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April 24, 2024

Mr. Scott Sparling

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Instructors, Mechanical Engineering Technology
MCEN 2471 – Technical Project (Capstone)

Dear Mr. Sparling, Ms. Claydon, Mr. Walker,

Attached is a copy of our final report titled “Design of Fluid-Jacketed Phosphate Dip Tank for Enhanced Heat Distribution and Modularity” as part of our requirements for completion of the MCEN 2471 – Technical Project (Capstone) course.

The report covers the following key areas:

Executive Summary: a brief summary of the report

Introduction: includes the definition and purpose of the project, its background/context, and existing solution.

Problem Identification: includes the design parameters, preliminary ideas, and selection of viable ideas.

Detailed Design: includes the final solution, thermal calculation, stress calculation, benefits of design, manufacturing, quality control, maintainability, and safety.

Cost Estimation: includes the final material cost of the project.

Lessons Learned and Recommendations: a point form of the team’s learnings and recommendations for future actions.

Conclusion: a summary of the report’s main points.

We thank you for your support throughout this project.

Sincerely,

Group Gear Heads

23 April 2024

Ethan Nott

23 April 2024

Mari Cel De Vera

23 April 2024

Leo Punongbayan

DESIGN OF FLUID-JACKETED PHOSPHATE DIP TANK FOR ENHANCED HEAT DISTRIBUTION AND MODULARITY

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Due Date: April 24, 2024

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Sponsor: Argus Machine Co. Ltd.

Randy Wiltermuth

Executive Summary

The objective of this project was to design a phosphate dip tank. This report contains the calculations, preliminary ideas, and drawings involved in the tank's design. The current dip tank is heated by an open flame underneath the tank containing the phosphate media. This causes two problems, uneven heating and warping of the inner tank. To solve these problems, a tank-within-a tank design was created which used a consistent and nondestructive method of heating. This was done by having an inner tank containing the phosphate media and an outer tank containing a heating medium. When the two tanks were assembled together, the heating medium would be displaced around the inner tank's walls. The heating medium is heated with a large branching tubing system which hot air is blown into. The operating temperature of the phosphate media is 200◦F for manganese phosphate and 190◦F for zinc phosphate. The external temperatures of the dip tank were calculated using the thermodynamic principle of heat transfer and the thickness of the tanks were calculated using thin plate theory. Since the inner tank rests on the outer tank, structural support such as c-channel steel had to be sized to support the weight of the tank assembly and the phosphate media. The two tanks were secured together using twelve (12) nuts and bolts. These were enough as the buoyant force of the heating medium compared to the weight of the inner tank and the phosphate media was negligible. The tanks were designed to use 304 stainless steel sheet metal and were supported with horizontal and vertical c-channels welded to the outside walls. The inside corners of the tanks were strengthened and protected with angle bars that were also welded to the inside edges.

Acknowledgments

We would like to express our sincerest gratitude to all the individuals who extended support and mentored us in completing this project.

To our instructors, Derek Walker, Michelle Zhang, Nathan DeVries, and Dan Racette for providing us guidance in our technical decisions and giving feedback to improve the quality of our work. To Audrey Claydon and Scott Sparling for their constant help and answers to even the silliest questions.

To our sponsor, Argus Machine Co. Ltd., especially Randy Wiltermuth, who gave us the opportunity to work on this project and provided first-hand information his experience with the existing equipment. The knowledge proved useful in completing this project.

To our family and friends, who provided emotional and moral support, giving us the will to overcome the stress, hardships, and obstacles that came in our way of accomplishing our task.

Most importantly, to our Almighty God who gave us the strength, wisdom, and capacity to undertake this project, and allowing us to deliver the requirements of this project on time, and with excellent quality.

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1.0 INTRODUCTION

1.1. Definition and Purpose

Phosphating is a chemical treatment process done on steel or iron components to provide a uniform and inert coating on its surface. In this process, the component is immersed in a hot, diluted phosphate solution, allowing the metal's top layer to react chemically with phosphate compounds in the solution, turning it into a layer of microscopic phosphate crystals. (Corrosionpedia, 2021). This provides the metallic components the signature black or grey surface coating which provides corrosion and wear resistance. Phosphate coatings range in thickness from .0002 to .0006 inches. (Acton Metal Processing Corp., 2023)

An effective phosphating process occurs only within a narrow range of temperatures within which the steel components must be held to dwell within a certain amount of time, typically lasting several minutes, to complete the chemical reaction. Outside of this temperature range, the process ceases. It is for this reason that the process relies on the use of an equipment called a phosphate dip tank which contains the hot phosphate solution where steel components are dipped. To provide a means to supply the heat required to sustain the chemical solution and regulate the heat input, the dip tank is equipped with a controlled heating system. (Industrial Heating Systems, n.d.)

1.2. Background/Context

The project sponsor, Argus, uses either of two phosphate coating processes in their range of products: (1) zinc phosphate, and (2) manganese phosphate, depending on customer or application requirements. The two processes share the same process as with typical set-up in the industry, differing only in the phosphating chemicals used and maintaining temperature. A typical phosphating process is shown in Table 1.

Table 1: Typical Phosphating Process

Step	Process	Temperature	Dwell Time
1	Cleaning Stage	Temp.: 55-95 °C (131°F - 203°F)	Time: 5-10 min.
2	Water Rinse	Temp.: 15-30 °C (59°F - 86°F)	Time: 0.5-1.5 min.
3	Activation	Temp.: 20-40 °C (68°F - 104°F)	Time: 0.5-1.5 min.
4	Phosphating	Temp.: 40-60 °C (104°F - 140°F)	Time: 3-10 min.
5	Water Rinse	Temp.: 15-30 °C (59°F - 86°F)	Time: 0.5-1.5 min.
6	Post-Rinse	Temp.: 20-40 °C (68°F - 104°F)	Time: 0.5-1.5 min.

Source: (ILVE Chemical Company LTD., 2019)

Due to the requirements of chemicals used by Argus in this process, the manganese phosphate solution must be maintained at a temperature of 200±5 F^{o} while the zinc phosphate solution must be kept at 190±5 F^{o}. Argus uses identical dip tanks for steps one to five in the processes mentioned in Table 1 to promote uniformity and parts interchangeability.

Argus' experience shows the process creates a sludge that needs to be removed regularly to avoid baking where the sludge hardens on the tank walls, making it hard to remove which increases maintenance down time.

1.3. Existing Solution

Argus' current design is an open flame design, like a cauldron containing the solution and heated by an open fire underneath as shown in Figure 1. The heat is harnessed from natural gas, fired from a burner which supplies a stream of flame to a flame header, distributing the heat across the length of the tank. A computer-controlled system regulates the rate of burner firing depending on the actual phosphate bath temperature using temperature sensors immersed inside the dip tank.

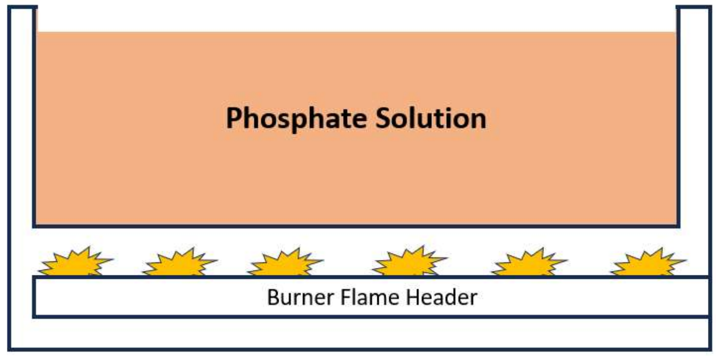

Figure 1. Illustration of Current Phosphate Dip Tank Set-up in Argus

Argus uses 304-grade stainless steel material in the construction of the dip tanks. The 304 stainless steel is mechanically stable at high operating temperatures and does not react with the phosphate solution, making it ideal for the application. The current design uses a single tank that contains the phosphate solution, bolted to the structural frame. An outer sheet metal serves as outer skin that prevents the escape of hot flue gas to the environment. A spring-actuated flat plate is fitted on top of the phosphate tank serving as a lid cover to prevent heat losses and fumes from escaping to the shop floor area. Figure 2 shows the actual phosphate dip tank set-up in Argus.

Figure 2. Photo of Current Phosphate Dip Tank Set-up in Argus

2.0 Problem Identification

While Argus' current dip tank design achieves the intended purpose of maintaining the phosphate solution at the operating temperature, some issues arose with the current design. Firstly, the open flame design exposes the phosphate dip tank to localized extremely high temperatures due to some areas being in direct contact with fire, causing uneven temperature distribution which warps the tank. The warpage of the tank causes parts and components to deform and misalign with one another, making disassembly and maintenance difficult. Secondly, the current design is a non-modular design having no convenient means of taking it apart easily, compounding the maintenance difficulty.

The objective of this project is to provide a solution to the main problems of the sponsor by designing a fluid jacket heating system for the phosphate dip tanks which addresses the uneven heat distribution issue and makes it modular to provide ease of maintenance.

2.1. Design Parameters

The general design objective is to achieve the parameters in Table 2 below:

Table 2: Summary of Design Parameters

General Design	Must have a modular design, must be able to taken apart for maintenance
	Must ensure even heat distribution
Outer Tank	Dimensional constraint: to fit to available space, the maximum dimension are 96" long, 40" wide and 52" high
Inner Tank	Can accommodate a work piece 84" long, 24" wide and 2,000 lb heavy
Heating	Able to maintain the manganese phosphate solution temperature at 200±5 F^{o} and the zinc phosphate solution at 190±5 F^{o}
	Consider mitigation of heat loss

2.2. Preliminary Ideas (4-Blocker)

The preliminary ideas are contained in the 4-Blocker found in Appendix F. The details of each idea are presented in the subsequent sections.

