SENIOR DESIGN PROJECT REPORT:

IOT BATCH MIXING SKID UPGRADE

Submitted to:

Professor (Robert Weissbach)

Electrical & Computer Engineering Technology

Program by

Siang Thang

Andy Lyons

Tendai Ruzvidzo

04/29/2023

IOT BATCH MIXING SKID UPGRADE

ABSTRACT

This report is a summary of the IoT Batch Mixing Skid Upgrade team’s senior design project to meet the requirements provided by Dr. Elizabeth Freije and Dr. Phil Pash. The request was to upgrade an existing tank instrumentation system that measures flow, temperature, level, and pressure within the system to an IoT capable instrumentation system. The team planned to replace current Endress and Hauser components with components that could communicate wirelessly. The report consists of the objective of the project, the design of the project, and components/devices that will be replaced. The focus of the report is to reveal our design, the new process of the system, how it functions, and the new devices and components that we replaced and tested for this project.

IOT BATCH MIXING SKID UPGRADE

TABLE OF CONTENTS

IOT BATCH MIXING SKID UPGRADE

IOT BATCH MIXING SKID UPGRADE

IOT BATCH MIXING SKID UPGRADE

REVISION HISTORY

Version	Date	Revised by	Description
1.0	12/09/2022	Siang T. Andy L. Tendai R.	Starting our report
2.0	03/30/2023	Siang T, Andy L, Tendai R	Draft
3.0	4/28/2023	Siang T, Andy L, Tendai R	Final Draft

1. INTRODUCTION

The world is changing quickly, especially over the last century. Today there is an expectation that all of the devices we use in our everyday lives must be wirelessly connected. While this may have seemed like a foreign concept more than one hundred years ago, there was a vision even then. The great Nikola Tesla was quoted, "It will soon be possible to transmit wireless messages around the world so simply that any individual can carry and operate his own apparatus." (“Nikola Tesla quote: It will soon be possible to transmit wireless ...”)

This concept was an important part of the direction we received from our project sponsors, Dr. Elizabeth Freije, and Dr. Phil Pash. For our project, we were required to upgrade an existing instrumentation system to an IoT capable instrumentation system. Instrumentation devices are devices that measure or manipulate physical variables such as flow, temperature, level, and pressure. Instrumentation devices exist to make sure the systems and processes operate effectively. Adding wireless communication processes will increase the efficiency and effectiveness of the system.

Our system consists of instrumentation devices that measure flow, pressure, temperature, and level of fluid in the tanks of the system. The system consists of four tanks in which the instrumentation devices and controls are found. All the existing instrumentation controls and devices are Endress and Hauser brand. In our project, we planned to replace the existing instrumentation controls with Endress and Hauser IoT capable instrumentation devices and controls. Endress and Hauser is a company that manufactures instrumentation devices and controls. According to the Endress and Hauser company website, "Endress and Hauser is a global leader in measurement instrumentation, services and solutions for industrial process engineering."

1.1 Problem Statement

Our problem statement is to replace the existing Endress and Hauser devices and controls on the Batch Mixing Skid with wireless Endress and Hauser devices and controls, without changing the operation of the mixing skid.

- **What?** Upgrade the Batch mixing skid to communicate wirelessly.
- **Where?** IUPUI - Using Endress and Hauser Devices and Controls.
- **When?** By May 2023.
- **To What Extent?** To upgrade the communication to wireless connections using an adapter attached to the existing devices to allow data logging as currently available.
- **I Know Because?** The existing Endress and Hauser devices and controls cannot data log

wirelessly, and this is a desired outcome.

Competitive landscape:

The main competitor for our project is Siemens. The strengths of the company are that it is well known in the industry and the supply chain may be stronger. The weaknesses are that the cost is high and not all of the sensors would be an easy replacement for Endress and Hauser.

1.2 System Overview

Our system is a mockup system that is similar to any batch mixers in the real world. It functions by taking two different liquids, mixing the liquids, and recirculating the mixed liquids into different tanks. Our system has 4 different tanks. Tank 1 is the mixed goods tank. Tank 2 is the finished goods tank. Tanks three and four are the fill tanks. In tanks 1 and 2, the liquid is introduced and then transferred to the finished goods tank in which the liquid is then mixed and transferred to the last tank, the finished goods tank. This is the end process of the system. The system process is run by a PLC program which has an HMI interface. The HMI interface has buttons and indicators. The start button, when pressed, starts the system if the requirements such as closing or opening valves are met. The indicators show the stage/ process at which the system is at when running.

2. REFERENCED DOCUMENTS

The listed documents are completed and signed by our customers/sponsors and advisor.

IOT BATCH MIXING SKID UPGRADE

Table 1: Reference Documents

Title	Document Reference #	Comment
Requirements Specification for Iot Batch Mixing Skid Upgrade	0.02	In Draft
High Level Design for Iot Batch Mixing Skid Upgrade Project	0.02	In Draft
Senior Design Report	0.01	Submitted and signed
Dugger_Lenahan_Final Pape r. Pdf	1	Adobe Portfolio 2017 Batch mixing skid project

3. SYSTEM-WIDE DESIGN DECISIONS

Inputs and Output

Our system has one major input and output that enables the other inputs and outputs. The input is liquid. We do not have a specific liquid identified for the system, but we are designing based on water as our liquid. The other inputs we have in our system are level, pressure and temperature sensors, flow meter, heater, valves, pipes, mixer, and tanks. Our inputs are interfaced with the PLC and run through a PLC program Studio5000. The level sensors we have in our system are the Endress and Hauser level flex m, Prosonic-M Level Sensor, Liquipoint Level Detection(conductive), the Liquipoint Level Detection(capacitive) and Liquiphant FTL20. All the listed inputs are to be replaced by IoT capable sensors from the same manufacturer/ supplier, Endress and Hauser. All inputs are connected to the four tanks that we have in the system independently. Each tank has some sensors on it. The outputs for our system are the end-product of heated, and mixed liquid as well as the data captured through

IOT BATCH MIXING SKID UPGRADE

Endress and Hauser cloud called Netilion.

System Behavior

The entire system is run by the PLC. The conditions on the sensors will enable smooth operation. After reviewing the Process Overview section in the Functional Specifications document and the documentation requirements section, our understanding of the system's behavior is that when the process starts running, there is a liquid in both tank one and tank two. If there is no detection of water through the level sensors in both tank one and two, the process status would be idle. Tank two has two level sensors for low- and high-level measurement, hence the system should work if the lower-level sensor is on, and the high-level sensor is off to prevent an overfill and spill. The other sensors in tanks one and two are for data logging and for the conductive level detection and the non-contact level measurements. Once the system is running and the liquid is sent to the mixing goods tank, then the liquid will be heated to a degree that is tolerable with the pipes as measured by the pressure sensor in the same tank. Next, the liquid will be sent to the final goods tank where different level measurements are done. These sensors measure capacitive level, temperature to detect any heat loss from the mixing good tank, and a continuous level measurement of powder and bulky granular solids.

Safety, Security and Privacy

We are still drafting the safety precautions for the operation of our system. The first item we will incorporate is a stop button. This will be an emergency safety stop that will be available in case we encounter a safety issue that would need us to stop the process immediately. Another one of our safety precautions is to make sure that the system only works in the presence of a liquid and the heater only works when a minimum amount of liquid is detected. To implement these safety precautions, we will add some PLC code to the existing PLC code for this system. We are also drafting some of our safety requirements based on the datasheets for the instrumentation controls and devices in our system.

4.0 SYSTEM DESIGN

4.1 System components

Our system has a total of four tanks that can be grouped into three subsystems. The first subsystem has two tanks: tank 1 and tank 2. The first subsystem is where the liquid is introduced to the system. From our understanding of the system and the process, a liquid is put in tank 1 and tank 2. There is a pipe and two valves that are for the redistribution of the liquid from the final goods tank. The second subsystem is the mixed goods tank. In this tank, the liquid from tank 1 and tank 2 are mixed and heated. The last subsystem in the hardware of our system is the final goods tank. After the mixture from the mixed goods tank is done mixing and heating, the mixture is then sent to the final goods tank in which the mixture will be redistributed to the first subsystem of the liquid through the pipes. Each of the subsystems has sensors included that monitor level, pressure, flow, and temperature.

