AENT4295 – EMERSON CAPSTONE PROJECT

Andrew Hohn, Abby Ratcliffe, Mike Engen, Sam Finkelson, Matt Ringsven, Pheng Thao

EJ Daigle

DUNWOODY
COLLEGE OF TECHNOLOGY

Team Composition

Andrew Hohn – Previously worked for Buhler, Inc. as an installation supervisor building flour mills. Tutor at Dunwoody since 2019. Graduated in 2019 with an AAS in Automated Systems and Robotics and worked at PaR Systems as a machine builder until returning to Dunwoody in 2020 to join the Automation & Controls Engineering BAS program. He recently joined John Henry Foster as a mechanical engineer. For this project, he handled project management, mechanical design, P&ID diagrams, and the bill of materials for Phases 1 and 2 of the system.

Abby Ratcliffe – Graduated with an AAS in Industrial Controls and Robotics in 2019 and returned to Dunwoody in 2020 to start the Automation & Controls Engineering program. She currently works for the FBI as an Electronic Technician. For the purpose of this project, she handled project documentation (such as the proposal, written report, presentation and pictures), along with assisting in implementing the mechanical design of the system.

Mike Engen – Graduated with an AAS in Electrical Construction and Maintenance in 2020 and continued at Dunwoody in 2020 to start the Automation & Controls Engineering program. For the purpose of this project, he handled electrical design, implementation of design, and electrical expertise.

Team Composition cont.

Sam Finkelson – Graduated with an AAS in Automated Systems and Robotics in 2019 and returned to Dunwoody in 2020 to start the Automation & Controls Engineering program. He currently works at Syntegon as an electrical engineer. For the purpose of this project, he managed inventory items we received, and handled HMI programming and panel wiring implementation for the program.

Matt Ringsven – Graduated with an AAS in Automated Systems and Robotics in 2017 and returned to Dunwoody in 2020 to start the Automation & Controls Engineering program. He currently works at MTS as an Engineering Technician. For the purpose of the project, he was our chief engineer: helping design, assemble, wire and implement phase one of the system.

Pheng Thao – Graduated with an AAS in Automated Systems and Robotics in 2019 and returned to Dunwoody in 2020 to start the Automation & Controls Engineering program. He currently works at Wunderlich-Malec Engineering as a Controls Engineer. For the purpose of the project, he designed and implemented the custom control panels and Wonderware software.

AENT - Program Outcomes

(1) an ability to apply knowledge, techniques, skills and modern tools of mathematics, science, engineering, and technology to solve broadly-defined engineering problems appropriate to the discipline;

(2) an ability to design systems, components, or processes meeting specified needs for broadly-defined engineering problems appropriate to the discipline;

(3) an ability to apply written, oral, and graphical communication in broadly-defined technical and non-technical environments; and an ability to identify and use appropriate technical literature;

(4) an ability to conduct standard tests, measurements, and experiments and to analyze and interpret the results to improve processes; and

(5) an ability to function effectively as a member as well as a leader on technical teams.

Abstract

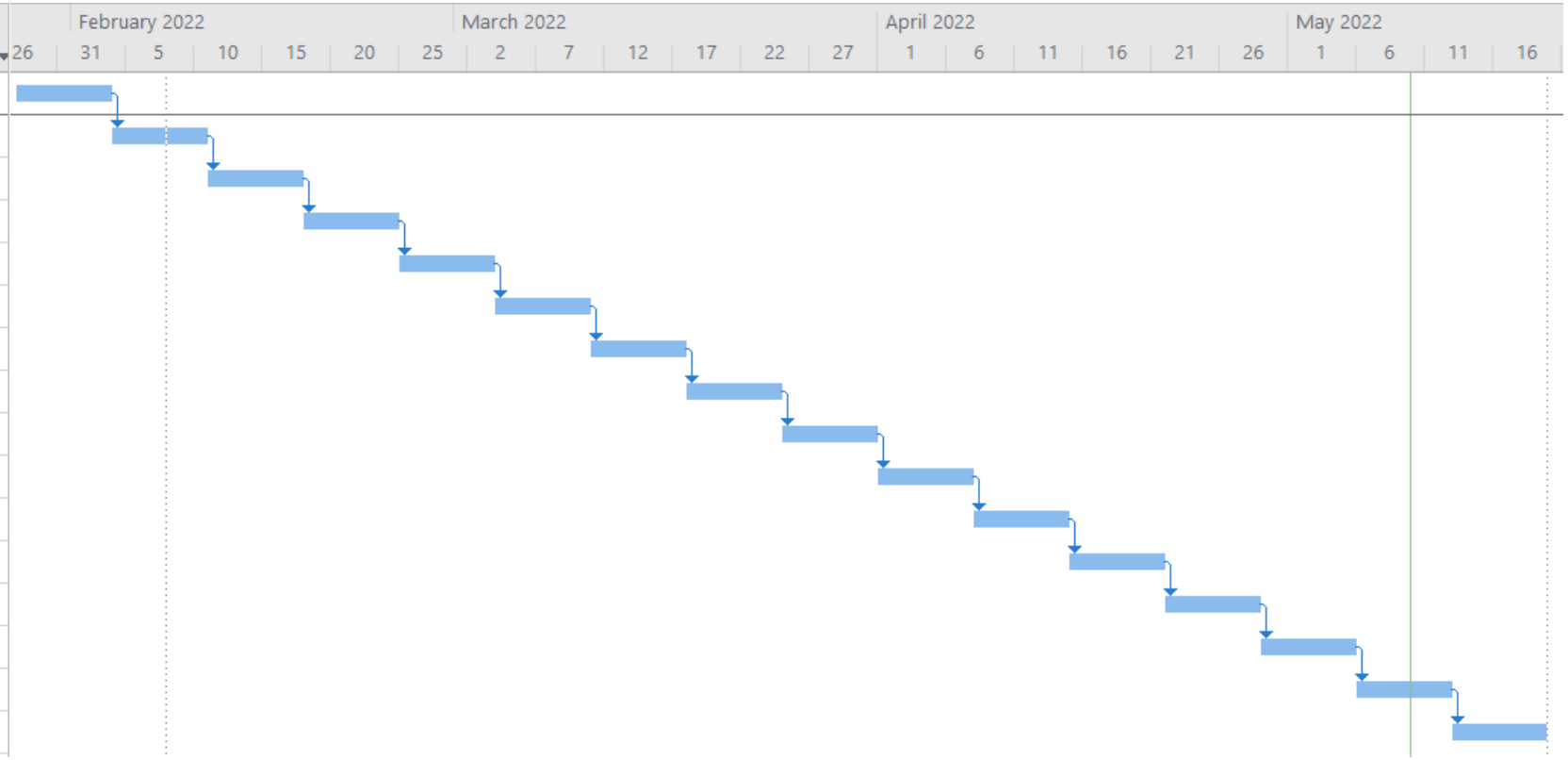
The goal of this capstone project was to design and build an industrial automation lab station for fluid handling in the Controls Engineering Lab, room blue 60. There are several benefits the lab station offers students: they can practice programming PID control systems with industrial instrumentation that they will likely encounter in their careers; they can observe real fluid dynamics and thermodynamics in action; and it provides opportunities for future capstone projects to expand its capabilities.