2.2.1 Concept 1: Heat Coil Design

Description: Finned coil tubes wrap around the internal periphery of the dip tank, with the coil surface directly in contact with the phosphate solution. Perforated baffle plates cover the heating coil to prevent damage by impact with the steel basket while allowing flow of liquid. The heating fluid inside the coil is circulated in an external heating system. See the following Figure 3.

Advantages: large heat transfer area, removable coils for easy maintenance, efficient heating since coils are submerged in the fluid

Disadvantages: expensive equipment, coils can be damaged when the basket is dipped, needs constant maintenance due to the scaling that will happen on the tubes

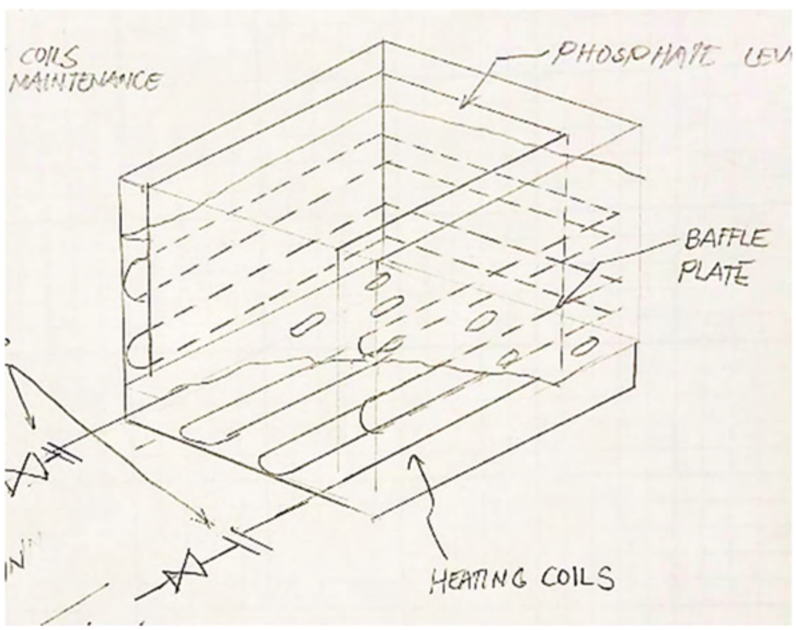

Figure 3. Heat Coil Design Concept

2.2.2 Concept 2: Circulating System Design

Description: The external shell or plate envelopes the external shell of the dip tank which allows a heating fluid to flow in the shell outside the dip tank. The heating fluid transfers heat to the dip tank shell which then transfers the heat to the phosphate solution. The heating fluid is circulated in an external heating system, as shown in Figure 4.

Advantages: It could minimize scaling on the side of the tanks, efficient and consistent heating method

Disadvantages: Difficult to make the inner tank removable, the entire system takes up a lot of space and would be difficult to implement in the shop

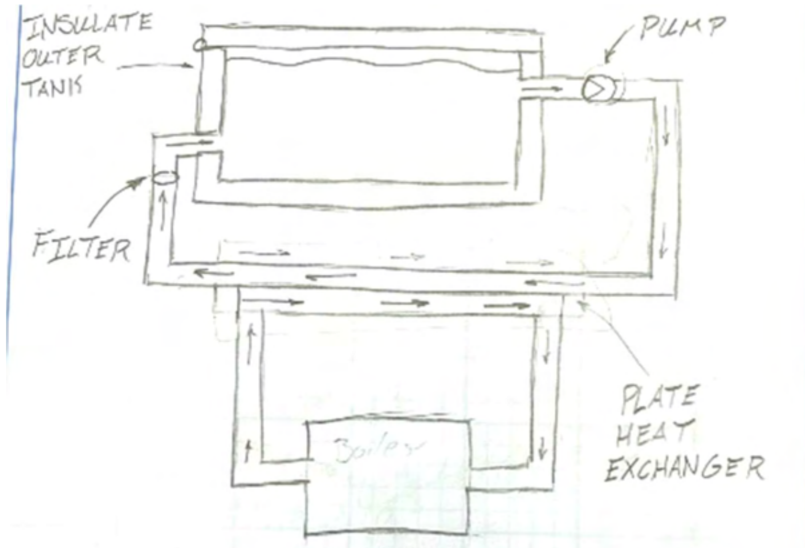

Figure 4. Circulating System Design Concept

2.2.3 Concept 3: Fluid Jacket Design

Description: The dip tank is placed inside an external tank that houses a firebox. The firebox underneath serves as the source of heat. A heating fluid occupies the space between the dip tank and the external tank. The heat produced by the combustion of fuel (i.e. natural gas) and the combustion of products is routed to the firebox to heat the walls of the firebox. The other side of the firebox is exposed to the heating fluid, transferring heat. The heat transferred to the heating fluid is then transferred to the dip tank, which is then transferred to the phosphate solution. See Figure 5.

Advantages: Retains heat efficiently due to the phosphate being surrounded by the heating medium, easily adaptable since it is similar to existing design, promotes circulation of hot fluid

Disadvantage: Complex temperature control

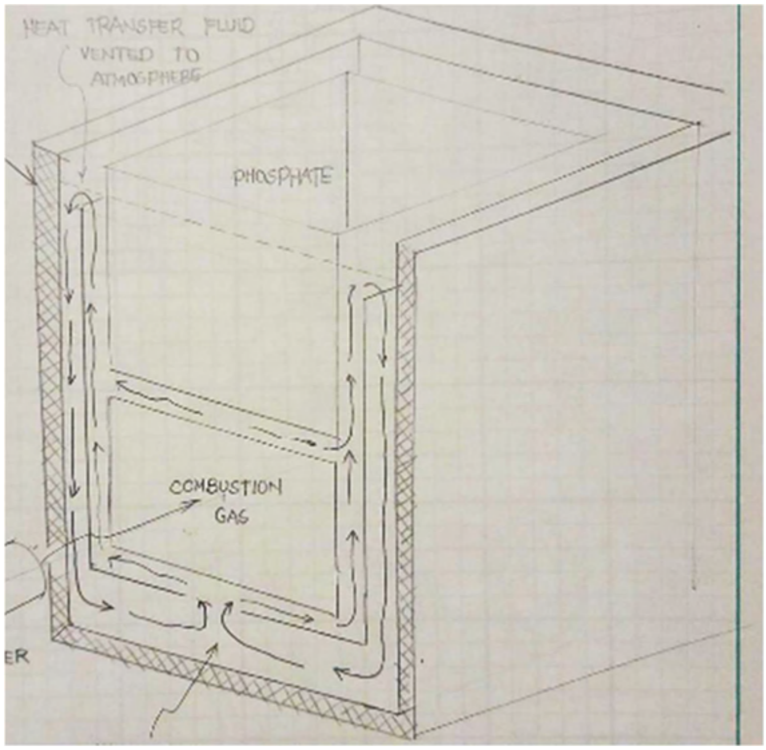

Figure 5. Fluid Jacket Design Concept

2.2.4 Concept 4: Tank Within a Tank

Description: The dip tank is placed inside an outer tank containing heat transfer fluid, and the underneath of the outer tank is heated by direct flame from a burner. The heat of combustion is transferred to the shell of the outer tank which heats the heat transfer fluid. The heat transfer fluid heats up the shell of the dip tank which then heats up the phosphate solution.

Advantages: Gas burner will be reused, retains heat efficiently due to the phosphate being surrounded by the heating medium, inner tank is removable

Disadvantages: Indirect heating, may require more money, risk of contamination

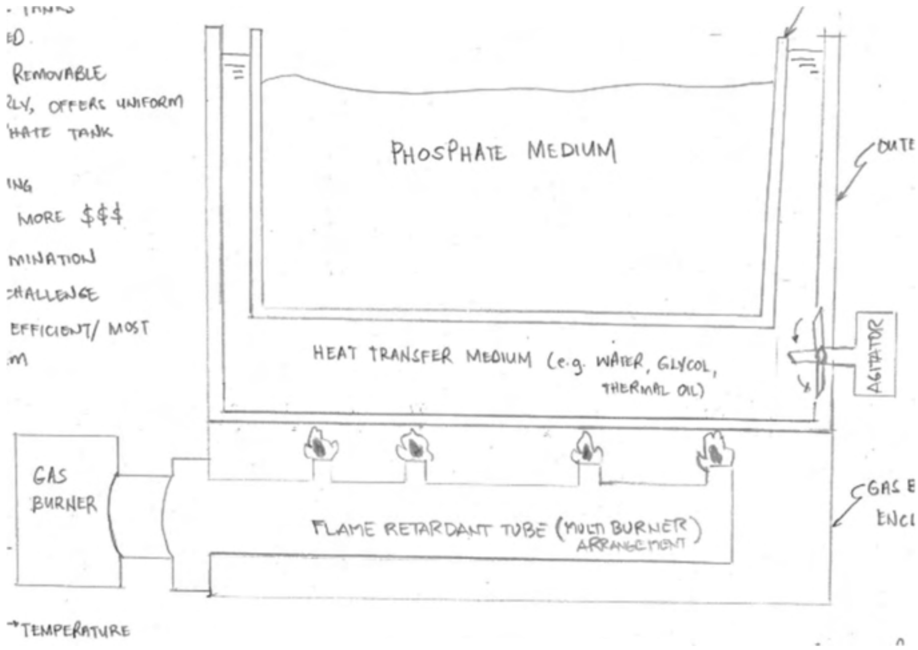

Figure 6. Tank-within-a tank Concept

2.3. Selection of Viable Ideas

2.3.1. Tank-within-a Tank Design

The tank-within-a tank is designed to have two tanks: a smaller, inner and a larger, outer tank. The outer tank will hold a calculated volume of heating fluid, and the inner tank will be placed inside the outer tank. The outer tank holds the fluid that wraps around the inner tank's sides and insulates it. Underneath the outer tank is a large, perforated tube with a blower on one end that will blow hot air onto the outer tank which heats the fluid which then heats the phosphate.