Figure 1. Process-Tank-Sensor Map

Process 1		**Process 2**	**Process 3**
Tank 1	**Tank 2**	**Mixed Goods tank**	**Final Goods**

IOT BATCH MIXING SKID UPGRADE

Prosonic-M level sensor - LT1 (transmitter)	Liquicap-T Level detector-LSH2 (Capacitance)	Deltapilot- Hydrostatic Level Measurement LT3	Liquipoint T level measurement-LT2 0conductive)
	Two Liquiphant FTL31	RTD Temperature sensor-TE1	Levelflex m Level transmitter for granular and powder solids
			RTD Temperature sensor-TE1
Proline Promass F 300 – FIQ1			

Figure 2. Product Specifications

Tag I.D.	Order Number	Measurement Description	New Model	Techology	I/O Requirements	Notes
FIQ1	83F08-ACVSAAAABBAC	Mixing Tank Flow to Finished Goods Tank	8F3B08-AADBAEHFADSACVSAA1+LA	Mass, Coriolis	Input, Analog, 4-20 mA	Endress+Hauser Promass "A" Flow Sensor, Totalizer Capability
HTR1	SG1153L	Mixing Tank Heater		Resistance	Output, Analog	Analog Output to Control a 115V AC Heater
LSH1	FTL20 - 032C	Feed Tank #2 High Level Switch	FTL31-AA4V3AAVBJ	Tuning Fork	Input, Discrete	Endress+Hauser Liquiphant T FTL20 3-wire PNP 10-35 VDC
LSH2	FTW31-A2A3BB2A	Finished Goods Tank High Level Switch	N/A	Capacitance	Input, Discrete	Endress+Hauser Liquipoint T FTW31 3-wire PNP 10-35 VDC
LSL1	FTL20 - 032C	Feed Tank #2 Low Level Switch	FTL31-AA4V3AAVBJ	Tuning Fork	Input, Discrete	Endress+Hauser Liquiphant T FTL20 3-wire PNP 10-35 VDC
LT1	FUM40-ANB2A4	Feed Tank #1 Level	N/A	Ultra Sonic	Input, Analog, 4-20 mA	Continuous, 4-20 mA
LT2	FM151-A1PRDJAC2C1A	Feed Tank #2 Level	N/A	Capacitance Switch	Input, Discrete	Continuous, 4-20 mA
LT3	FMB70 - ABT1F422DCAA	Mixing Tank Level	N/A	Static Pressure	Input, Analog, 4-20 mA	Continuous, 4-20 mA
LT4	FMP40 - ALN2GNJB21CA	Finished Goods Tank Level		Time-Domain Reflectometer (TDR)	Input, Analog, 4-20 mA	Continuous, 4-20 mA
SRLS1				Level Radar	N/a	Mobile connectivity with NB-IoT, LTE-M or 2G (fallback)LTE/ 2G
MXR1	E46205	Mixing Tank Motor/Agitator		DC Motor	Output, Discrete, 24 VDC	Continuous, 4-20 mA
P1	5UXN4	Mixing Tank Recirculation Loop Pump		DC Motor	Output, Discrete, 24VDC	24 VDC
PT1	PMC131 - A22F1Q4H	Recirculation Loop Pressure		Static Pressure	Input, Analog, 4-20 mA	Range TDB
SV1	EF8210G093	Feed Tank #1 Output Solenoid Valve	8262H020	Discrete	Output, Discrete, 24 VDC	24 VDC
SV2	EF8210G093	Feed Tank #2 Output Solenoid Valve	8262H020	Discrete	Output, Discrete, 24 VDC	24 VDC
SV3	EF8210G093/EF8210G033	Finished Goods Tank Input Solenoid Valve		Discrete	Output, Discrete, 24 VDC	24 VDC
SV4	EF8210G093	Finished Goods Tank Output Solenoid Valve		Discrete	Output, Discrete, 24 VDC	24 VDC
Pump 1	Hilitand7un5vx6iqw	Pump out water from Tank 1 to Mixing Tank				
Pump 2	Hilitand7un5vx6iqw	Pump out water from Tank 2 to MixingTank				
Pump 3	5UXN4	Pump to Feed, Mixing, Finsihed Tank				
Pump 4	71822067	Pump water out of the system				
T1		Feed Tank #1		N/A	N/A	Stores Ingredient #1
T2		Feed Tank #2		N/A	N/A	Stores Ingredient #2
T3		Mixing Tank		N/A	N/A	Mixes, Heats and Recirculates Ingredients
T4		Finished Goods Tank		N/A	N/A	Holds and Dispenses Final Product
TE1	TH11-B1AADC1AK1	Mixing Tank Temperature Element		Resistance Temperature Detector (RTD)	N/A, Associated with TT1	4-20mA - output PT100 class B 3-wire
TE2	TH11-B1AADC1AK1	Finished Goods Tank Temperature Element		Thermocouple (TC)	Input, Low Level Analog, mV	J Type, Direct to PLC Input Card
TIC1		Temperature Controller		Analog	Output, 4-20mA	PLC Based, P&ID Control
TT1		Mixing Tank Temperature Transmitter		Analog	Input, Analog, 4-20 mA	4-20 mA

4.2 Software

Our software consists of three types of software, all used to program and communicate with the

IOT BATCH MIXING SKID UPGRADE

PLC and HMI:

- RSLinx, used to create communication between the PLC and the computer using ethernet.
- RS Logix 500, used to program the system.
    - Our system does not contain any systems built from scratch. Instead, we edited the program, used the program to troubleshoot the system.
- FactoryTalkView, used to program the HMI.
    - Our system does not include any original programming. However, we needed the software to know how the HMI operates.

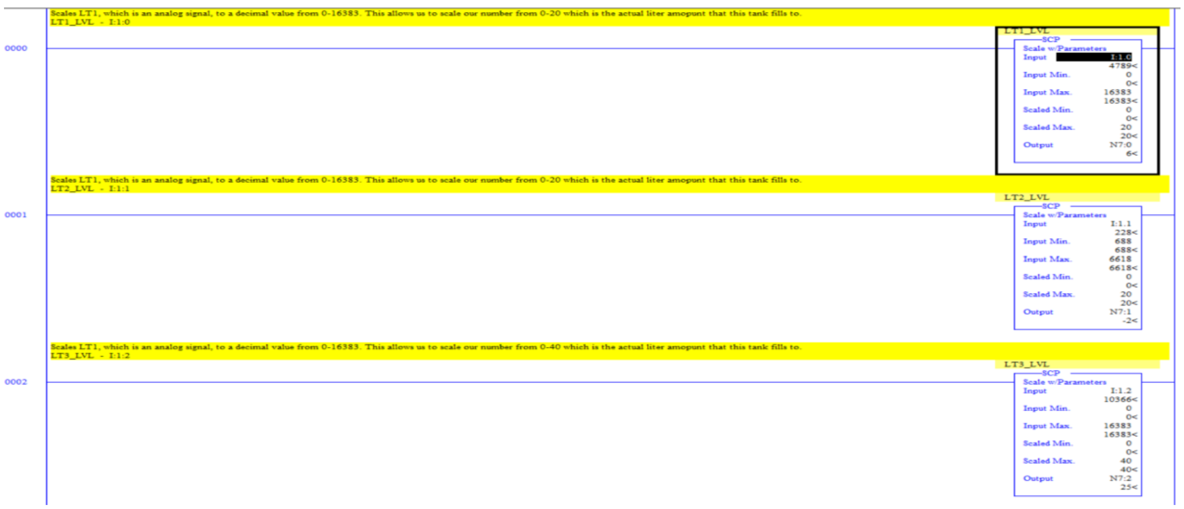
The PLC program has a main program that calls for different subroutines. There are 4 different subroutines which are scale, fill, mix, and transfer.

Scale subroutine

The first subroutine is scale. It is used to scale the sensor to correspond with a physical value. For this subroutine, there is the component SCP which calls different parameters used to scale the values on the sensor. To expedite the process for the batch mixing skid, we changed the maximum value to 10 gallons for the fill tanks and 20 gallons for the mixed goods and finished goods tank.

IOT BATCH MIXING SKID UPGRADE

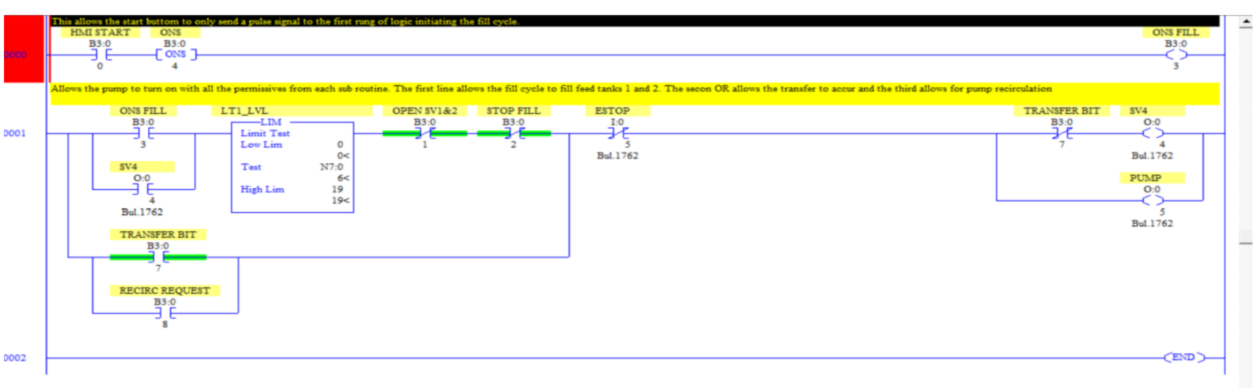
Figure 3. Scale subroutine diagram



Fill subroutine

The second subroutine is the fill routine. This routine was created to fill tanks 1 & 2. The routine only runs when the requirements for the system are satisfied. These requirements include manual operations such as closing certain valves as per the operation manual.