Top Level Requirements

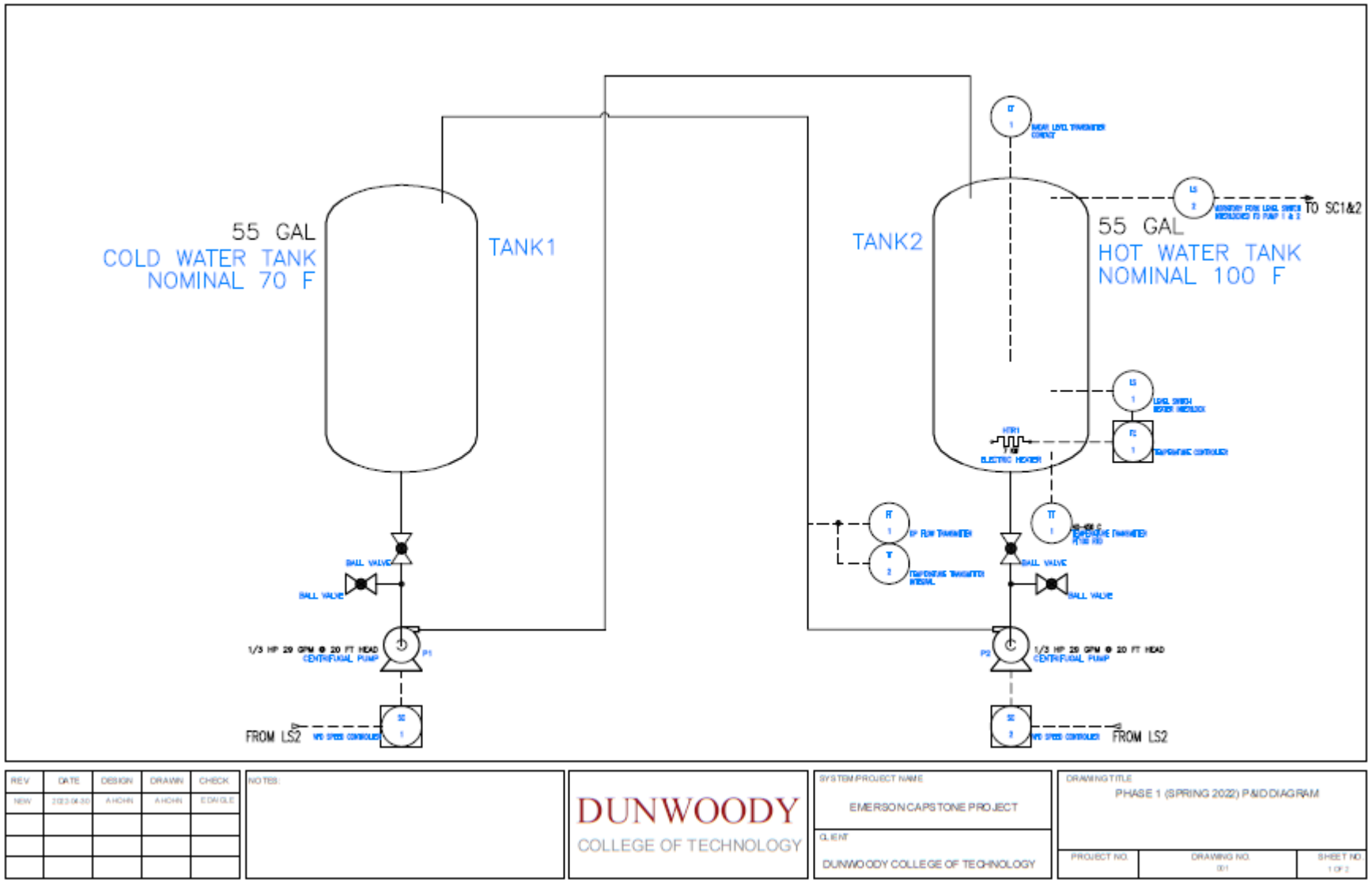
Requirements	Assessment
Move Water	Accomplished by using VFDs and PLC program to move water through tanks.
Measurement	Accomplished by using a vibratory fork level switch to prevent overflow, and a level transmitter to measure water level.
HMI Display	Accomplished by using a PLC and headless HMI to display level in real time
P&ID	Accomplished by drafting Piping & Instrumentation Diagrams in AutoCAD Electrical; printed and displayed in plexiglass for reference and troubleshooting.
Easy to Use	Accomplished by using intuitive, clearly labeled buttons, switches, and indicator lights interfaced to the PLC.
Prevent Overflow	Accomplished by using less than a full tank of water in the entire system and a redundant fork level switch on Tank 2 to turn off both pumps (wired for safe failure).