2.3.2. Fluid Jacket Design

The fluid jacket dip tank is a specially designed tank where the walls of the tank are lined with a layer of heating fluid. Underneath the tank, there is a fire box underneath the phosphate tank where hot air is blown into which heats the lining fluid which in turn heats the phosphate.

3.0 Detailed Design

3.1. Final Solution

The final solution was a modified version of the tank-within-a tank design. There were two main changes to the initial design. The first change was that the tube was submerged within the heating fluid since there was a 12-inch space between the bottom of the inner and outer tank. Since it was submerged in the fluid it will no longer be perforated. The second change was the design of the fire tube. Instead of a single tube, it was designed to be a branching series of tubes. This allows for a larger heat transfer area which will heat the fluid more efficiently and with less energy. A suction fan was to be installed at the end of the exhaust firetube that will create induced convection throughout the heating tube. Induced convection makes sure that there are no cold spots. The two tanks were stiffened using vertical and horizontal 3-inch c-channels that line the tank walls. The inside corners have 1-½” equal leg angle bars that stiffen and protect the corners of the tanks. The problem of designing the tank to be modular was solved by having 6” x 6”-90◦ angle bars along the top of the inner tank. This allows it to rest on the eleven (11) vertical c-channels that bear the load of the inner tank and phosphate. These c-channels were taking the load of the phosphate solution and the inner tank. Flat plate theory was used to calculate the thickness of both tanks. The inner tank was 7/64” thick, and the outer tank was 3/16” thick. See Figure 7 for illustration.

When the dip tank was fully assembled, the inner tank displaced 9.5 ft^3 of the heating medium. This creates an upwards buoyant force which can be a problem when disassembling the dip tank. The buoyant force can be calculated by taking the heating medium's density and volume, which results in a force of 518 lbs. However, the mass of the inner tank is 2340 lb, making the buoyant force negligible.

The two tanks were assembled using twelve (12) ½”-13 UNC bolts and a matching rectangular washer, the inner tank 6” x 6” angle bars were slotted, and the top c-channels welded on the outer tank have threaded holes that line up with the slots. There were also four (4) ¾”-10 UNC eyebolts fastened into 6” x 6” angle bars. The eyebolts were positioned along the length of the tank at the minimum points of sag.

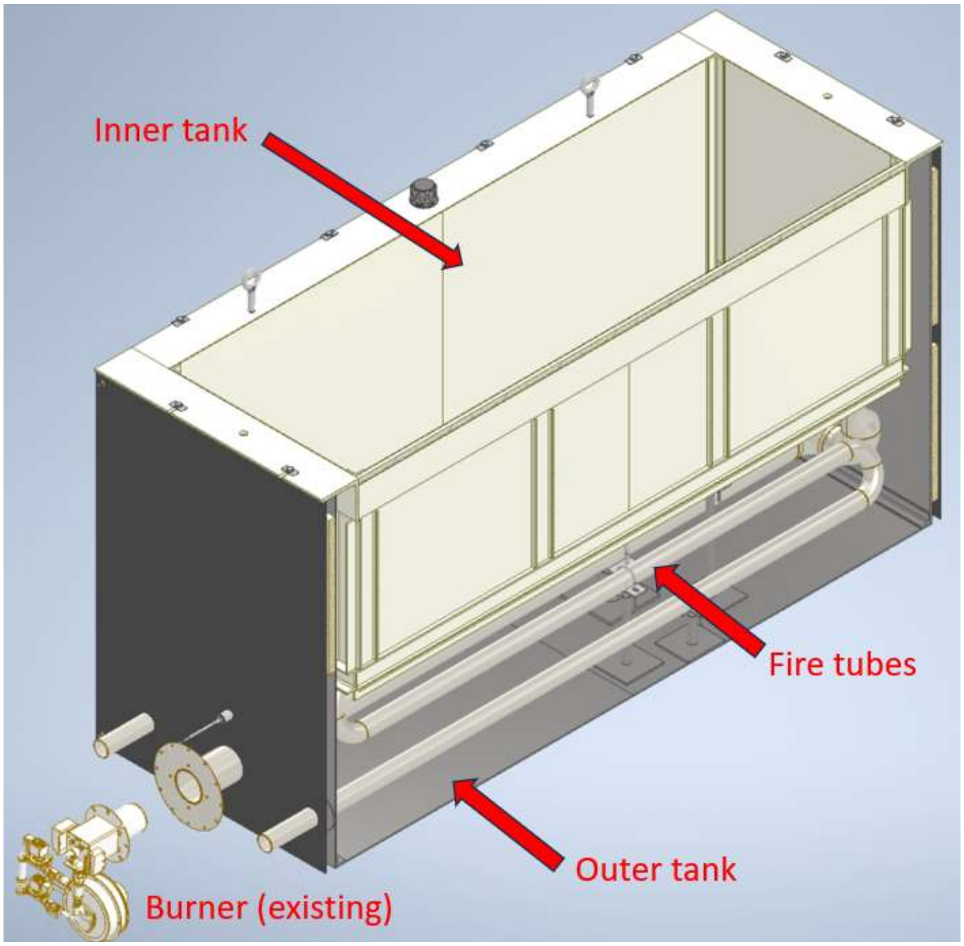

Figure 7. Final Solution: modified tank-within-a-tank design

3.2. Thermal Calculation

In the absence of thermodynamic simulation software, the foundation of the final design was established through the conceptualization of the basic thermodynamic model, represented in Figure 8, and hand calculations of solved solutions. The basic concept is grounded in the first law of thermodynamics, energy going in the system must be equal to energy going out of the system.

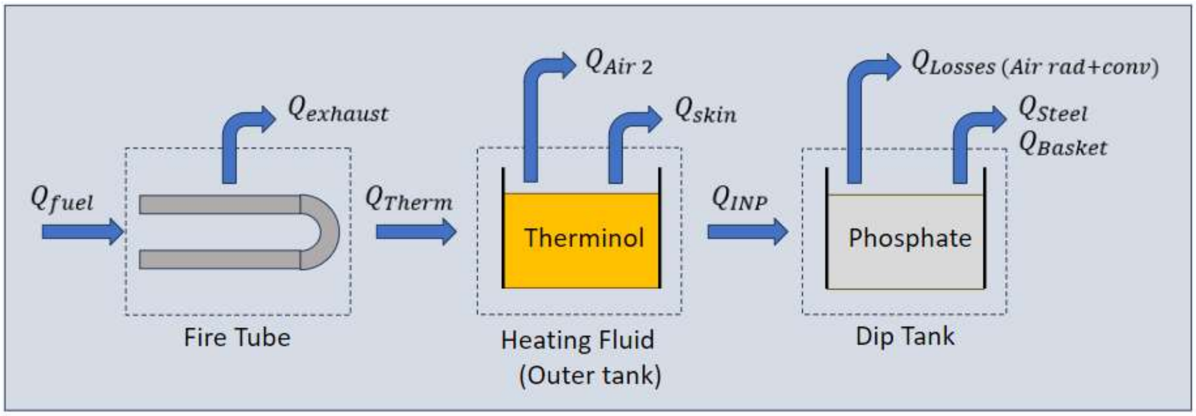

Figure 8. Basic Thermodynamic Model

The phosphate's operating temperature is 200°F. This temperature is the basis for all the thermodynamic calculations. However, since the phosphate is heated by a heating medium, its temperature is equally as important. When doing the calculations to solve for this temperature two scenarios were looked at, when 2000lb or 500lb is dipped. The first step is to solve the energy loss of the two previously stated cases, when solving for this, both the material and cage must be considered, as well as the losses in the air in the inner tank. These heat values can be summed up together and represented by Q_{INP} in the diagram, which is the energy going into the inner tank. This must be equal to the energy going out of the inner tank represented by $Q_{Losses\ (Air\ rad\ +\ conv)}$ and $Q_{steel\ +basket}$. The detailed calculation is presented in Appendix G (Calculation of Product Heat Requirement). Then the thermal resistance of the convection regions and inner tank wall must be calculated. Once this is done the heating medium's temperature can be calculated, as presented in Appendix I (Calculation of Heat Transfer Fluid Temperature). When 2000 lb mass is dipped the heating medium must be 225◦F, and when 500 lb mass is dipped the heating medium must be 205F. This temperature is near the boiling point of water, which means an oil-based heating medium must be used. Therminol 55 was selected for its high boiling point, heat capacity, and availability in the North American market, see Appendix M (Selection of Heat Transfer Fluid) for the detailed properties of Therminol 55.

Next, is to analyze the heat balance in the outer tank (Therminol tank). To determine the required heat input in the outer tank (Q_{Therm}), all the heat losses from the outer tank external skin (Q_{SKIN}), air above the outer tank ($Q_{Air\ 2}$), and the heat given up to the inner tank (Q_{INP}) must be accounted. The detailed calculation of Q_{SKIN} and $Q_{Air\ 2}$ can be found in Appendix J (Calculation of Heat Losses on Outer Tank Skin) and H (Calculation of Heat Input to Inner Dip Tank and Air Heat Losses), respectively. The heat input to the Therminol (Q_{therm}) was calculated to be 150,000 BTU per hour, considering a cycle of 2000 lb of steel dipped in the inner (phosphate) tank every 15 minutes. The calculation of Q_{Therm} is presented in the later portion of Appendix H.