Figure 4. Fill subroutine diagram



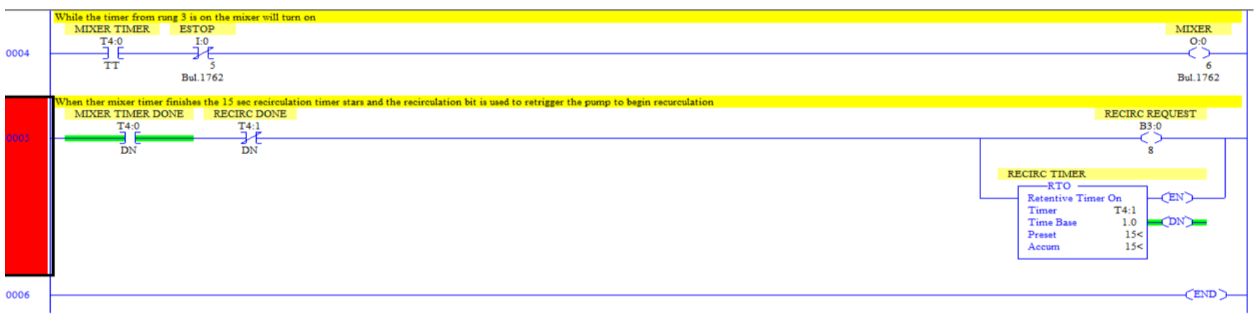
Mix subroutine.

The third subroutine is the mix routine. In this routine, the materials from tanks 1&2 are

IOT BATCH MIXING SKID UPGRADE

transferred to the mixing goods tank and when all the material has been transferred, the mixing process takes place (mixer turns on for a certain time).

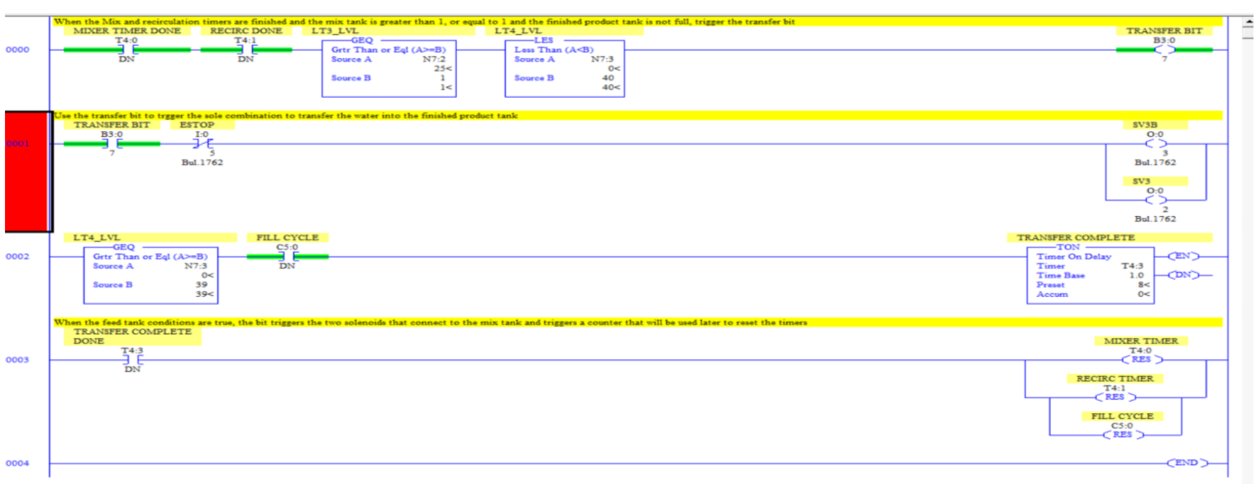
Figure 5. Mix subroutine diagram.



Transfer subroutine

The last subroutine is transfer. The transfer routine transfers the material from the mixed goods tank to the finished goods tank after the mixer is done mixing.

Figure 6. Mix subroutine diagram.



IOT BATCH MIXING SKID UPGRADE

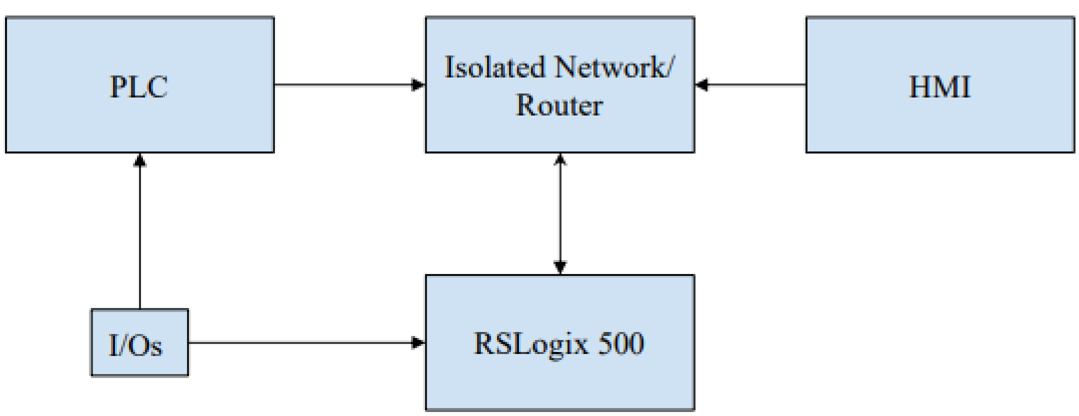
4.3 <u>Concept of execution</u>

For the software components, we used a router for communication between the PLC and RSLogix 500 since our PLC was not in the school network. Because of this, we had to create an isolated network. The communication system we created consists of direct communication from the isolated router, RSLogix 500, using an ethernet cable. The system itself runs based on a PLC program, hence making use of the brain of the system. The PLC we are using is Allen Bradley series 1200 that works with RSLogix 500. The main system in the software is the CPU because it is being used to interface the PLC program into the batch mixing Skid to make it run.