Project GANTT Chart

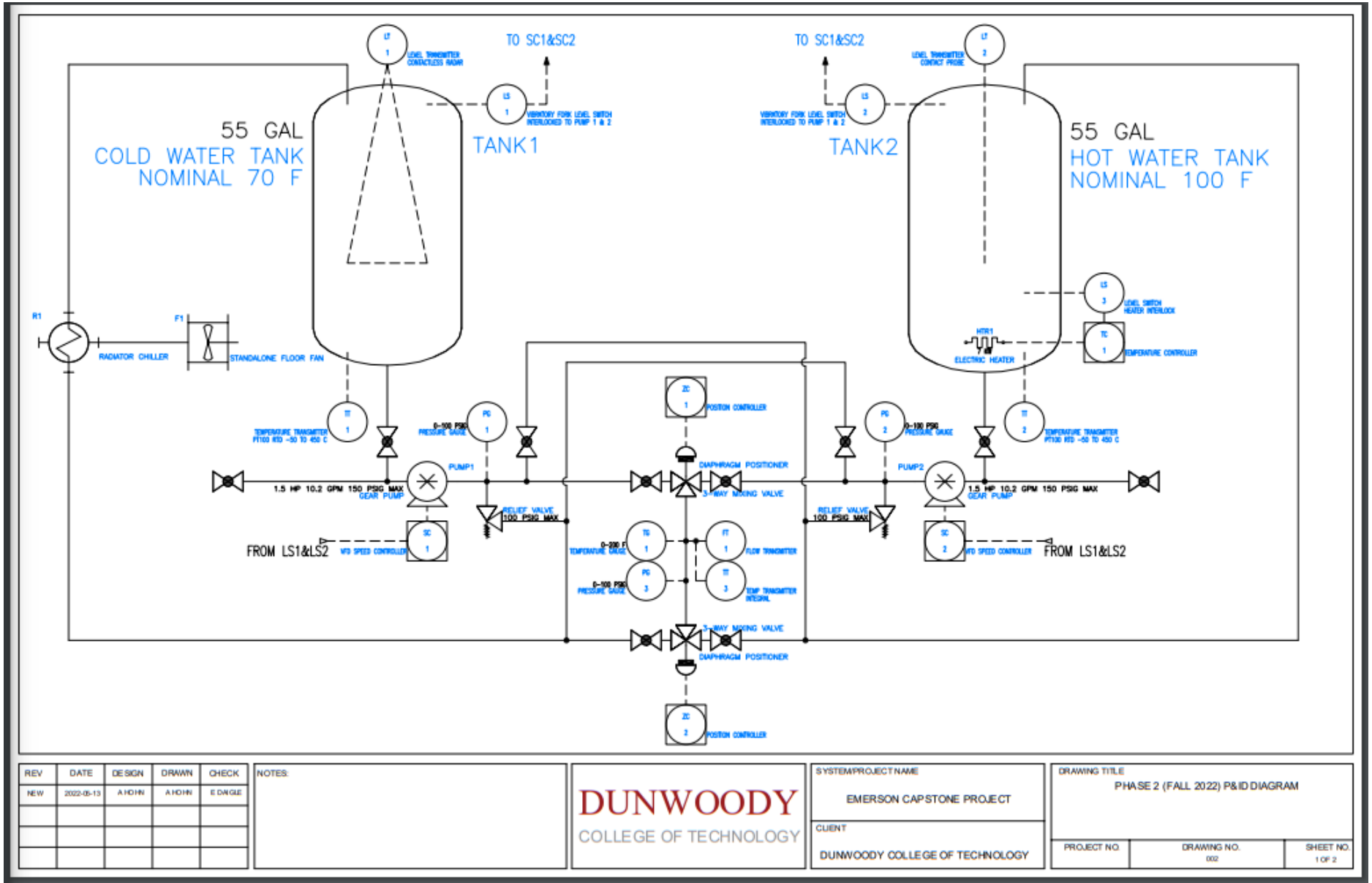
Task Name	Duration
Start Project	5 days
Visualize project	5 days
Order parts	5 days
Emerson meeting	5 days
Work on sizing pipes	5 days
HMI programming	5 days
Program PLC	5 days
Start assembling tanks	5 days
Start assembling panel	5 days
Working on projects	5 days
Install Level sensor	5 days
Install Heater and high level sensor	5 days
Finish Panel	5 days
Test manual control and level sensor	5 days
Wrap up HMI and practice presentation	5 days
Present	5 days