Lastly, the heat balance in the fire tube was analyzed to determine the amount of heat input in the fire tube, representing the fuel consumption (natural gas firing rate) needed to provide the heat value of Q_{therm} and accounting for heat losses in the exhaust gas ($Q_{exhaust}$). This calculation is necessary to determine the required heat transfer area of the fire tube which was then used to design the size of the tubes and the number of passes. It was calculated that a minimum of 19.7 ft^2 of area is needed to facilitate the heat transfer while maintaining the desired operating temperatures. This translates to the need to have a minimum tube size of 2 inches in diameter, 80 inches long with 7 passes as detailed in Appendix K (Calculation of Fire Tube Heat Transfer Area). Since equal heat distribution is an essential objective of this project, it was decided a 4" diameter inlet tube will be installed in the middle of the tank which branches out to 2 opposite directions at the other end of the tank, downsizing to 2 inches diameter tubes thereafter, see Figure 9.

Heat loss at the outer tank is mitigated using 1" thick ceramic fiber insulation. This helps lower the Q_{SKIN}, resulting to lower operating temperature of Therminol and reduced heat input requirement. See Figure 11 under Safety subheading.

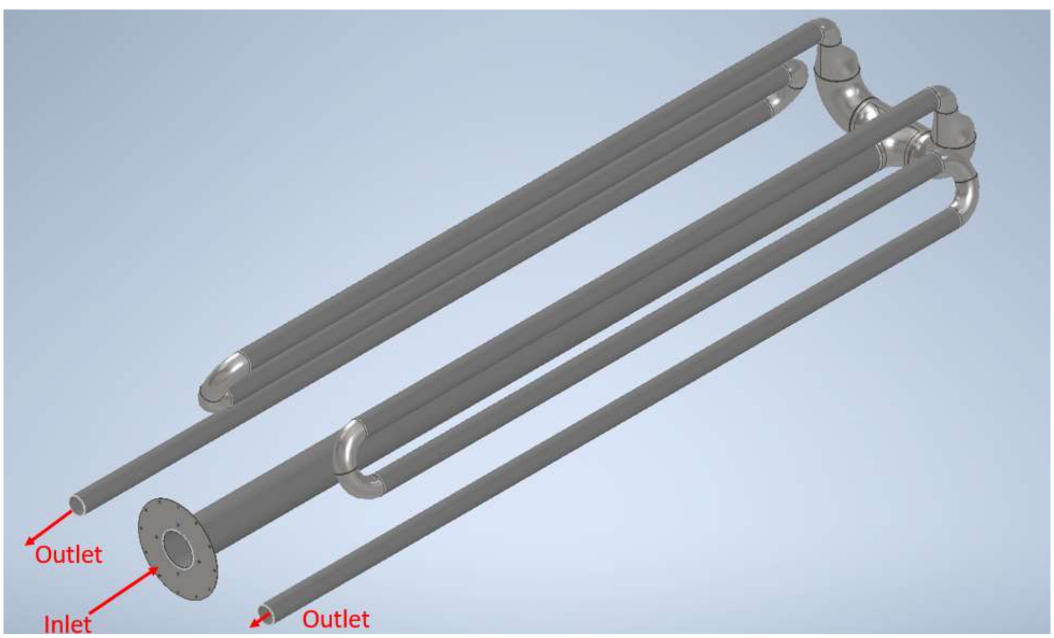

Figure 9. Fire Tube Design

3.3. Stress Calculation

The inner tank rests on the eleven (11) vertical C-channels of the outer tank's supporting frame, column analysis had to be done to size the C-channels to ensure they could support the load of both the inner tank and phosphate. The detailed calculation of column sizing is shown in Appendix U (Calculation of C-channel Column Size). A safety factor of two (2) was used to allow for a large threshold of safety with this safety factor considered the C-channels were sized at 3”. While the c-channels are taking all of the axial force from the inner tank, the tank walls experience stress due to static fluid pressure from heating fluid and phosphate. To ensure that the tank wall thicknesses are adequate the flat plate theory was used to solve for the wall thickness of the inner and outer tanks in order to avoid bulging of sheet metal. The C-channels are considered as stiffeners in the flat plate theory analysis, so the number of C-channels used in the inner and outer tank is also influenced by the calculations. The result of these calculations were a thickness of 7/64” for the inner tank and 3/16” for the outer tank, as detailed in Appendix O (Calculation of Inner Tank Thickness) and Appendix P (Calculation of Outer Tank Thickness). The two tanks were secured together using 12 bolts (Appendix Q: Calculation of Inner Tank Bolt Size), to size these the upward buoyant force of the displaced heating medium has to be considered. The inner tank displaces 9.55ft^3 which results in a buoyant force of 518 lb, which is negated by the weight if the inner tank and phosphate (2340 lb.). The driving factor for the size of the bolts was the size of the c-channel that the inner tank is mounted to.

There are four ¾”-10UNC lifting eye bolts provided to enable the lifting of the inner tank during maintenance. Each bolt was designed to lift the entire weight of the inner tank at a 45◦ sling angle, with a safety factor of two (2) which could be used to account for a shallower sling angle. However, the use of a spreader bar is still recommended to increase the sling angle and lessen the stress in the bolt and sling. The detailed calculation can be found in Appendix R (Calculation of Inner Tank Lifting Eyebolt Size).

To ensure that the weight of the fire tubes is properly supported and will not warp or deform the outer tank sheet metal, reinforcing pads were designed to increase the strength at the areas having pipe penetration. This results in the use of gauge 12 stainless reinforcing sheet metal to increase the thickness at the penetration area. The detailed calculation is found in Appendix S (Calculation of Fire Tube Reinforcing Pad Design). In addition, pipe support or stanchions were used to support the weight of the fire tubes at the points of minimum sag. The analysis and calculation for this design can be found in Appendix T (Calculation of Tube Support Spacing).

3.4. Benefits of Design

There are two main benefits of the tank-within-a tank design. First, consistent and evenly dispersed heating due to the heating medium “jacketing” around the inner tank and nondestructive heating due to the blower supplying hot air into the fire tube which heats the heating medium. This “jacketing” effect is beneficial because the heating medium will insulate and heat the phosphate at the same time. The consistency of the heating of the tank allows for less heat loss when in operation. Second, since the inner tank is heated indirectly through a heating medium there will be far less warping than having an open flame directly under the inner tank. The warping causes the tank to be difficult to assemble and disassembly due to the bolt holes being misaligned.

3.5. Manufacturing

The inner tank was designed to use 7/64” (12 Ga) 304-stainless steel sheets that were bent and welded based on the drawing’s specifications. The outer tank was designed to use 3/16” (7 Ga) 304-stainless steel metal sheets. The recommended forming process for sheet metal is V-bending which can be done by local fabrication shop such as GT Metals (GT Metal Products, 2024). The tanks were reinforced with vertical and horizontal 304 SS c-channels welded to the walls and base. Angle bars were welded into the inside edges of the tanks to support and protect these points of stress concentration. The fire tubes were designed from Ø4” and Ø2” 304 Sched 10 stainless steel pipes and fittings joined together by welding.

Post weld heat treatment is recommended to be performed after welding to remove residual stresses in welds which minimizes risk of cracking and weld failure.

3.6. Quality Control

Potential defects is most likely to arise during welding due to stresses in the heat affected zone which can weaken the base metal and fail during loading cycles. To mitigate this, the recommended quality control method is volumetric non-destructive testing through ultrasonic flaw detection (B-scan) or radiographic test, as allowed by spatial constraint, after post weld heat treatment. Hydrostatic test of fire tubes is also recommended to ensure that there is no leakage.

3.7. Maintainability

As per Argus’ experience, the expected main degradation mechanism of the dip tank is the accumulation of hardened phosphate scales and sludge at the bottom and side wall of the inner tank that are exposed to the phosphate solution. This will impede the heat transfer between the Therminol and the phosphate solution, which means that eventually the rate of firing should increase and the operating temperature of Therminol will increase as well. To prevent this and keep the system operating efficiently, it is recommended to perform cleaning and descaling of inner tank every month. The modularity of the design makes assembly and disassembly convenient for the maintenance crew.

Another degradation mechanism is the accumulation of soot and solid combustion products inside the fire tube. At regular interval, the fire tube inlet and outlet pipes can be disconnected and steam/air blowing or water flushing can be performed to remove impurities and foreign particulates inside.

It is also necessary to conduct thickness measurement (typically by Ultrasonic thickness gauging) at regular intervals to ensure adequate thickness that can last until the next scheduled maintenance.

A summarized recommended maintenance activities and schedule is presented in Table 3 below.

Table 3: Recommended Maintenance

Maintenance Activities	**Frequency**
Descaling and sludge removal	Monthly
Breather Cleaning	Monthly
Sight glass cleaning	Monthly
Fire tube thickness measurement	Annually
Fire tube internal cleaning	Annually

3.8. Safety

The main safety concern in this design is the risk of fire or explosion when the oil-based Therminol heats up too much or comes in direct contact with fire. Since the fire tube's external surface is exposed to Therminol, it is necessary to ensure that the thickness of the fire tube is being monitored during scheduled maintenance, ensuring adequate thickness to avoid leakage. Likewise, during operation, temperature fluctuations are anticipated and there may be a need to increase the rate of heat input in the fire tube which means that the rate of natural gas firing can vary depending on process demands. This can be safely done as long as the temperature of the heat transfer fluid, Therminol, does not exceed the flash point of 379°F. Therefore, a safety mechanism should be in place to continuously monitor the Therminol temperature and initiate a trip or automatic shutdown when the temperature reaches around 370°F.

An overpressure protection feature is designed using a breather mechanism installed on the lid of the inner tank, see Figure 10. This allows atmospheric air to freely go in and out of the outer tank during temperature cycles, preventing pressure or vacuum build-up in the outer tank. However, a potential safety concern potential would arise should there be a blockage of the breather, so adherence to proper maintenance schedule to clean the breather is important.