4.4 <u>Interface design</u>

System Communication

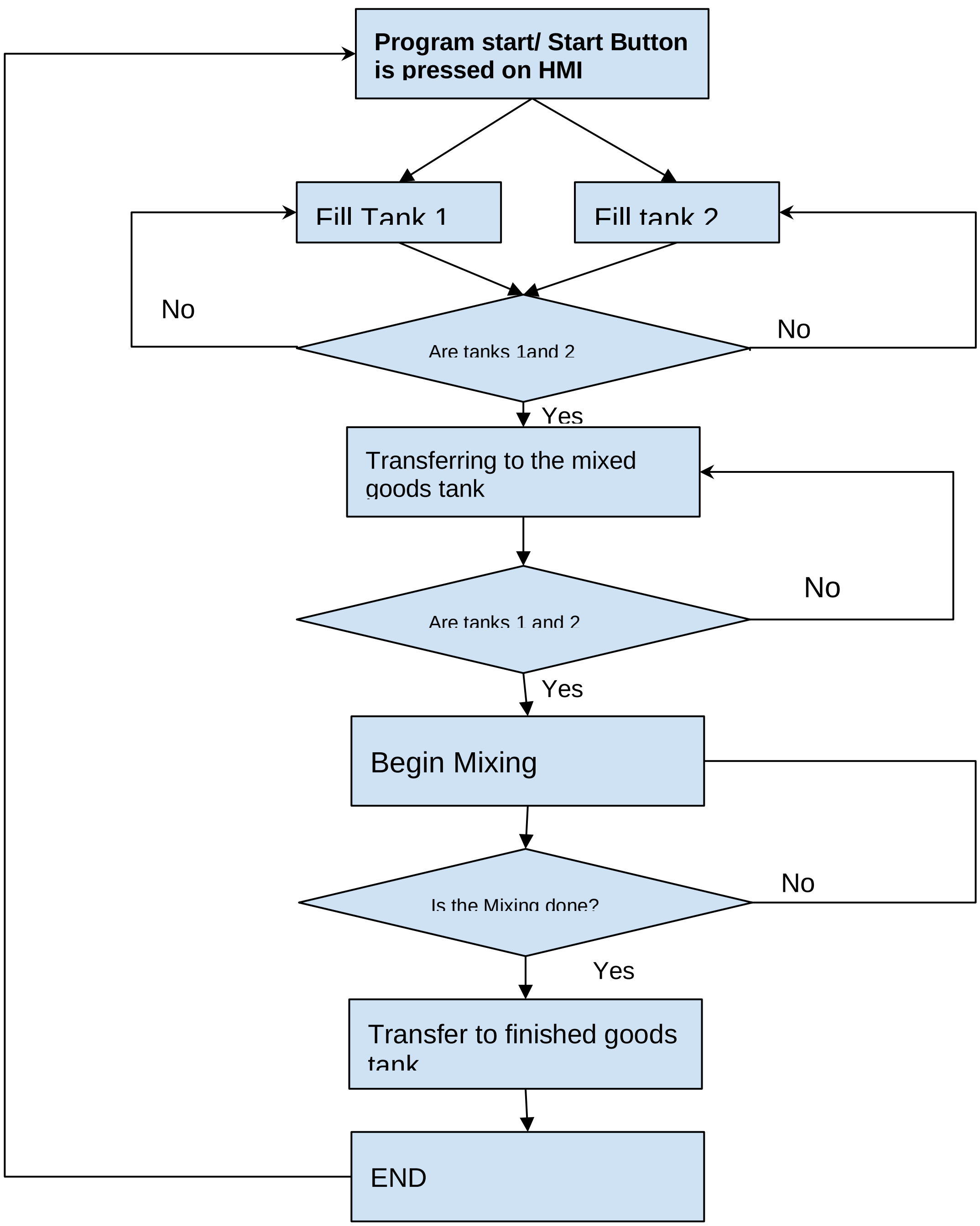
Figure 7. System Communication Diagram



IOT BATCH MIXING SKID UPGRADE

Process Flow

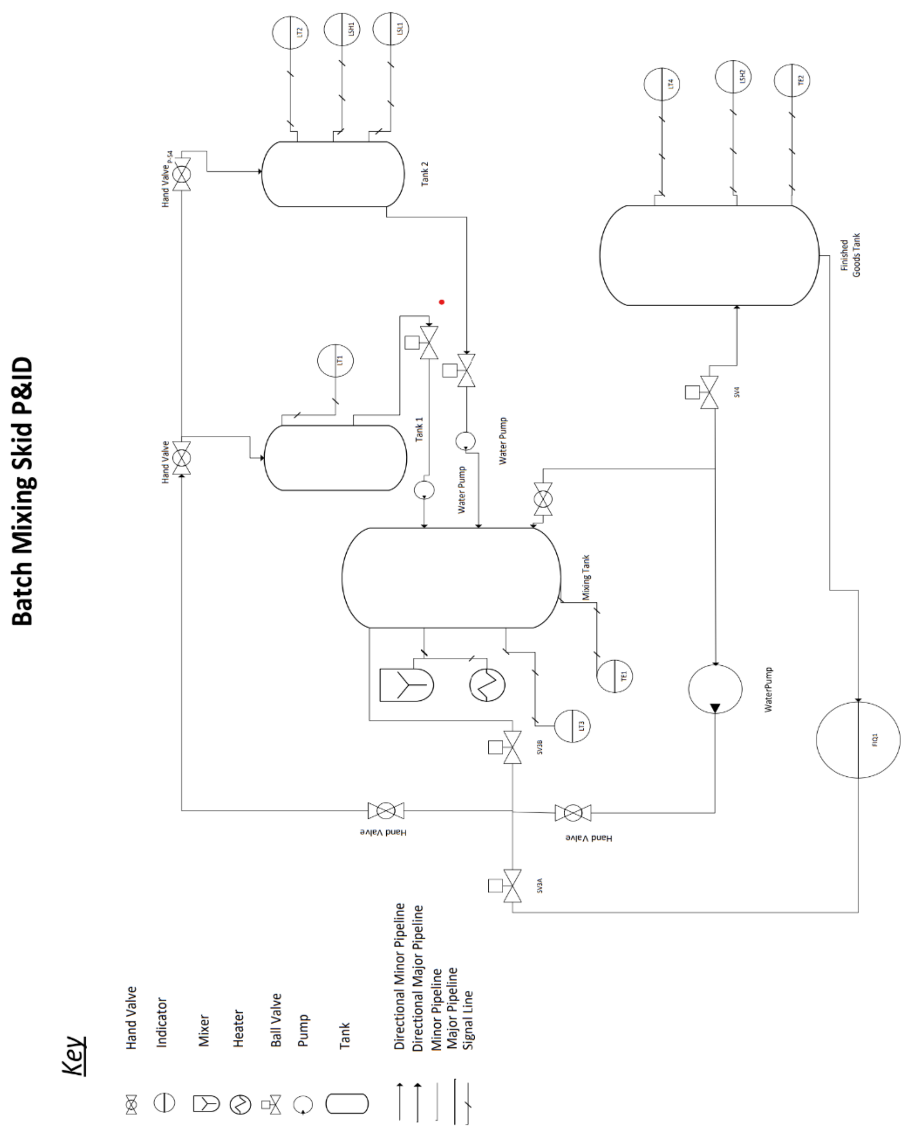
Figure 8. Process Flow Diagram



IOT BATCH MIXING SKID UPGRADE

P&ID

Figure 9. P&ID Diagram



IOT BATCH MIXING SKID UPGRADE

System Requirements Test

Test Description	System Requirements Test
Location	Batch Mixing Skid, Instrumentation devices, PLC, and HMI
Interlock	None
Limit	None

Step	Actions	Expected Results	Observed Results
1.	Switch on/ plug in the Batch mixing skid system into power	System turns on, HMI turns on, Instrumentation devices with LED screens will turn on	
2.	Manually close the valve to the mix tank	Valve will close	
3.	Manually close the valve to the recirculation loop.	Valve will close	
4.	Press starts on the HMI	Tanks 1 & 2 will start filling up	
5.	Check HMI when tanks 1 & 2 are being filled	HMI will Indicate filling	
6.	Check HMI for the levels of the liquid in tanks 1&2	HMI will show the levels on both tanks as values as well as a visual of the water being filled	
7.	Check HMI for the tank that fills first and close the valve to tank	Verify the tank is filled to 100% or the scale in the PLC program and also verify the valve is close	
8.	Wait for the other tank to fill	The process for the system will start once the other tank is filled	

IOT BATCH MIXING SKID UPGRADE

Step	Actions	Expected Results	Observed Results
		to 100%.	
9.	Check to see if the liquid is being transferred to the mixed goods tank	Verify by looking at the HMI, the HMI will indicate transferring and the values of the liquid from tanks one & 2 will go down as the one from the mixed goods tank will increase	
10.	Check if the mixed goods tank is filled to a 100%, or the scale from the PLC	Mixer will turn on; HMI will indicate mixing	
11.	After mixing is done, check if the liquid is transferring to the finished goods tank.	Verify mixer turned off, verify by looking at the HMI, the HMI will indicate transferring and the values of the liquid from the mixed goods tank will go down as the one from finished goods tank will increase	
12.	Open Netilion on a Device	Netilion will open	
13.	Set devices on Netilion	Devices will show as devices register on the Netilion account	
14.	Set Netilion to log data from the SRLS 1 and 2 at 30 sec intervals	Netilion will log the data at 30 sec intervals, as evidenced by the time and sate shown for each recording.	
15.	Check the values of the SRLS 1 and 2 from Netilion	Netilion will show the data	

IOT BATCH MIXING SKID UPGRADE

Step	Actions	Expected Results	Observed Results
16.	Export the data from Netilion in form of an excel sheet	The data will be shown in excel in form of a spreadsheet.	

Test State: ____ Passed ____ Failed Test Run #__________

Tested by: __________________________ Date: ______________________

Comments:

System Operation

We created our system operation steps based on the previous project on the Batch Mixing Skid in 2018. In addition to these steps, we created an excel sheet that has all the steps listed for the operation of the system as a checklist to make sure the system is running. The excel sheet also has action items and point of contact/ references in case anything is down or not working.

Operation – Adapted from Dugger_Lenahan_FinalPaper. Pdf

1. Close the hand valve to the mix/transfer tanks.
2. Open the valve to the feed tanks.
3. Close the recirculation valve at the bottom.

IOT BATCH MIXING SKID UPGRADE

4. Press start on HMI

    - Observe feed tanks and shut off valve to the tank that gets full first. The right tank typically gets full first so keep that valve halfway closed at all times and this should allow them to fill at the same time.

5. Once the other fills, the process will begin on its own

    - The tanks will now begin gravity feeding into the mix tank so that the mix process can begin. This process will take a long time, so observe the tank levels on the HMI and it will indicate when it moves to the next part of the process and what the levels currently are at.

6. Once draining begins into the mix tank, turn all valves back to the original positions. It is imperative that the valves get turned back or the pump will try to pump closed valves which is bad on all of the components. Make sure the valves are all in the correct position during the mix drain because you will have ample time to do so.