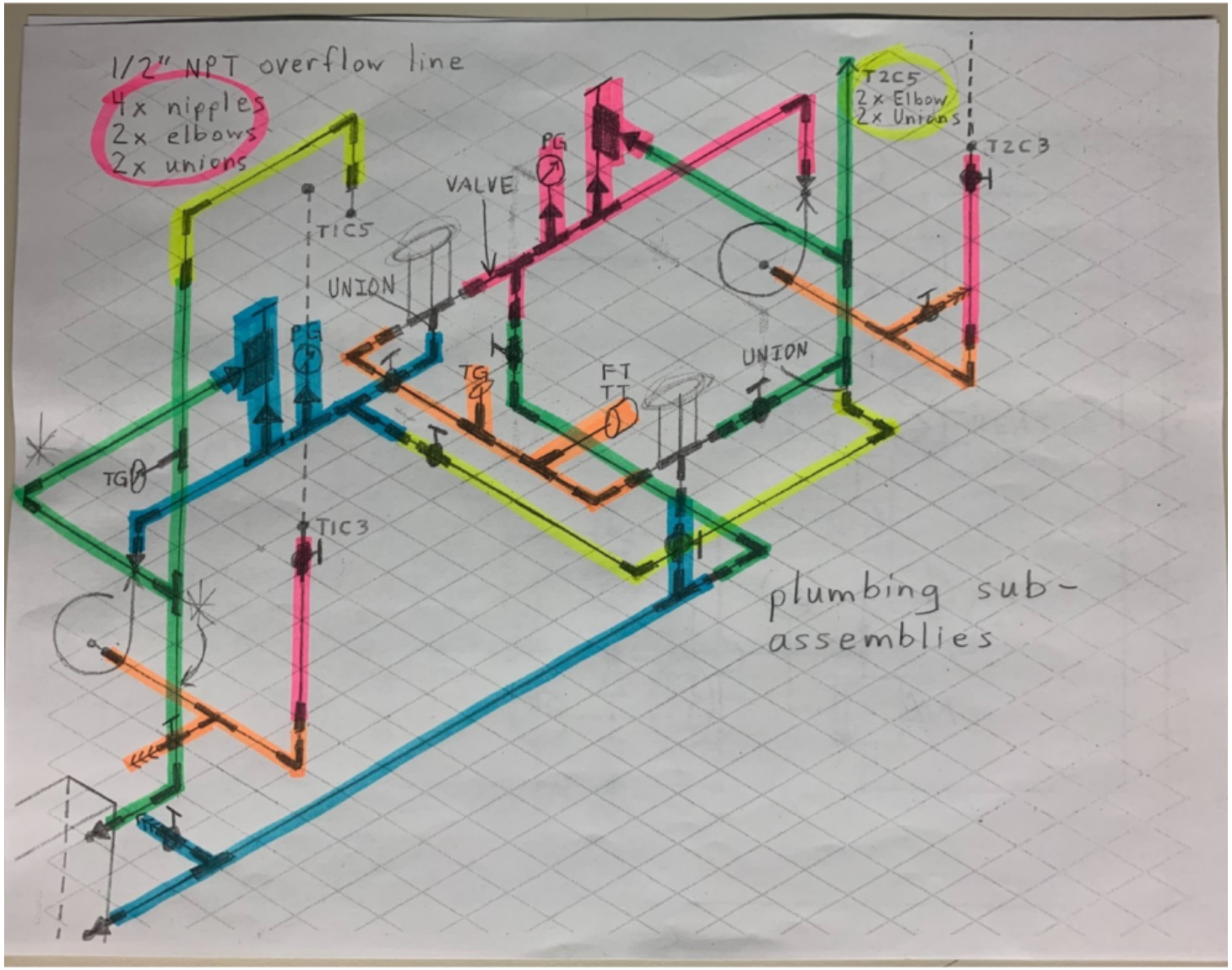
Technical Slide – Mechanical Phase 1



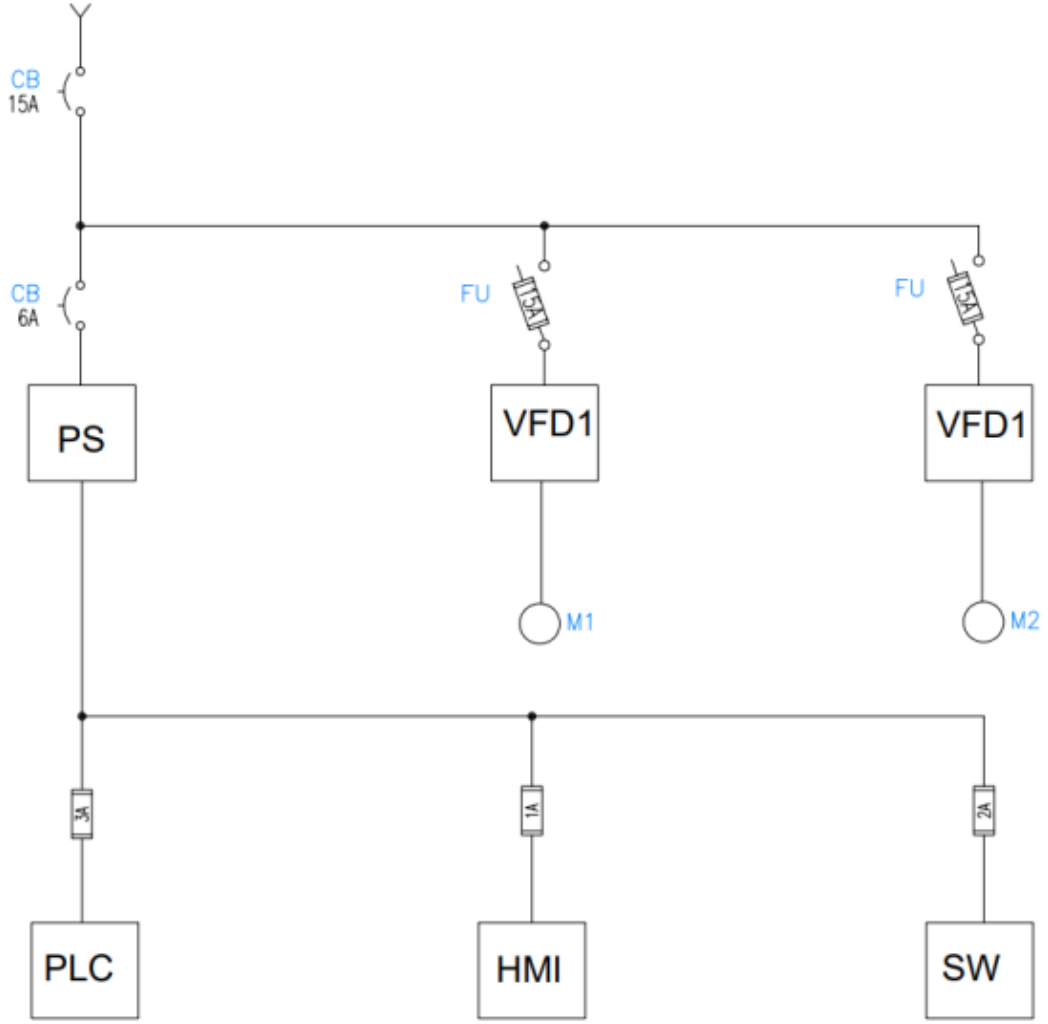
Technical Slide – Mechanical Phase 2