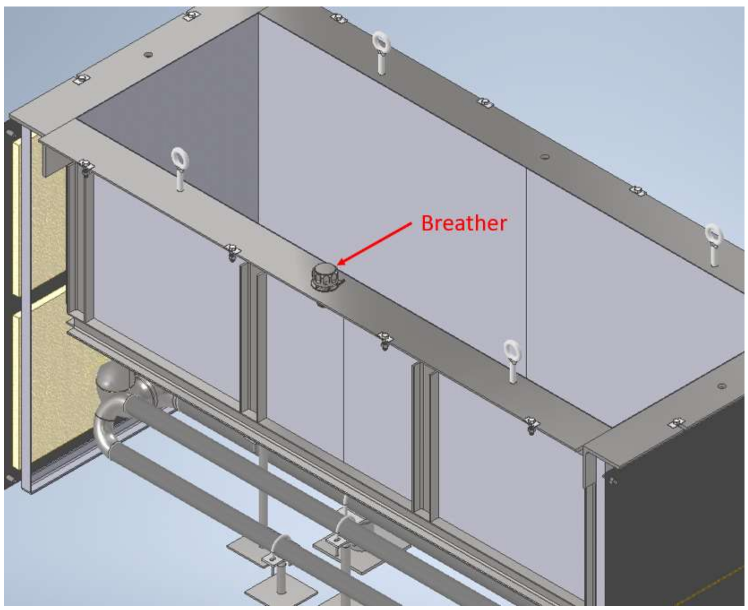

Figure 10. Outer Tank Breather

Another safety aspect is the hot surface of the inner tank. The engineering control is through the use of ceramic fiber insulation with metal sheet external cladding. This keeps the external metal sheet temperature cool at near ambient temperature, and also minimizes heat loss in the process. See Figure 11.

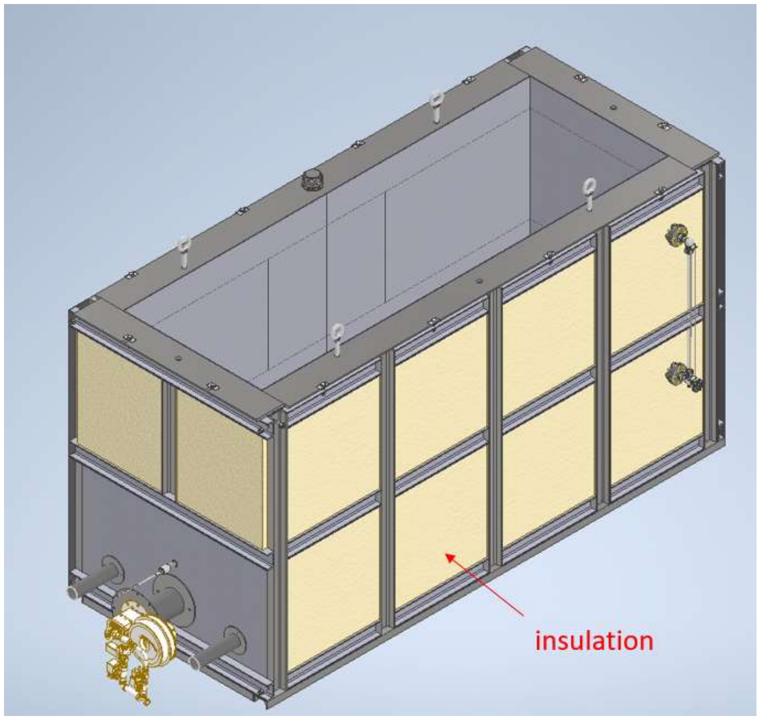

Figure 11. Outer Tank Insulation

3.9. Cost Estimation

The breakdown of the cost of this project can be found in Appendix V. It is important to note that the components chosen for this project are locally sourced and available in the market. The vendors recommended for the buyout parts are included in the drawings's bill of materials and also found in Appendix V.

The total material cost of the dip tank assembly is approximately $39,640 (CAD). This is because all metals are 304-stainless steel. The most expensive part of the assembly is the structural support for both the inner and outer tank.

4.0 Lessons Learned and Recommendations for Future Actions

A capstone project holds significant importance for students. It prepares the students for the workforce, enhances the skills through the application of the theories learned from different courses, and gives valuable practical experiences. The following are the lessons learned after having the opportunity to work on this project:

- When sourcing materials, it is best to check if it is available locally before sourcing a vendor outside of Canada.

- Even if the design is good on paper, it might not be the same in actuality. Make sure to give thorough attention to details when 3D modeling your design. Since fabrication is not part of the scope of this project, 3D modeling will be the closest idea if the design will work or not.

- Teamwork is the key to the group's success

The following are the recommendations for future actions:

- The use of PID to control the gas burner
- Add two or more thermocouples to make sure that the temperature of the Therminol is consistent.
- Add cladding to the inner tank lip for safety.

- The recommended level indicator/ sight glass is from Wika Instruments, model LGG.

- Use computational fluid dynamic (CFD) software for a more accurate thermodynamic analysis through computer simulation

5.0 Conclusion

The modified tank-within-a-tank design that was utilized in this project was able to address the main concerns in the current design, satisfying the objectives of this research. Firstly, the chosen design makes use of heat transfer fluid which enables even heat distribution of the phosphate dip tank due to the natural convection of the heat transfer fluid. This prevents the issue of warping of the tanks. The chosen heat transfer fluid, Therminol 55, was selected for its high heat capacity and boiling point. A high heat capacity means it easily stays at a consistent temperature, while a high boiling point means that it can accommodate operational adjustments depending on process demand. Secondly, a modular design was achieved through utilization of two tanks, an inner and outer tanks that can be easily disassembled for ease of maintenance. The outer tank will contain 62 cubic feet of Therminol 55 and the heating tube. To assemble the dip tank the inner tank is put inside of the outer tank and the top edges are bolted together. This displaces the heating medium which wraps the fluid around the inner tank, and this fluid layer is what heats up the dip tank.

The design not only achieves the main objectives, but is also practical, safe, and maintainable. The aspect of practicality is demonstrated by the choice of materials for construction that are commercially available and can be sourced locally, while the required manufacturing processes can be outsourced to local fabrication shops as well. The aspect of safety is also infused in the design through the use of breathers, insulation and reliable fire tubes that is not susceptible to corrosion. In terms of maintainability, the design requires minimal maintenance with built-in features that make the required maintenance convenient to perform.

The summary of final design is shown in Table 4 below.

Table 4: Summary of Final Design:

Outer Tank Assembly		
	Tank	304 SS, Sheet Metal 7 GA.
	Structural Support (ID)	304 SS, 1 1/2" x 1 1/2" Angle bars
	Structural Support (OD)	304 SS, C3" x 4.1
Inner Tank Assembly		
	Tank	304 SS, Sheet Metal 12 GA.
	Structural Support (ID)	304 SS, 1 1/2" x 1 1/2" Angle bars
	Structural Support (OD)	304 SS, C3" x 4.1
Inner Tank Lip		
	Lip	304 SS, 6" x 6" Angle bars

Fire Tube Assembly	
Inlet	304 SS, Ø4" Sch 10 Pipe
Middle Tubes	304 SS, Ø2" Sch 10 Pipe
Outlet	304 SS, Ø2" Sch 10 Pipe
Tees, elbows, and reducer	304 SS (for Sch 10 pipe)
Inlet Support	304 SS, Plate
Outlet Support	304 SS, Plate
Ø4" Saddle Support	T304 SS
Ø2" Saddle Support	T304 SS
Sight Glass	
Recommended: Wika Instruments	Glasses from borosilicate glass
Model LGG	Gauge body: Steel 1.0460, 1.0570
Others:	
Lifting Eyebolt	304 SS
Breather Vent	304 SS
1/2"-13 x 1 3/4" LG. Hex Head Screw	18-8 SS
Rectangular Washer for 1/2" Screw	18-8 SS
5/8"-11 x 1 1/2" LG. Button Head Screw	18-8 SS
5/8"-11 Hex Nut	18-8 SS
Insulation	Ceramic Fiber
Cladding	Halogen-free NBR

6.0 REFERENCES

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7.0 APPENDICES

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Appendix A: Technical Report Checklist

MCEN2471: Capstone **Instructors:** **Mr. Scott Sparling, Mr. Rick Chetram**

This Final Report Checklist was prepared from the document originally prepared by Dr. Dale Ladoon.

Final Report Checklist

Complete this checklist and paste it into your logbook.
Do not submit your report until all the checklist items have been completed in your report.
All team members must confirm that the checklist items have been completed in the report and sign the checklist.

General

- ☑ Letter of Transmittal on front of report and signed by all team members.
- ☑ Report proofread for correct grammar and spelling by all team members.
- ☑ Descriptive report title.
- ☑ Page numbers: For preliminaries, use roman numerals. For Main Report body, use Pg. X/Y.
- ☑ No page number on title page.
- ☑ Recommended report structure followed.
- ☑ Report written in the 3rd person.
- ☑ Bullets and lists used, where appropriate, to make the report easier to read.
- ☑ 11 pt. font: Calibri or Arial.
- ☑ 1.5 line spacing. (for text body)
- ☑ Styles as per sample document.

Figures and Tables

- ☑ Figures and tables have a *numbered* caption that is attached to the image.
- ☑ All figures and tables in the body of the report are referred to by *number* in the body text.

References

- ☑ Reference all thoughts, figures, data, equations, etc., that are not your own.
- ☑ Reference list complete and follows APA citation format as per COMM1102 and Moodle sources.
- ☑ References properly cited in the body of the report.

Appendices

- ☑ All appendices are labeled (numbers or letters), in order, and have page numbers.
- ☑ All appendices are listed in the Table of Contents.

Drawing Package

- ☑ Meets NAIT Mechanical Engineering Technology working drawing standards.
- ☑ Drawing Checklist completed and inserted in report.