7. The process will now finish on its own once the process finishes

<u>Operation Checklist</u>

Figure 10 Operation Checklist Diagram

IOT BATCH MIXING SKID UPGRADE

	A	B	C	D	E	F
1	**Check List For the Batch mixing Skid**					
2		Yes	No	Notes	Action Items	Point Of Contact
3	Does the system turn on when plugged into the source					
4	Check the HMI					
5	Is the HMI on?					
6	Is the PLC on?					
7	Are there any alarms on the PLC?					
8	Check the PLC program for any contacts that are supposed to be on but not on or vice versa					
9	If there is any liquid in the tanks, are the meters indicating values on the HMI					
10	If not are the meters indicating null					
11	Did you check the PLC					
12	Fill tank 4 with water					
13	Close the hand valve to the mix tank					
14	Close the hand valve to the transfer tank/Finished goods tank					
15	Open the valves to the feed tanks					
16	Close the recirculation valve at the bottom of the system					
17	Press start on the HMI					
18	Did the process start					
19	Are tanks 1 and 2 being filled					
20	Shut off the valve on the tank that gets filled first					
21	Did you shut the valve					
22	Did it stop filling?					
23	Did the other tank fill?					
24	Did the process start?					
25	Did it start on its own?					
26	Is the system draining into the mix tank					
27	Return all the valveves to their original positions					
28	Did the process continue?					
29	Did the process finish?					
30						

5. BILL OF MATERIALS

Figure 11. Bill of Materials Image

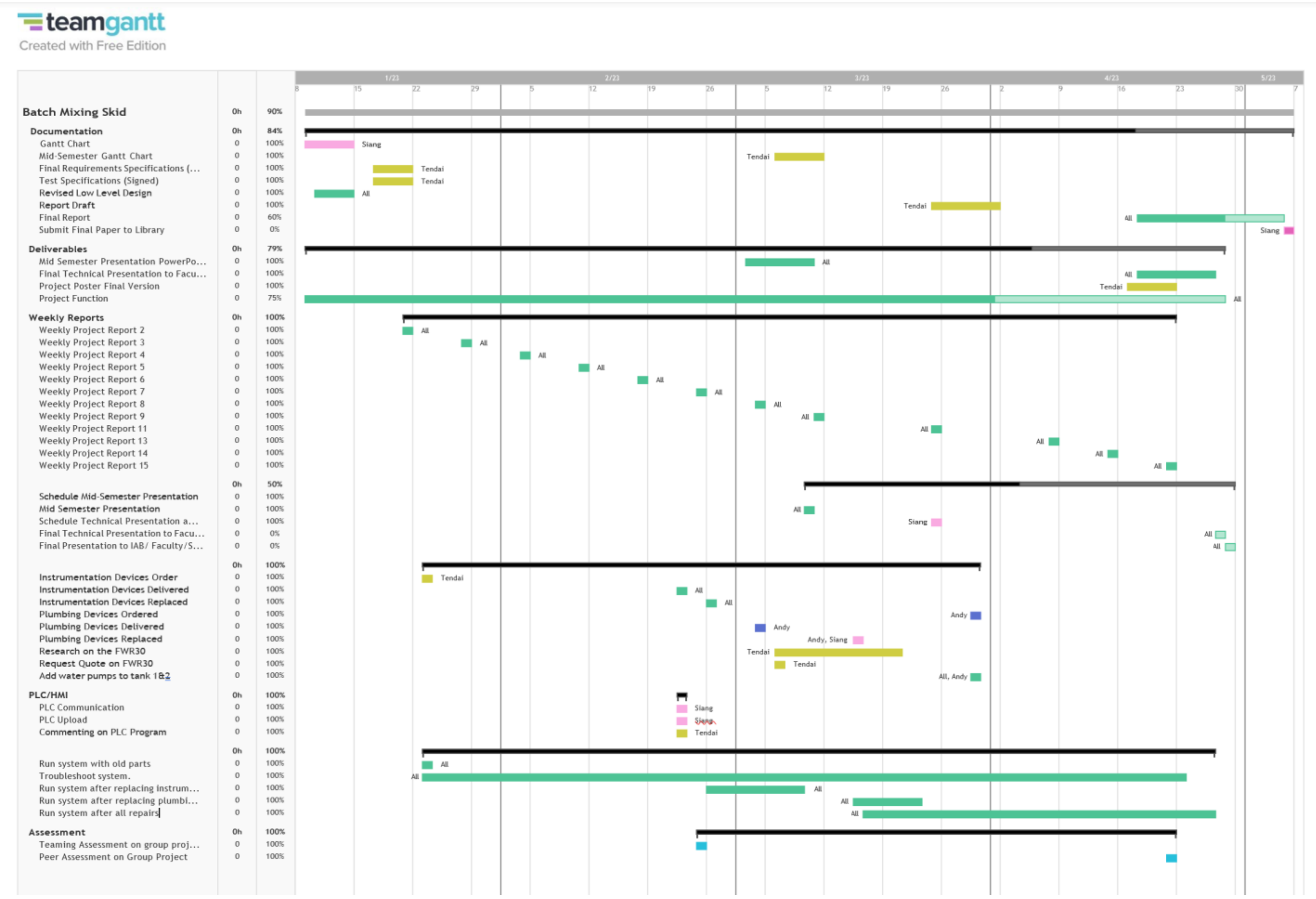
	Part	Part Name	Part Number Old	Part Name	Part Number New
1	FIQ1	Promass 83	83F08-ACVSAAAABBAC	Promass F 300	8F3B08-AAIBAEHFADSACVSAA1
2	LSH1	Level Sensor	FTL20 - 032C	Liquiphant FTL31	FTL31-AA4V3AAVBJ
3	LSL1	Level Sensor	FTL20 - 032C	Liquiphant FTL31	FTL31-AA4V3AAVBJ
4	SV1	Output Valve	EF8210G093	Output Value	8262H020
5	SV2	Output Value	EF8210G093	Output Value	8262H020
6	PUMP1			Motor	Hilitand7un5vx6iqw
7	PUMP2			Motor	Hilitand7un5vx6iqw

IOT BATCH MIXING SKID UPGRADE

The figure shows all the parts that we are/ have already replaced and / are adding to the system. The FIQ1, LSH1, LSL1 and the SV 1 & 2 are the parts we have already replaced. The SRLS is the new part we are adding to the system to satisfy the requirement for data logging.

Timeline

Figure 12. Timeline image



IOT BATCH MIXING SKID UPGRADE

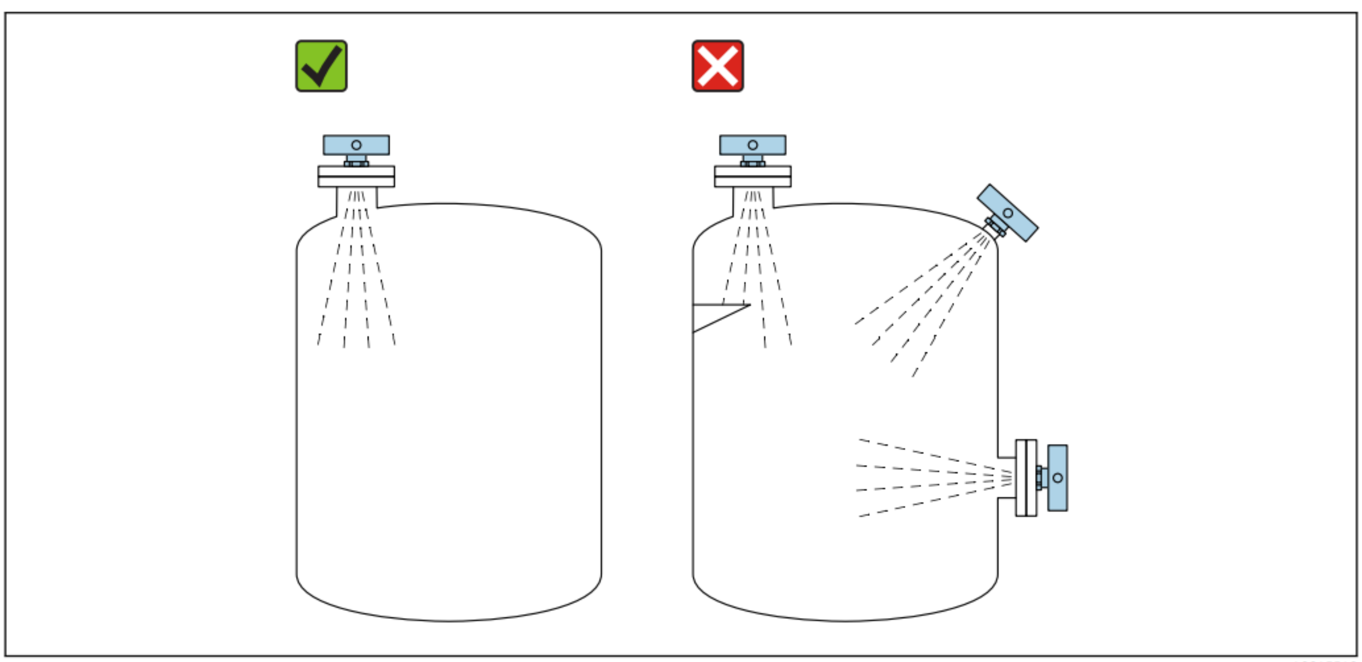
6.Future Plans

6.1 FWR30

Installation plan

- Indoors
- On the lids of tanks 1 and 2
- Mount the device horizontal to the tank lids to avoid interference with signal.
- Make Sure that the radar antenna is not covered by any metal objects.
- Make sure there are no distractions or interferences in the direct vicinity of the radar.