Technical Slide – Mechanical Phase 2



Technical Slides – Electrical P&ID



Technical Slides – Electrical Control Panel

Technical Slides – Electrical Control Panel Cont..

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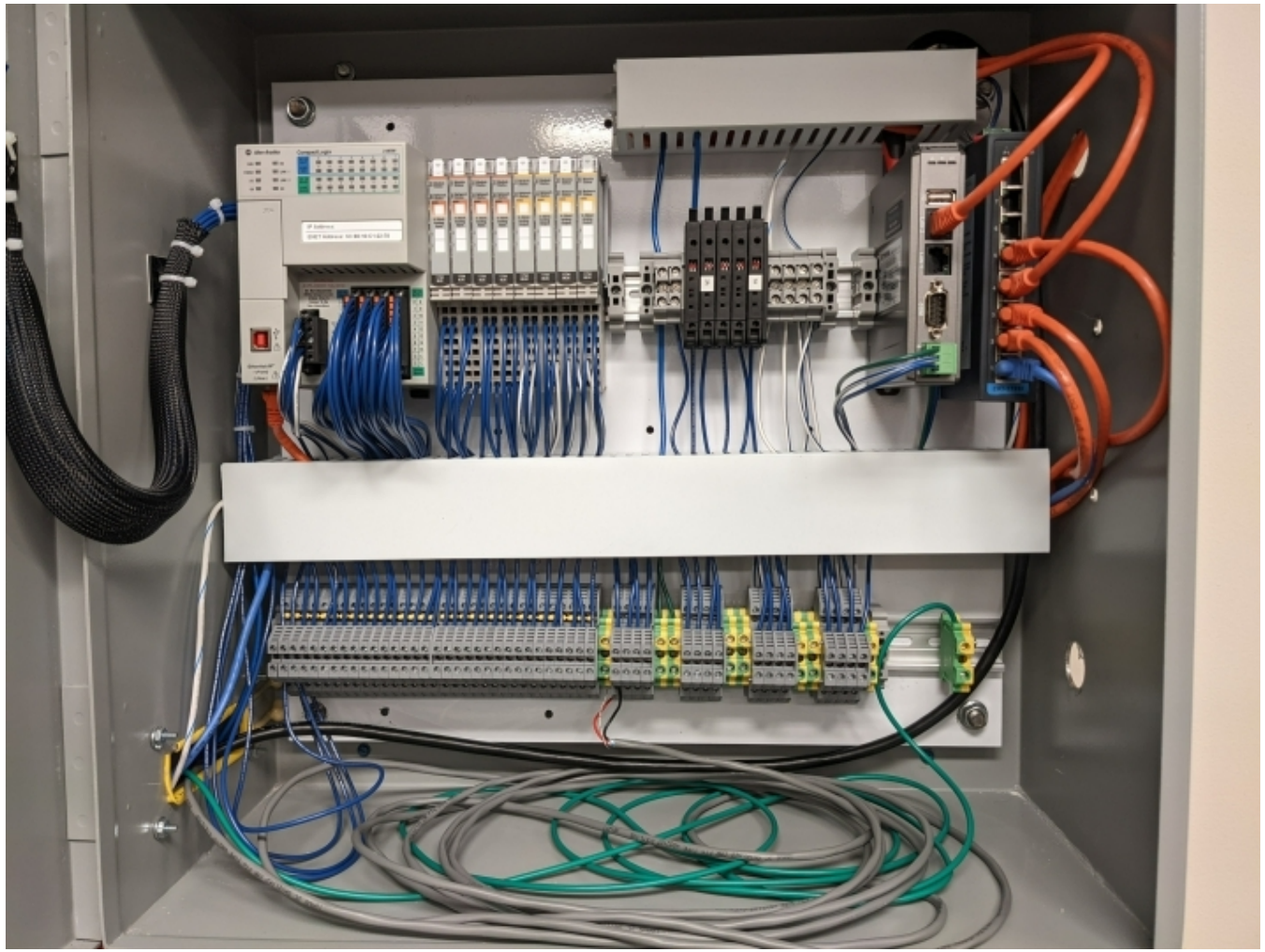
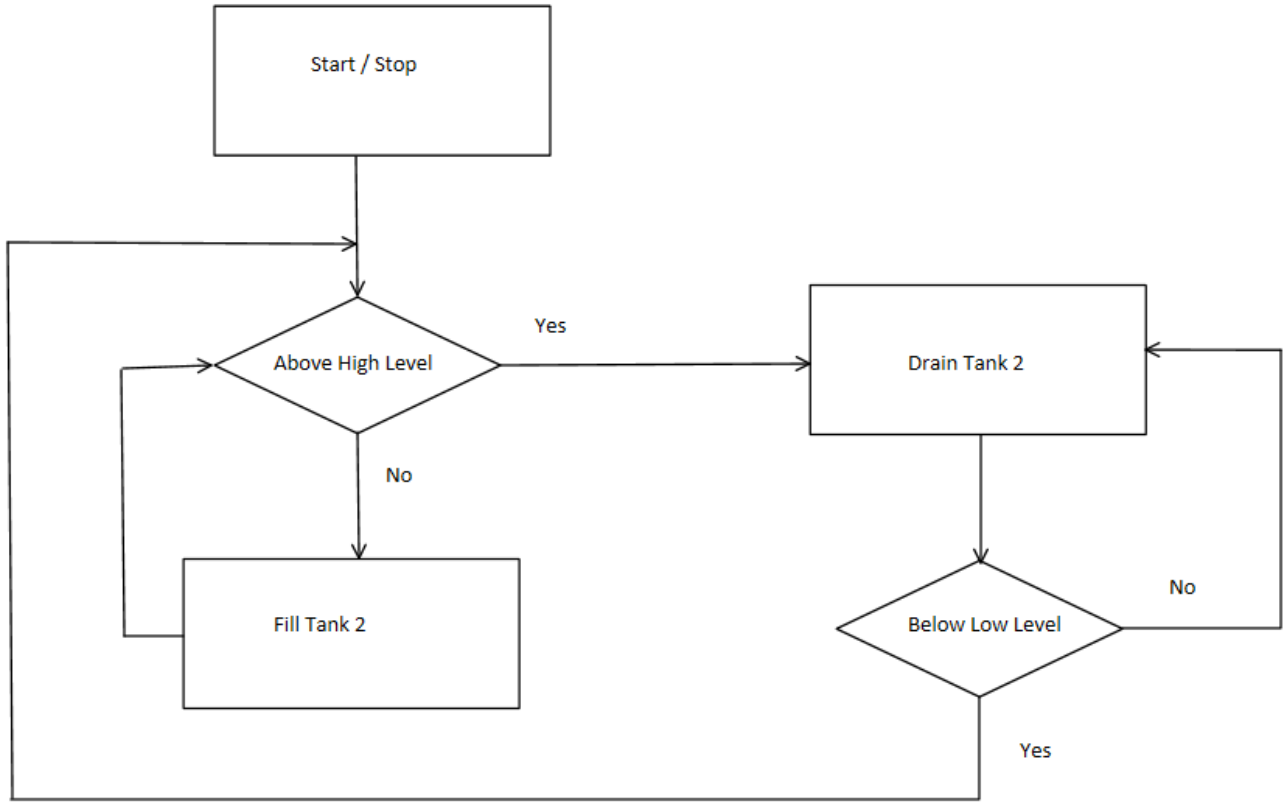


