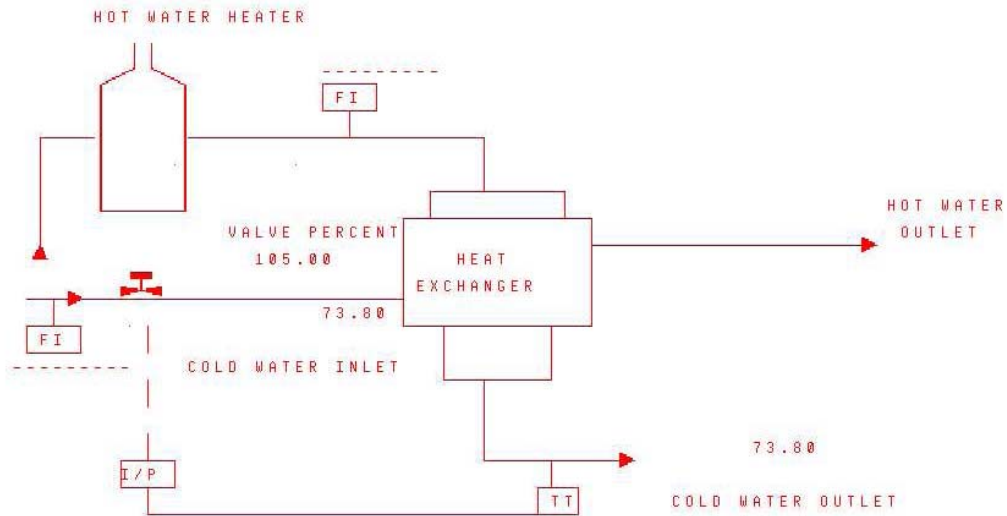


Figure 14 – Operator Interface for Heat Exchanger System

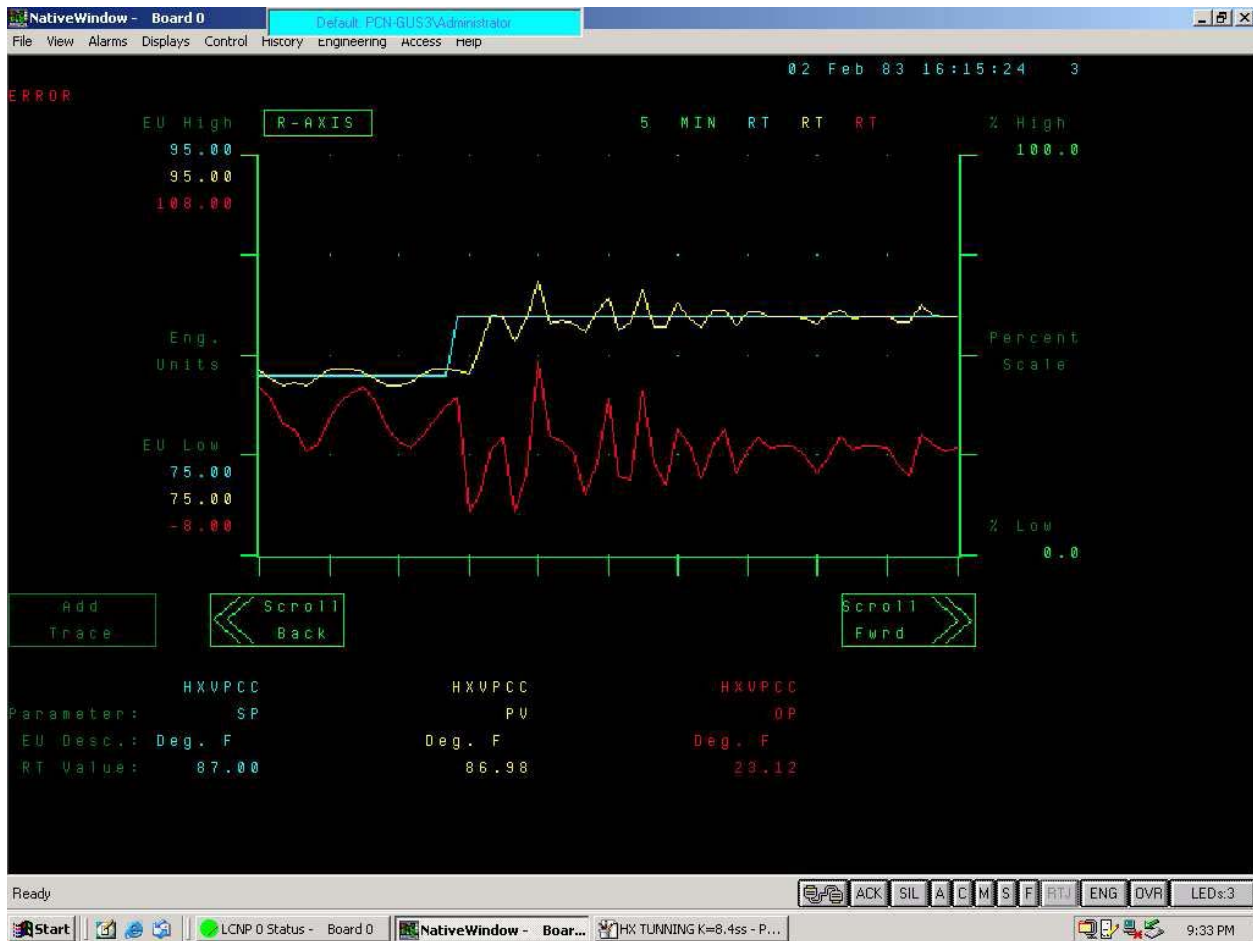


Figure 15 – Testing of the Heat Exchanger Control System

The work described here represents about one year of development. Since then (in the last year and a half) further developments have occurred. These include interfacing of a Bayport process trainer to the TDC-3000 (figure 16), and acquiring and interfacing a Polaris Hands-on-Trainer to both the TDC-3000 and the Delta-V (Figure 17).

In summary, a large amount of investment has been made to upgrade the process control capabilities at McNeese. Funding has come from various sources, much of it from private and industrial partners, whose contributions are gratefully acknowledged. Future developments include expanding the outdoor unit to include distillation capabilities.

This has been a rewarding experience. Possessing knowledge about the Honeywell systems and possessing knowledge about operating the systems represent a valuable addition to any engineer's resume'.