Figure 13. FWR30 Install



IOT BATCH MIXING SKID UPGRADE

Decision Matrix for Install

Figure 12. Decision Matrix for FWR30

Selection matrix for the tanks to put the FWR30s

Criteria	Tank 1	Tank 2	Mixing tank	Finished goods tank
Technical	9	9	5	5
Surface	9	9	1	9
Intereference	7	7	7	7
Lid Mobility	9	9	1	9
Space/Environment	9	9	5	3
	43	43	19	33
Total	86.00%	86.00%	38.00%	66.00%

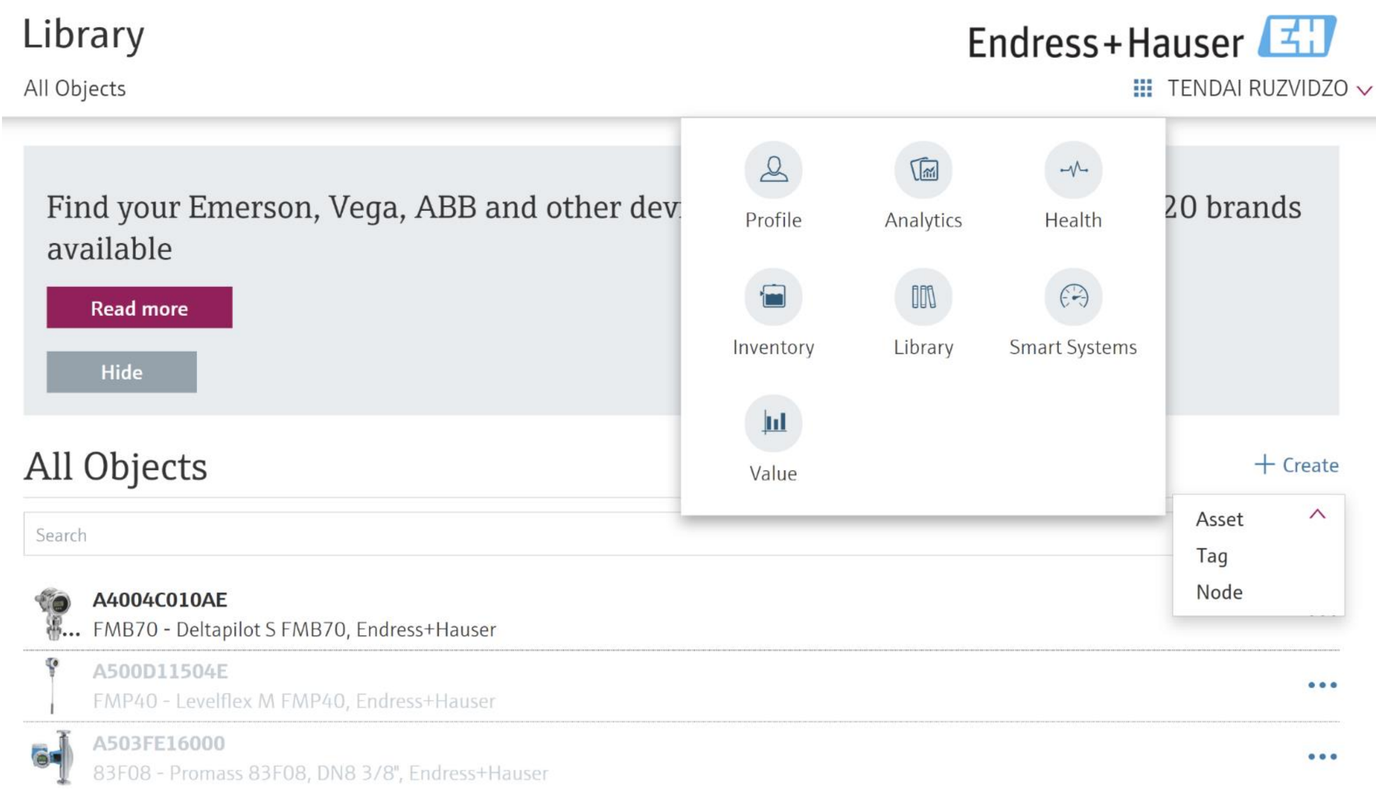
6.2 Netilion

Setting up Netilion

1. Create or Login to Netilion.
2. In the apps icon click Library.
3. Click on all objects.
4. Click create.
5. Create an asset by scanning or entering information manually.
6. Set desired parameters and create tags.
7. After setting up turn on Device that has just been set up with Netilion.

IOT BATCH MIXING SKID UPGRADE

Figure 15. Setting a device with Netilion

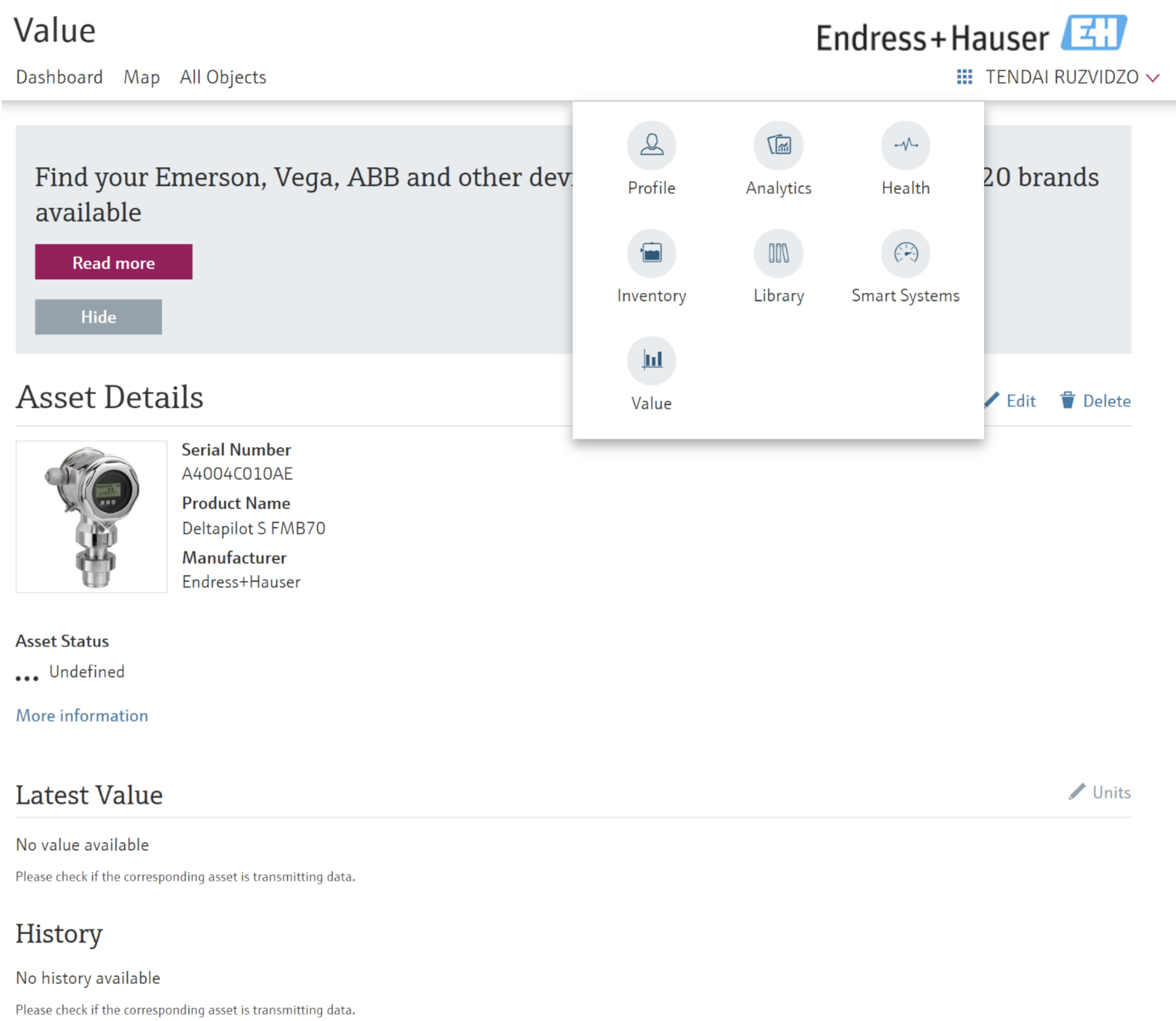


IoT Feature/ Data Logging in Netilion

1. Sign in to Netilion Value.
2. Click on the app's icon at the top of the page.
3. On the dashboard click on desired tag.
4. In the History section, click on export.
5. Confirm export file.