Technical Slides – Electrical Control Panel Cont..

Technical Slides – Programming



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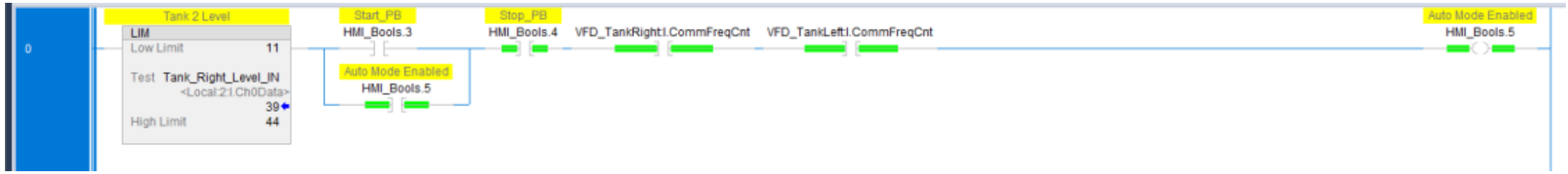

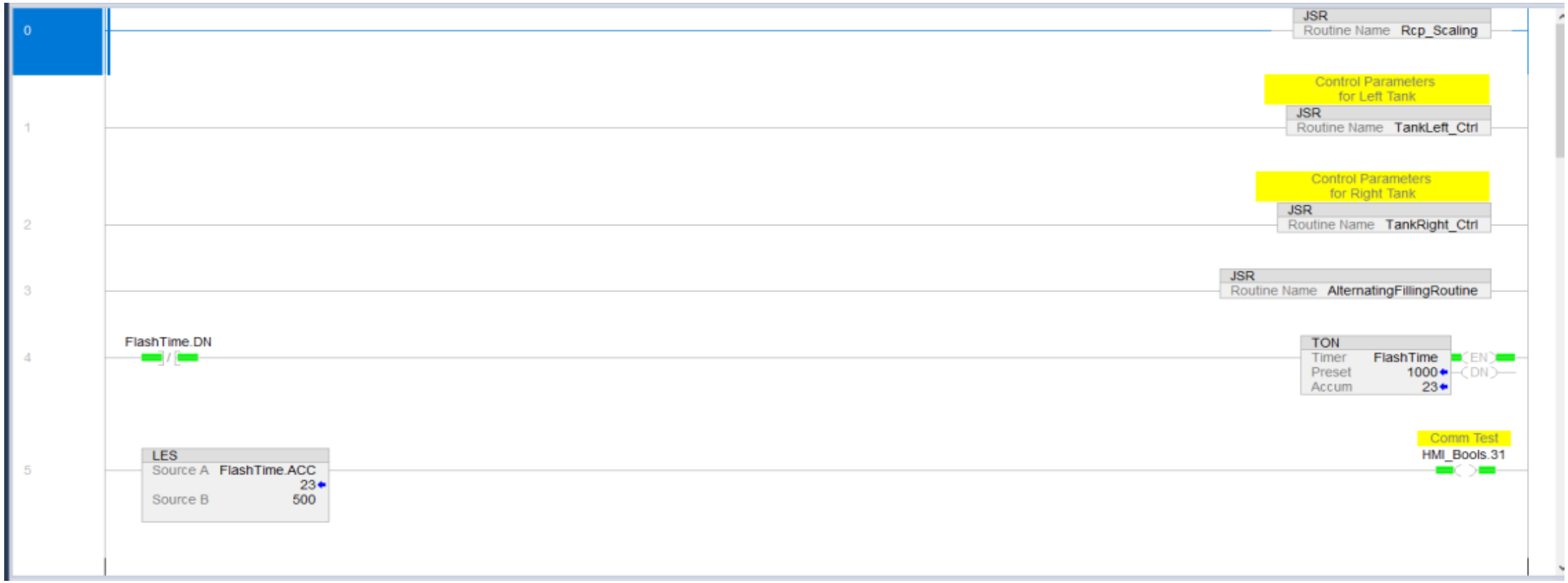

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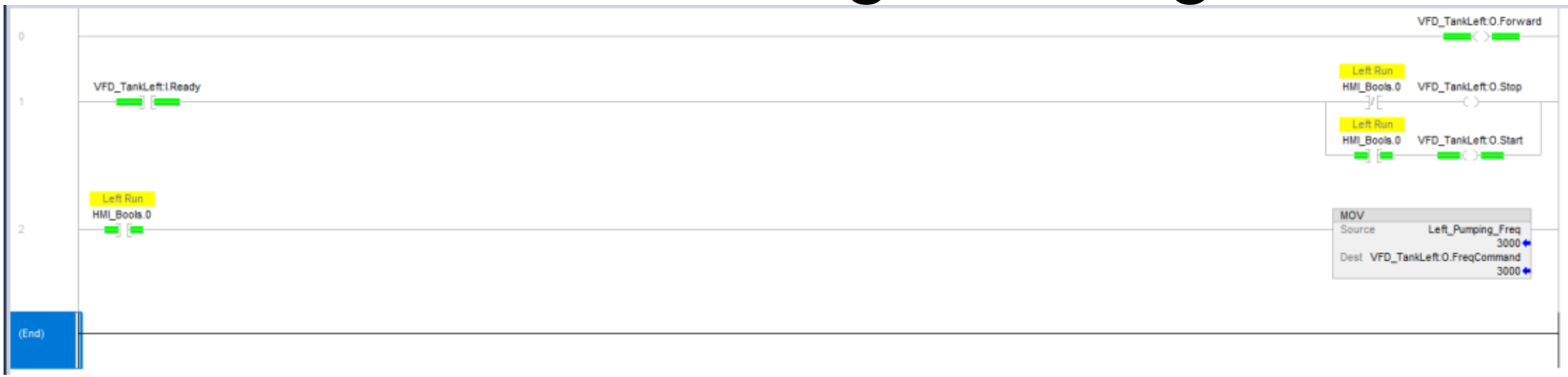