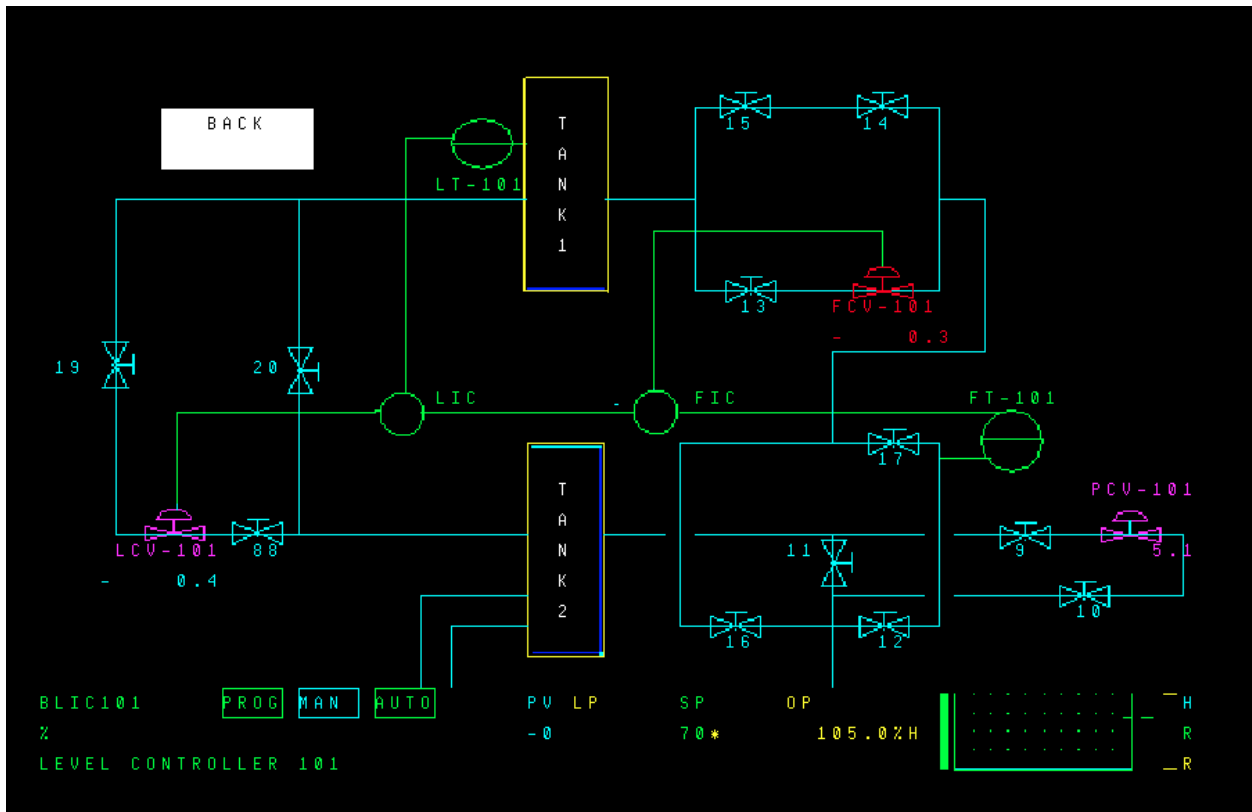


Figure 16 – Operator Interface for Bayport Trainer



Figure 17 – Polaris Hands-on-Trainer

Appendix I - Honeywell Equipment					
Model #	Extension #	Reference #	Box #	Location	Assy #
C-JDP00		CF05		B3	
J-JDD50		DR04		B3	
J-JDD50		DF04		B3	
J-JDD50		EF04		B3	
J-JDD50		BR04		B3	
C-TCB	TCB20	DR06	BOX 9	C2	
C-TCB	TCB50	ER07	BOX 8	C2	
C-TCB	TCB20	ER06	BOX 8	C2	
C-TCB	TCB50	DR07	BOX 9	C2	
C-TCB	TCB50	DF07	BOX 6	C2	
C-TCB	TCB50	BR07	BOX 11	C2	
C-JDP00		DF05		B3	
C-JDP00		BR05		B3	
C-JDP00		DR05		B3	
C-TCB	TCB50	EF07	BOX 7	C2	
C-TCB	TCB20	BR06	BOX 11	C2	
C-TCB	TCB20	CF06		C2	
C-TCB		CF07		C2	
C-TCB	TCB20	EF06	BOX 7	C2	
C-TCB	TCB20	DF06	BOX 6	C2	
C-JDP00		ER05		B3	
C-JDP00		EF05		B3	
C-SSC61-2		CF05		B5	
C-SSC61-1		CF04		B5	
					51103224-100
IBI WITH A/D					82408215-001
				B4	4DP7APPRT201-0
RiS 1218				B4	
J-CB535				A3	
J-CB531	CB530	ER02	BOX 8	A3	
J-CB531	CB530	DF02	BOX 6	A3	
J-PF200	PF200	EF03	BOX 7	A3	
J-PF200	PF200	DR03	BOX 9	A5	
J-CB531				A5	
J-CB531	CB530	EF02	BOX 7	A5	
J-PF200	PF200	DF03	BOX 6	A5	
J-CB531	CB530	BR02	BOX 11	A2	
J-PF200	PF200	ER03	BOX 8	A2	
J-PF200	PF200	BR03	BOX 11	A2	
J-CB531	CB530	DR02	BOX 9	A2	
J-PF200	PF200		BOX 14	B1	
J-CB531	CB530			B1	
J-CDP50				B2	
J-CDM50				B2	
J-JDD50	JDD50	ER04		B3	
J-OD500				NW	
PISB13	MODEL 165			B5	
PISB13	MODEL 165			B5	