Figure 16. Data logging

IOT BATCH MIXING SKID UPGRADE



IOT BATCH MIXING SKID UPGRADE

7. CONCLUSIONS AND RECOMMENDATIONS

The project consists of upgrading existing batch mixing skids into IoT instrumentation devices. This report covered the objective of the project, the design, the functionality, and bill of materials that will be used to upgrade the older devices. Essentially, even after upgrading the components and devices the system should run and function how it used to be but allow users to data log with the new devices. Since we are still in the process of designing our system, we could not really test the system due to software complications and system complications. These are works in progress.

IOT BATCH MIXING SKID UPGRADE

8. Appendix

8.1 Decision Matrices

Hardware Parts Decision Matrix

Selection Matrix			
	Flow Measure System		
Criteria			
	Proline Promass F 300	Proline Promag P 300	Proline Promag W 500
Price	6	10	3
Size	10	6	3
Capability	10	6	10
Ease of use	10	10	10
Manufacturer	10	10	10
Iot Capability	10	0	0
	56	42	36
Total Ranking Points	93.33%	70.00%	60.00%

Decision Matrix for one of the parts we replace, the flow meter. The matrix is based on the Price of the flow meter but most importantly the IoT capability, in this case the Io adapter capability.

PLC Decision Matrix

IOT BATCH MIXING SKID UPGRADE

Selection Matrix			
		PLC	
Criteria			
	Micrologix	CompactLogix	ControlLogix
Price	9	6	3
Lab Practicality	6	9	9
Capability	3	9	9
Ease of use	6	9	9
Education	3	9	9
Availability	9	1	1
	36	43	40
Total ranking points	60.00%	71.67%	66.67%

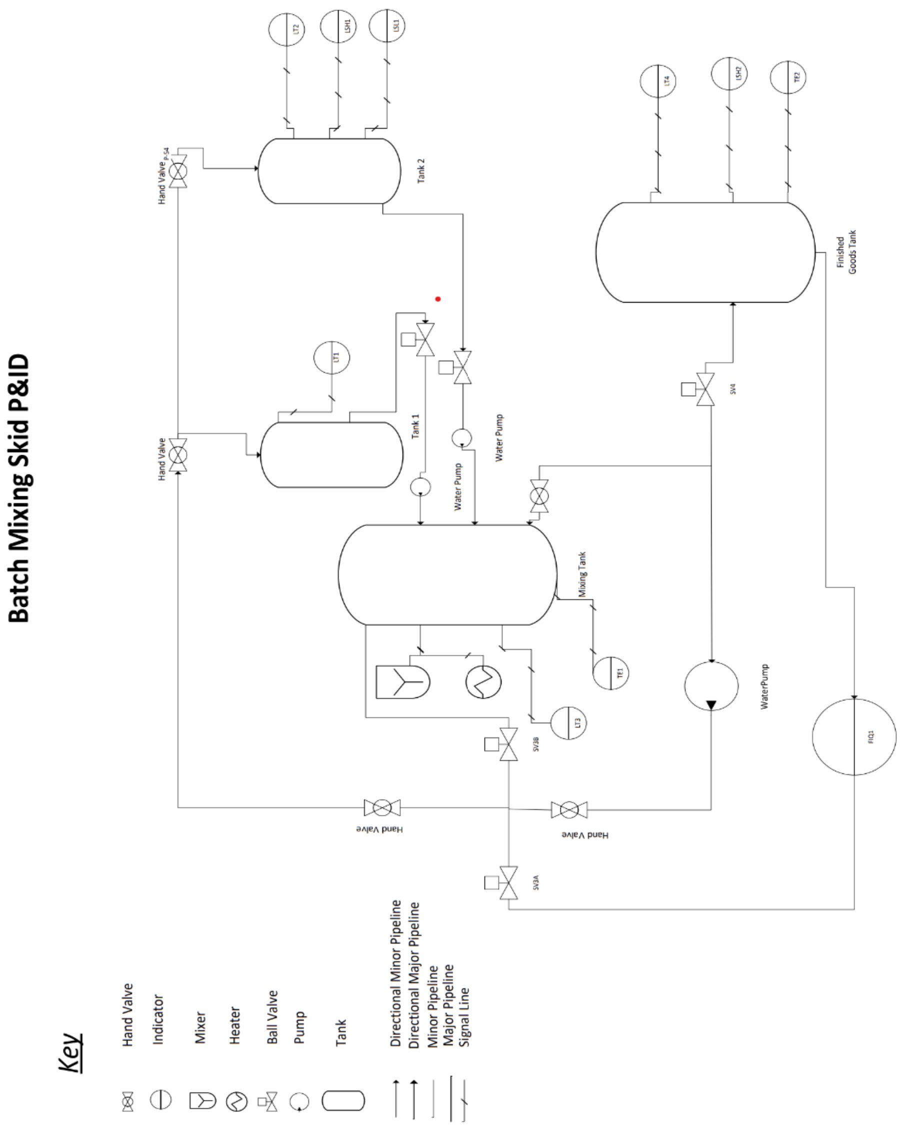
The most reasonable PLC we would have gone with would have been the Allen Bradley CompactLogix. The school did not have any extras for these, so we had to use the MicroLogix.

8.2. Designs

P&ID

Our P&ID illustrates the flow of product from the first step of filling tanks 1 &2 to the final process in tank 4 where the finished product is stored.

IOT BATCH MIXING SKID UPGRADE

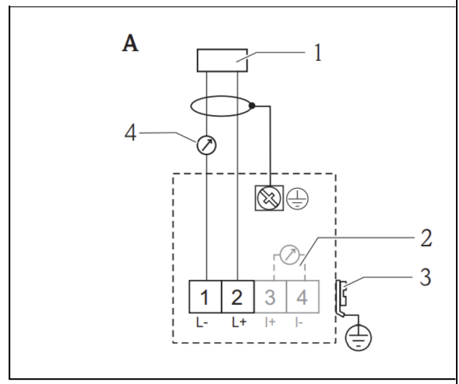


8.3. Instrumentation devices

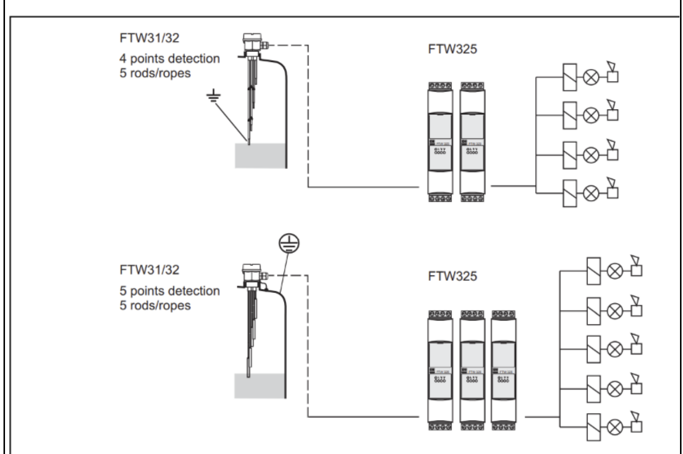
Figure 3, Pg 12

IOT BATCH MIXING SKID UPGRADE

LT1-Prosonic-M Level Sensor

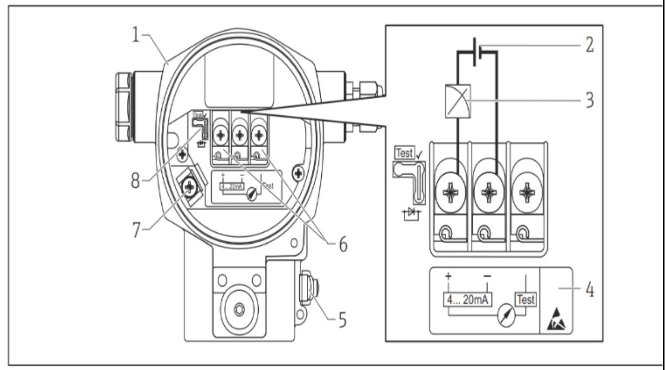
Level Sensor LT1	The LT1 sensor is the Ultrasonic Level measurement sensor. • Envelope curves on the on-site display for simple diagnosis • Easy remote operation, diagnosis and measuring point documentation with the free operating program Field Care supplied. • Suitable for explosion hazardous areas (Gas-Ex, Dust-Ex) • Optional remote display and operation (up to 20 m (66 ft) from transmitter) • Integrated temperature sensor for automatic correction of the temperature dependent sound velocity	