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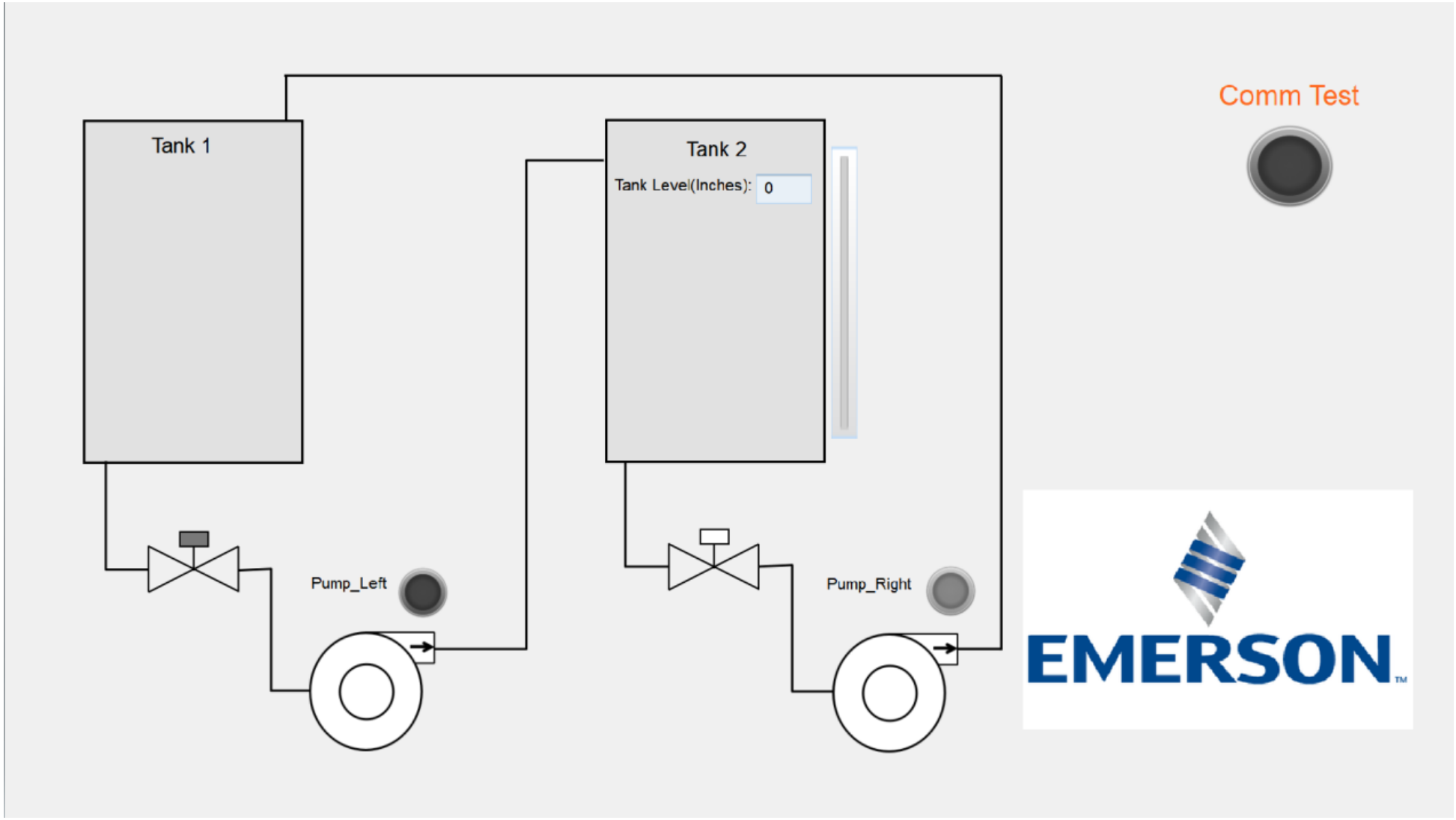

Project Bill of Materials: Mechanical

Item Description	Part Number	Quantity	Total Cost	Vendor
Plumbing Components: 1" NPT Stainless Steel	Various #s, listed on full Bill of Materials	126	$2,886.56	McMaster Carr
3-Phase Electric Submersible Tank Heater	3656K136	1	$460.00	McMaster Carr
3-phase Variable Speed Electric Pump	1BF40334	2	$2,360.00	Grainger
405P Compact Orifice Plate Primary Element	405PS010T065D3	1	$2,010.00	Emerson
55-gallon stainless steel tank	P53390	2	$12,910.00	Midwest Tank
Non-Contact Radar Level Probe	5408A1SHA1NA1NAZZCAD2	1	$4,360.97	Emerson
Normally open float switch	49175K38	1	$31.00	McMaster Carr
PT100 RTD Sensor	Unkown	2	$426.90	Emerson
RTD for Primary Element Orifice Plate	405PS010T065D3	1	$213.45	Emerson
Temperature Transmitter	3144PD1A1NAM5XA	2	$4,017.40	Emerson
Thermowell	114CE0060TAA2SC017AXW	2	$360.92	Emerson
Vibratory Fork Level Switch	2120D1DV1NADA0000	1	$1,243.64	Emerson
		Sub Total	**$31,280.84**	

Project Bill of Materials: Electrical/Controls

Item Description	Part Number	Quantity	Total Cost	Vendor
1734-IE2C Two-Channel Analog Input Module	1734-IE2C	4	$361.80	Allen Bradley
1734-OE2C Two-Channel Analog Output Module	1734-OE2C	4	$376.92	Allen Bradley
1734-TBS point I/O bases	1734-TBS	11	$76.89	Allen Bradley
Conduit/Cable Trays	B09DYMRL2T	4	$104.00	Amazon
Headless HMI Module	CMT-FHDX-220	1	$729.38	Maple Systems
MicroLogix 1769-L18ERM-BB1B PLC	1769-L18ERM-BB1B	1	$972.80	Allen Bradley
Monitor for HMI Display (LG TV 50in)	Unkown	1	$349.99	Micro Center
PowerFlex VFD’s	25B-V4P8N104	2	$768.50	Allen Bradley
		Sub Total	**$3,740.28**	

GRAND TOTAL FOR PROJECT	**$35,021.12**

Conclusion

- Phase 1 of the system is operational; moving water and measuring level.
- Pumps transfer water at VFD frequency as low as 20 Hz
- Used the level transmitter to measure and display level on headless HMI in real time
- Challenges:
  - The manual pipe threader dies weren't meant for stainless steel pipe, so a lathe was used to thread the pipes more reliably for more accurate assembly.
  - While calibrating the level transmitter, we struggled to determine the parameters to get it to read the level accurately in real time, and we eventually identified the culprit to be the dead zone where it enters the tank.
  - We continue to struggle with water clarity and purity, and we suspect the bleach additive is rusting the cast iron housings of the pumps which is discoloring the water.

Recommendations for the Future

- Implement our phase 2 proposal; especially positive displacement gear pumps with pressure relief valves and return lines for linear flow behavior
- Clean and electroplate the insides of the tanks with copper to prevent algae growing above the water line
- Filter the water while the tanks are being refilled after Summer
- Only use homeopathic copper-based sterilizer in the water instead of caustic bleach
- Install containment dam in case of water leaks

Music Video

- Emerson.mp4

Questions

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Demonstration

- Go to Controls Engineering Lab (BLU60) to demonstrate system.