Team Members: Signature and Date:

23 April 2024

23 April 2024

Leo Punongbayan 23 April 2024

Appendix B: Project Information

MCEN2471 Technical Project (Capstone)

Project: Tanks a Lot Thermal Dynamics

Objective

Not all parts need to be made from high-priced stainless steel. Mild steel is more then capable and it comes with a cheaper price tag. Mild steel does have a drawback in that it has a tendency to rust. Coating the mild steel after machining aids in slowing down the oxidation process. In addition the coating minimizes galling when parts are assembled.

Abstract

would like to design a water jacket style zinc or manganese phosphate dipping tank and corresponding venting system.

Client Contact Information

Intellectual Property Ownership

The solution developed by the NAIT student team(s), and the documentation supporting it, will be the intellectual property of [redacted].

Deliverables to Industry Sponsor

Final design report, working drawing set, cost estimate, engineering calculations, and any supporting data (i.e. specification sheets, test data, etc.).

MCEN2471 Technical Project (Capstone)

Project: Tanks a Lot Thermal Dynamics

ARGUS	INTERNAL DOCUMENT			Document No. EP017-001		Rev. 0
NAIT Capstone Project Design a Phosphate System (Water-Jacket Tank) – Scope of Work						
Created: Randy Wiltermuth Date: 20 Nov 2023		Reviewed: Loren Kowalchuk Date: 27 Nov 2023		Approved: Randy Wiltermuth Date: 27 Nov 2023		ECN No.

1.0 PURPOSE

To provide a Scope of Work that will be used by the NAIT project team to create a proposed phosphate system for the NAIT Capstone program.

2.0 SCOPE

To develop and design a phosphate system for zinc and manganese phosphate coating of steel components after final machining.

Argus' expectations are that the project team shall consider sizing, method of heating, capture and exhaust of off-gases, and a method for loading/unloading parts in the tank. If time does permit, then the focus shall be on the tanks and method of heating only.

Expected deliverables shall be a Project Plan, Project Presentation, Technical Report, and Project Logbooks.

3.0 REFERENCE STANDARDS

202948-01	Safety Data Sheet, Houghto-Phos™ 6100 (Quaker Houghton)
N/A	Safety Data Sheet, SS Zinc Phosphate (Can-Four Industrial Supplies LTL)

4.0 RESPONSIBILITIES

Argus Engineering	Provide information and design parameters relating to the project. Review progress with students on a scheduled basis (to be established).
NAIT Instructor	Assign and guide the project team through the design process.
NAIT Project Team	Develop a practical solution for the project and present their design.

5.0 GENERAL

5.1 Argus proposes that the NAIT project team develop a system that could replace our current tanks, which places some limitations on the size and operation of the new tanks.
5.2 It is preferable that the tanks be identical, regardless of the phosphate media.
5.3 Zinc phosphate is used for general product surface treatment.
5.4 Manganese phosphate is used for products with premium threads (Licensor requirement).

6.0 PHOSPHATE SOLUTIONS

6.1 Zinc Phosphate.
- 6.1.1 SS Zinc Phosphate mixed with fresh water.
- 6.1.2 The optimum operating temperature is 190±5 °F (88±2.8 °C).
- 6.1.3 Refer to the Safety Data Sheet provided for more information.

6.2 Manganese Phosphate.
- 6.2.1 Houghto-Phos™ 6100 chemicals mixed with fresh water.
- 6.2.2 The optimum operating temperature is 200±5 °F (93±2.8 °C). Too high will neutralize the solution, too low and the product does not coat properly.
- 6.2.3 The process creates a sludge (free iron, etc.) that needs to be removed. If it allows to bake onto the tank walls, it becomes hard and is very difficult to remove.
- 6.2.4 Refer to the Safety Data Sheet provided for more information.

7.0 DESIGN PARAMETERS

7.1 General Design
- 7.1.1 Preference is for a water-jacket design.
- 7.1.2 Method of coating shall be fully submerged (dip tank).
- 7.1.3 Inner tank to be removable for cleaning and maintenance.
- 7.1.4 All materials shall be suitable for the application.

Can-Four Industrial Supplies LTI SAFETY DATA SHEET:

Section 1: Product and Company Information

Product Name: SS Zinc Phosphate

Zinc Phosphate Coating

OSHA Date 3/1/2021

Manufacturer: Can-Four Ind. Supplies
PH:(877) 515-8882 email:info@canfourindustrial.com
PERS Emergency: 800-633-8253

Section 2: Hazards Identification

Signal Word: Danger

Hazard Class:

Skin Corrosion/Irritation 1A	Causes severe skin burns and eye damage
Acute Toxicity- Oral 4	Harmful If Swallowed

HMIS RATING SCALE

0 - MINIMAL
1 - SLIGHT
2 - MODERATE
3 - SERIOUS
4 - SEVERE

HEALTH	3
FLAMMABILITY:	0
REACTIVITY:	1
PERSONAL PROTECTION:	D

Precautionary Statements

Prevention

Do not breathe dusts or mists.
Wash thoroughly after handling.
Wear gloves, protective clothing, eye protection and face protection.
Do not eat, drink or smoke when using this product.

Response

If swallowed: Rinse mouth. Do NOT induce vomiting.
If on skin (or hair): Take off immediately all contaminated clothing. Rinse skin with water/shower.
If in eyes: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing.
If inhaled: Remove person to fresh air and keep comfortable for breathing.
Immediately call a poison center or doctor.
Wash contaminated clothing before reuse.

Storage: Store Locked Up.

Disposal: Dispose of contents and container in accordance with local regulations.

Section 3: Composition / Information on Ingredients

CAS#	Ingredients	%BWT
7664-38-2	Phosphoric Acid	<10
7779-88-6	Zinc Nitrate	<25
7779-90-0	Zinc Phosphate	<25

The balance of the ingredients are not classified as hazardous or are below the concentration limit to be classified as hazardous under the criteria
Federal OSHA Hazard Communication Standard 29CFR 1910.1200.

SAFETY DATA SHEET

HOUGHTO-PHOS™ 6100

SDS according to the U.S. OSHA Hazard Communication Standard (29 CFR 1910.1200), Revison 2012

Section 1. Identification

Product code	:	202948-01
Product name	:	HOUGHTO-PHOS™ 6100
Other means of identification	:	Not available.

Relevant identified uses of the substance or mixture and uses advised against

Relevant uses	:	Drawing
Uses advised against	:	Any other purpose

Supplier	:	Quaker Houghton PA, Inc. 901 E. Hector Street Conshohocken, PA 19428 USA T: 610-832-4000 Wallover Oil Company 21845 Drake Road Strongsville, OH 44149 USA www.wallover.com T: (440) 238-9250 ProductStewardship@quakerhoughton.com www.quakerhoughton.com
Emergency telephone number (with hours of operation)	:	CHEMTREC US/Canada:1-800-424-9300 or 1-703-527-3887 (24 hours)

Section 2. Hazards identification

OSHA/HCS status	:	This material is considered hazardous by the OSHA Hazard Communication Standard (29 CFR 1910.1200).
Classification of the substance or mixture	:	SKIN IRRITATION - Category 2 EYE IRRITATION - Category 2A RESPIRATORY SENSITIZATION - Category 1 SKIN SENSITIZATION - Category 1 CARCINOGENICITY - Category 1A TOXIC TO REPRODUCTION - Category 1B SPECIFIC TARGET ORGAN TOXICITY (REPEATED EXPOSURE) - Category 2

GHS label elements

Hazard pictograms :

Appendix C: Letter of Acceptance

Northern Alberta Institute of Technology
11762 – 106 Street
Edmonton, AB T5G 2R1

January 10, 2024

Mr. Scott Sparling

Mr. Derek Walker

Ms. Audrey Claydon

Instructors, Mechanical Engineering Technology
NAIT
11762 – 106 Street
Edmonton, AB T5G 2R1

Dear Mr. Sparling, Mr. Walker, and Ms. Claydon:

This letter is to acknowledge acceptance of the capstone project as a requirement of our MCEN 2471 course. We are committed to fulfill the requirements as stated in the scope of this project.

Enclosed with this letter is the Student Team Selection Letter.

Sincerely,

10 JAN 2024
Mari De Vera
Team Leader
Gear Heads

10 JAN 2024
Leo Punongbayan
Team Secretary
Gear Heads

Ethan Nott
Member
Gear Heads
10 JAN 2024

Appendix D: Project Plan

PROJECT PLAN

1.0 PROJECT IDENTIFICATION	
Team Name	Gear Heads
Project Name	Tanks A Lot Thermal Dynamics
Description	Develop and design a water-jacket phosphate system for zinc and manganese phosphate coating of steel components after final machining.
Sponsor	Argus Machine Co. Ltd.
Team Leader	Mari De Vera

2.0 RATIONALE

Manganese phosphate and zinc dip tanks are used to coat steel components after machining. The current phosphate coating tanks set-up is damaging the tanks due to exposure to an open flame. The design must keep the solution at a consistent temperature during the dipping process and must be a cost-effective method to satisfy the requirements of the phosphate media. Mitigation of heat loss and recovery time when the temperature drops must also be considered.

3.0 PROJECT OBJECTIVES AND GOALS

- The project's objective is to find a reliable and consistent method of heating the phosphate dip tanks. The manganese phosphate tank must be kept at a temperature of 200±5 F^{o} and the zinc phosphate tank must be kept at 190±5 F^{o}.
- Preferably to re-use of existing equipment (e.g., tanks, baskets, etc.)
- Inner tank to be removable for cleaning and maintenance.
- Consideration of the mitigation of heat loss and recovery time when the temperature drops due to cooling effects must also be considered.

4.0 PROJECT SCOPE AND CONSTRAINTS

The following tasks will be accomplished.