LT2 – Liquipoint Level Detection Conductive

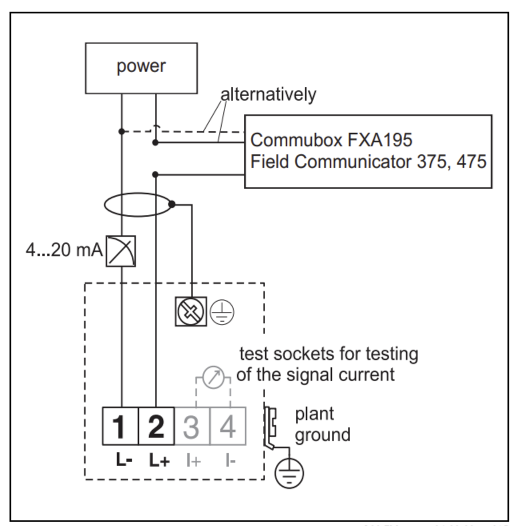
Level Sensor (LT2)	The LT2 is another level sensor found in tanks. It is a point level switch for multiple point detection in conductive liquids .• Detect up to five-point levels with one probe • Two-point control and additional MAX and MIN detection • Option between rod or rope version for optimum adaptation to the application • Flexible instrumentation: – with built-in electronic insert, either transistor (PNP) or relay output – for connection to a separate transmitter power supply unit	

IOT BATCH MIXING SKID UPGRADE

LT3 – Delta Pilot Pressure Sensor

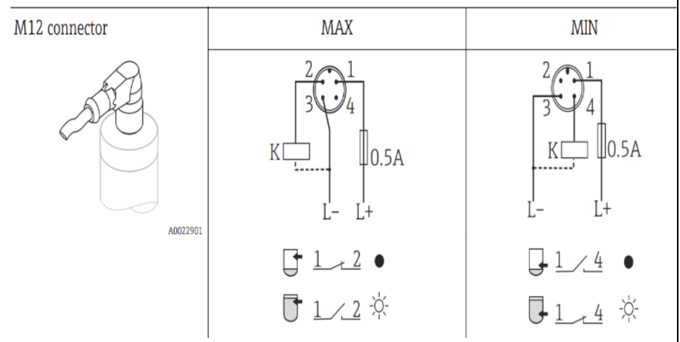
Level Sensor (LT3)	The LT3 sensor is found in tank and is used it is a hydrostatic level measurement sensor. Pressure sensor with CONTITETM measuring cell Condensate-resistant. The LT3 sensor hardware design consists of: • Process isolating diaphragm • Measuring element • Rear isolating membrane of the CONTITE™ measuring cell.	

LT4 -Levelflex M

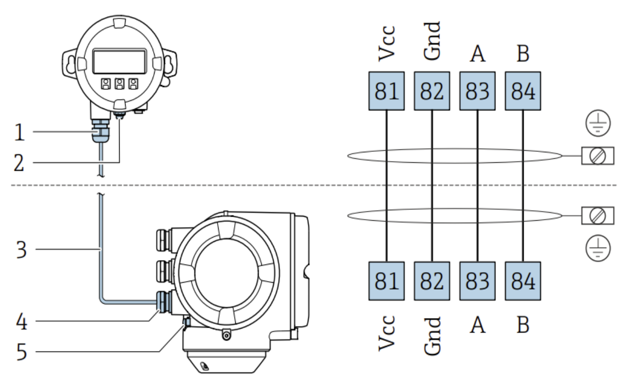
Level sensor LT4	The LT4 level sensor is a continuous level transmitter used for continuous measurement in bulk solids and liquids. It also interfaces measurement in liquids. Probes are available with threaded process connections from ¾" and flanges from DN40 (1½"). • Rope probes, above all for measurement in bulk solids, measuring range up to 35 m. • Rod probes, above all for liquids • Coax probes, for liquids • Onsite envelope curve on the display for easy diagnosis. • Probe rod and probe rope can be replaced/shortened.	 L00-FMxxxxxx-04-00-00-en-015

IOT BATCH MIXING SKID UPGRADE

LSL1/LSH1 – Liquiphant FTL31

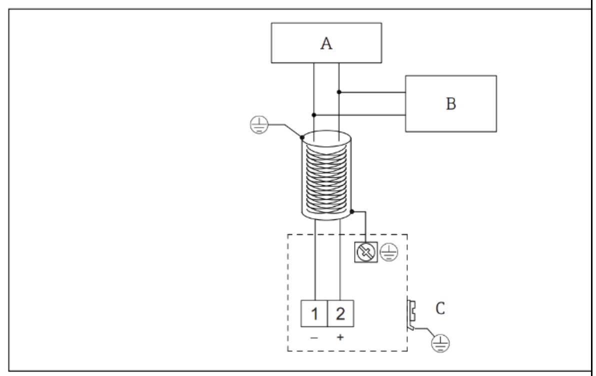
Level Switch (LSL1/ LSH1)	The LSL1 sensor is used as a level limit sensor. The LSL1 measures low level in tank 2. The Liquiphant FTL31 is a point level switch for liquids and is used in tanks, vessels, and pipes. It is used for overfilling prevention or pump protection in cleaning and filter systems as well as in cooling and lubrication vessels, for instance. The measuring system comprises: • Liquiphant FTL31 point level switch, e.g., for connection to programmable logic controllers (PLC), • a mini-contactor or solenoid valve.	

FIQ1- Proline Promass F300

Flow Sensor (FIQ1)	The FIQ1 flow measuring sensor It is used for Coriolis Mass Flow measuring. Also, it's a universal and multivariable flowmeter for liquids and gases. **Hardware consists of:** • Compact dual-compartment housing with up to 3 I/Os • Backlit display with touch control and WLAN access • Remote display available	

IOT BATCH MIXING SKID UPGRADE

LSH2 – Liquicap Level Detection Capacitive

Level Switch LSH2	The LSH2 sensor is another level sensor used to measure continuous level measurements in liquids. **The complete measuring system consists of:** • the capacitance Liquicap M FMI52 level probe • the FEI50H electronic insert • the transmitter power supply unit NB: DC voltage must be supplied to the electronic insert. The twin-core feeder is also used for HART protocol signal transmission	

8.4 Data Sheets

These are the links to the datasheets we used. They are also in PDF format, and we used them to know the communication of the devices to the PLC.
FTL31-Datasheet.pdf
TI101DEN_1009.pdf
F300-Datasheet.pdf
TI00358FEN_1512.pdf
FMU-Series-Datasheet.pdf
TI00416PEN_2421.pdf
FTW31-FTW32-Datasheet.pdf
TI364Fen_0108.pdf
TI01490FEN_0321.pdf

8.5 Final Test Plan

We created a test plan for the entire system including the IoT capability test. This is found on pg.19. We also have an operation checklist for the function of the system on pg. 23.

IOT BATCH MIXING SKID UPGRADE

Reference

Dugger, Brennen, and Nick Lenahan. vol. 1, pp. 3–33, *Dugger_Lenahan_FinalPaper.Pdf*.

"“Proline Promass F 300 Coriolis Flowmeter.” *Proline Promass F 300 Coriolis Flowmeter | Endress+Hauser*, https://www.endress.com/en/field-instruments-overview/flow-measurement-product-overview/coriolis-flowmeter-promass-f300-8f3b?t.tabId=product-overview.

“Vibronic Point Level Detection Liquiphant FTL31.” *Vibronic Point Level Detection - Liquiphant FTL31 | Endress+Hauser*, https://www.endress.com/en/field-instruments-overview/level-measurement/Vibronic-level-Liquiphant-FTL31?t.tabId=product-overview.

ID, netilion.endress.com/app/library. Accessed 3 May 2023.

ID. (n.d.). https://netilion.endress.com/app/value

ENDRESS+HAUSER LIQUIPHANT FTL31 MANUAL Pdf Download | ManualsLib, https://www.manualslib.com/manual/1237689/EndressPlushauser-Liquiphant-Ftl31.html.

Endress+Hauser to expand, adding jobs and STEM opportunities in Greenwood, https://www.wrtv.com/news/local-news/johnson-county/endress-hauser-to-expand-adding-jobs-and-stem-opportunities-in-greenwood.

Technical Information Liquiphant FTL31 - Gasdetectorsusa.com, https://www.gasdetectorsusa.com/iac/download/EH_Liquiphant_FTL31_Datasheet.pdf.

Liquicap M FMI51, FMI52 - Endress+Hauser, https://portal.endress.com/wa001/dla/5000545/6651/000/03/TI00401FEN_1412.pdf.