- The thermodynamics and heat transfer calculations
- Design of main heating tank and support systems. Preference is for a water-jacket system.

The following must be considered:

- Tank sizing
- Methods of loading/unloading parts in the tank
- Capture and exhaust of off-gases.

Outside of scope:

- Building of tank

5.0 REQUIREMENTS AND DELIVERABLES (CLIENT)

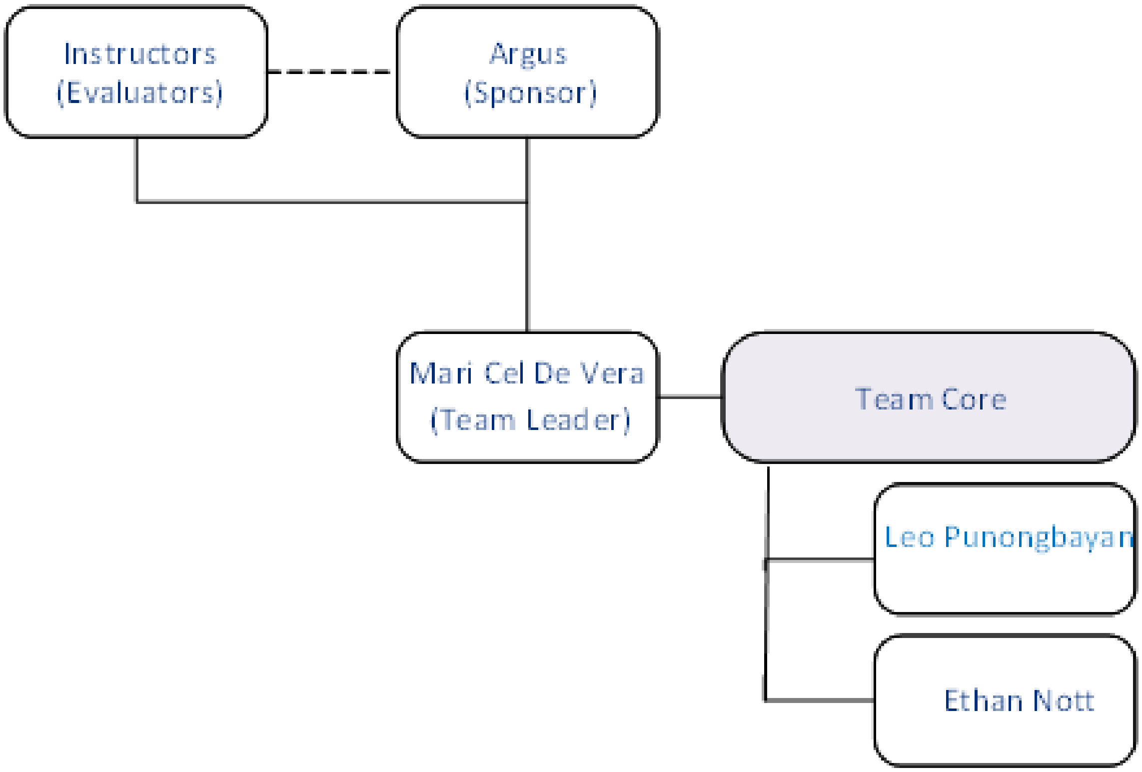
• Main objective: To develop and design a phosphate system for zinc and manganese phosphate coating of steel components after final machining. If time permits, the project shall include sizing, method of heating, capture and exhaust of off-gases, and a method of loading and unloading parts in the tank.
• Project features and constraints:
  ○ The system must maintain the operating temperature of Zinc phosphate tank at 88±2.8 °C bath temperature, and Manganese Phosphate tank at 93±2.8 °C
  ○ It is preferred that the tanks be identical.
  ○ It is preferred that tanks have water-jacket design.
  ○ Tanks should be able to accommodate all products fully submerged.
  ○ Optional scope (if time permits): include the design for ventilation system.

6.0 PROJECT DELIVERABLES (COURSE/INSTRUCTORS)	
Name	**Description**
Team Charter	A set of guidelines and/or agreement that the team members will follow
Logbook	A culmination of all our notes and ideas
Final Report	Complete write up of our project

7.0 ACTION PLAN (PROJECT SCHEDULE)		
Item	**Major Events/Tasks/Deliverables/Milestones**	**Dates**
11.	Presentation	April 3, 2024
12.	Reports	April 24, 2024
13.	Logbooks	April 24, 2024

8.0 PROJECT ORGANIZATION		
8.1 Team Roles and Responsibilities (FLOWS FROM PROJECT ORG CHART)		
Name	**Position**	**Roles and Responsibilities**
Mari De Vera	*Team Leader*	*Team Point of Contact, Facilitator, Work Project, Evaluator, Draftsman*
Leo Punongbayan	*Team Secretary*	*Meeting Minutes, Work Project, Evaluator, Draftsman*
Ethan Nott	*Team Member*	*Work Project, Evaluator, Draftsman*
8.2 Project Organization Chart		

8.0 PROJECT ORGANIZATION
8.1 Team Roles and Responsibilities (FLOWS FROM PROJECT ORG CHART)



9.0 PROJECT COMMUNICATION (MODE AND FREQUENCY)	
Team to Sponsor	**Sponsor to Team**
• ***Weekly:*** *status email updates from Team Leader (TL)* • ***Meetings****: once a month (NAIT Library)* • ***Urgent:*** *text, phone calls, e-mail, or teams' message (preferably through e-mail)*	• *Site visits (as requested)* • *Email from the Team Leader*

10.0 APPROVAL (BY TL, SPONSOR, AND MENTORS)			
Name	**Position**	**Signature**	**Date**
Scott Sparling	**Instructor**		
Derek Walker	**Instructor**		
Audrey Claydon	**Instructor**		
Randy Wiltermuth	**Sponsor**		
Mari Cel De Vera	**Team Lead**		

- **Project Gantt Chart Attached**

Capstone (MCEN 2471) Project: Gear Heads - Phosphate Conversion Coating System (Water-Jacket Tank)

Project Task/Deliverable/Milestone	*Starting*		*Conceptual Design*		*Detailed Design*								*Ending*		
	Week 1	**Week 2**	**Week 3**	**Week 4**	**Week 5**	**Week 6**	**Break**	**Week 8**	**Week 9**	**Week 10**	**Week 11**	**Week 12**	**Week 13**	**Week 14**	**Week 15**
Form Team-Letter (Team Name, Members, Roles)	x														
Project Preferences-Letter (Top 4)	x														
MS1 - Project Assigned															
Plant Visit			◆												
Project Plan, research, project design and documentation			/												
MS2 - Ideation															
Brainstorming			/												
4-Blocker, Downselect			/												
MS3 - Decision Analysis															
4-Blocker Selection/Presentation				x											
Project Plan Presentation				x											
Preliminary design selection				x											
Gantt Chart				x											
MS4 - Design Analysis															
Team Peer Review						◆									
Final Design					/	/		/	/	/	◆				
MS5 - Final Design Completed															
Calculations, Drawings, Consultations								/	/	◆					
MS6 - Man., Assembly, QC Completed															
Draft Technical Report															
Draft Drawing Package								/	/	/	/	/	◆		
Create Presentation												◆			
MS7 - Team Presentation Completed - 20%															
Presentation Day													◆		
MS8 - Technical (Final) Report Submitted - 70%															x
MS9 - Individual Logbooks Submitted- 10%															x

Appendix E: Team Charter

TEAM CHARTER

PROJECT IDENTIFICATION

Team Name: Gear Heads

Project Name: Tanks a Lot Thermal Dynamics

Description: Develop and design a water-jacket phosphate system for zinc and manganese phosphate coating of steel components after final machining.

Sponsor (Client): Argus Machine Co. Ltd.

TEAM MEMBERS

Name	Role	Responsibilities
Mari De Vera	Leader	Team Point of Contact, Facilitator, Work Project, Evaluator, Draftsman
Leo Punongbayan	Secretary	Meeting Minutes, Work Project, Evaluator, Draftsman
Ethan Nott	Member	Work Project, Evaluator, Draftsman

CONTACT INFORMATION

Name	Cellphone Number	E-mail
Mari De Vera	(780) 935-6311	mantona1@nait.ca
Leo Punongbayan	(587) 930-3001	lpunongbayan1@nait.ca
Ethan Nott	(780) 504-9703	enott1@nait.ca

COMMUNICATION GUIDELINES

	Guidelines
1	We will communicate through Microsoft teams, e-mail, and text messaging, or in-person.
2	We will use Microsoft Teams for file sharing.
3	We will meet every Tuesdays and Fridays at 12:15 – 12:45 for team updates unless an additional meeting is required.
4	We will confirm actions and decisions in writing.
5	We will communicate early and often.

MEETING GUIDELINES

	Guidelines
1	If we cannot attend a meeting, we will decline and propose an alternative time. We will prioritize project team meetings on the allotted time.
2	We will be present and active in meetings, putting other work aside.
3	We will be open about which actions we can take and commit to completing them on time.
4	We will arrive on time.

DECISION-MAKING PROCESS

Team members are free to make decisions about the best way to complete their work, but anything that impacts project scope, time, or cost, must be agreed by the majority. In case of conflicting ideas, the team should arrive at a consensus. If no consensus was drawn, the team leader will take precedence.

If the team comes across a concern that cannot be resolved within the team's capacity, the team will consult the Capstone Project Instructors – Mr. Derek Walker, Mr. Scott Sparling, and Ms. Audrey Claydon – for guidance.

TEAM VALUES AND PRINCIPLES

	Value or principle
1	There are no silly questions, and it is always good to ask for more information.
2	For each problem we will bring a solution.
3	We will work as a team to solve problems. We know we can ask for help anytime.
4	We are always open and honest.
5	We work hard, but we also support each other to keep a good home life balance.
6	No withholding of information or issues between team members.
7	We stand by our agreements once we make them.

BEHAVIORS

	Guidelines
1	We are willing to stand behind the purpose, the rules, and the goals of the team.
2	We will complete and fulfill our commitments.
3	We only make commitments we are willing and intend to keep.
4	We support each other, early and often.
5	We keep time commitments.

CONFLICT RESOLUTION

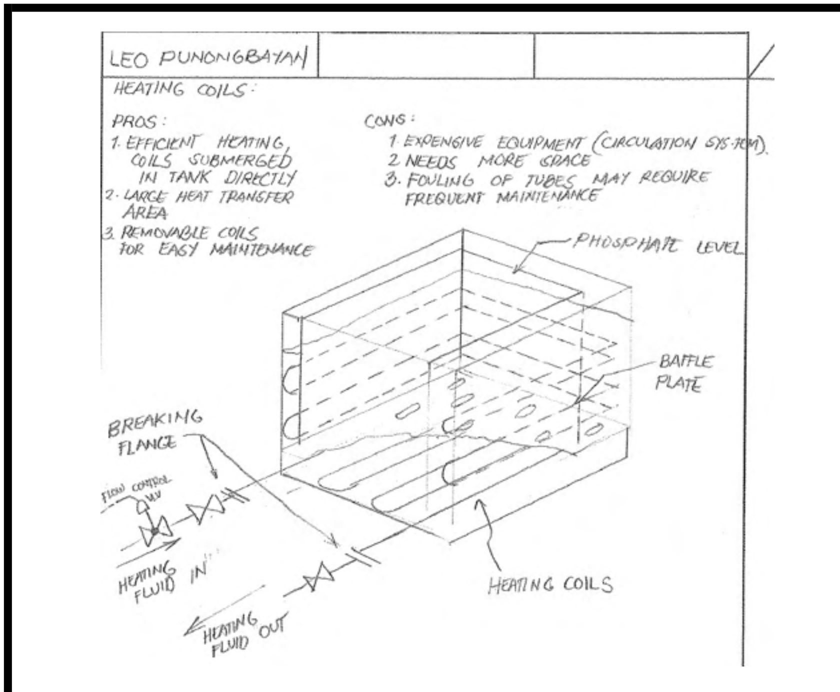
	Guidelines
1	We will use problem-solving techniques and scientific approach to resolve conflicts.
2	Conflicts must not be disclosed outside the team.
3	Conflicts that arise between the members must be mediated by the team leader.
4	If the conflict is beyond the capability of the team leader, the team will consult the Capstone Project Instructors – Mr. Derek Walker, Mr. Scott Sparling, and Ms. Audrey Claydon – for guidance.
5	The team must make a rationale decision, not based on personal interest.

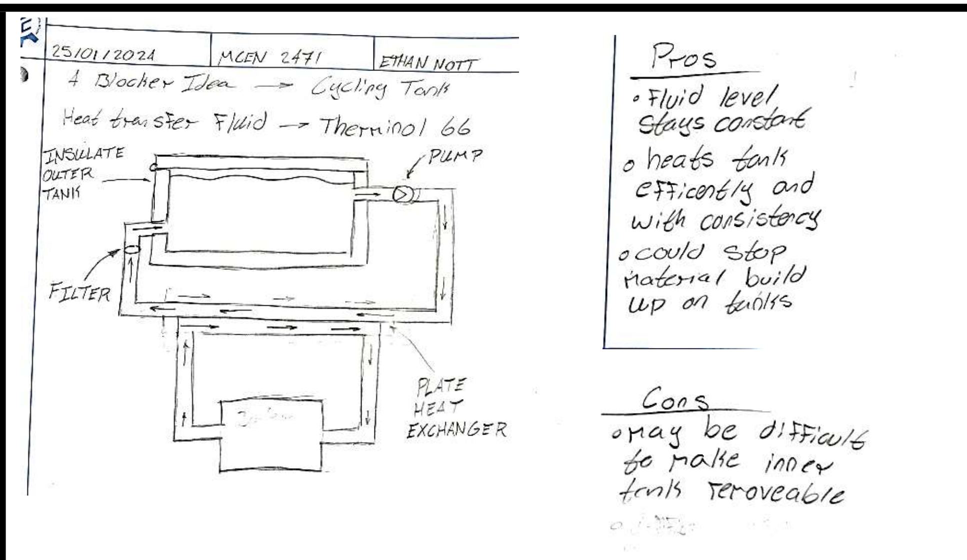
APPROVAL

Name	Position	Signature	Date
Mari De Vera	Leader		22 JAN 2024
Leo Punongbayan	Secretary		22-JAN-2024
Ethan Nott	Member		23-JAN-2024

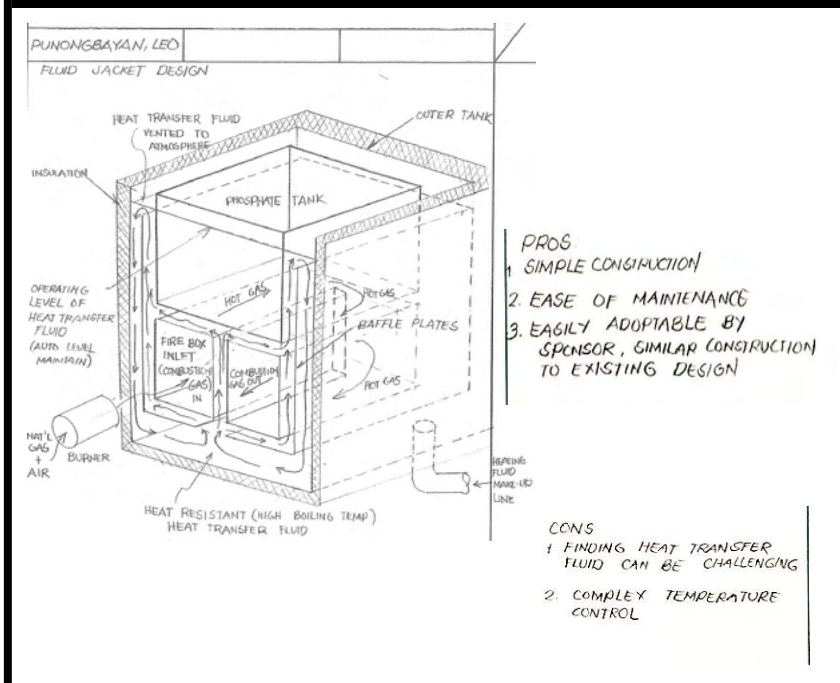
Appendix F: 4-Blocker

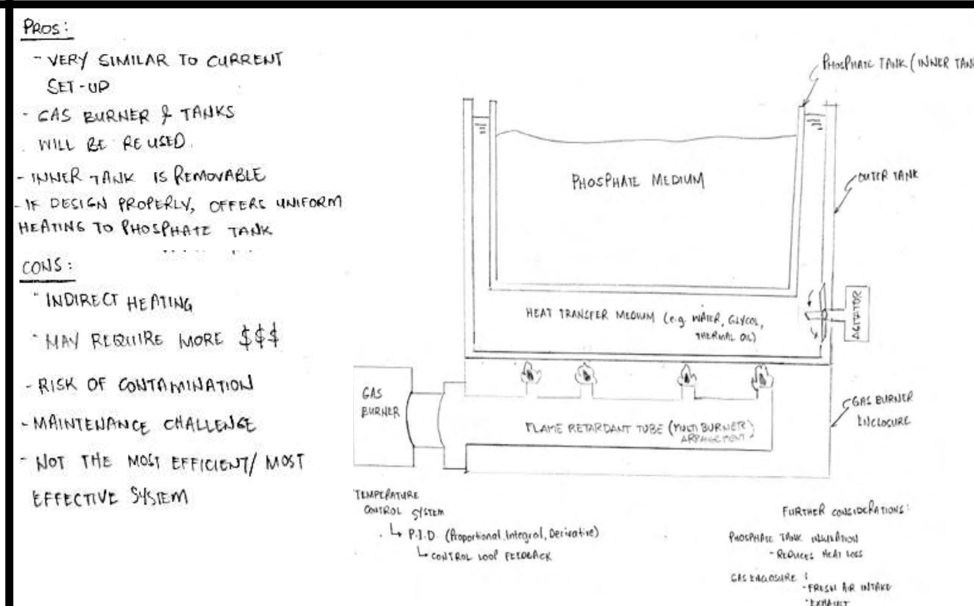
Gear Heads 4-Blocker





CIRCULATING SYSTEM CONCEPT





TANK-WITHIN-A-TANK CONCEPT

Appendix G: Calculation of Product Heat Requirement

29/01/2024	MCEN 2471	ETHAN NOTT

HEAT LOSSES

CONDUCTION

STOCK → 4140 STEEL

$$Q_S = (2000\ lb)\left(0.113\ \frac{BTU}{lb\text{-}F^\circ}\right)(200^\circ F - 130^\circ F)$$
$$= 15820\ BTU$$

BASKET → 304 STAINLESS STEEL

$$Q_B = (350\ lb)\left(0.120\ \frac{BTU}{lb\text{-}F^\circ}\right)(200^\circ F - 130^\circ F)$$
$$= 2940.\bar{0}\ BTU$$

$$\Sigma Q = Q_B + Q_S$$
$$= (2940.\bar{0}\ BTU) + (15820\ BTU)$$
$$= 18760\ BTU$$

$$\underline{\Sigma Q = 18760\ BTU}$$

MECHANICAL ENGINEERING TECHNOLOGY NAIT

CONVECTION

$$h_\alpha = 0.881140 \frac{BTU}{hr\text{-}ft^2\text{-}F^\circ}$$

$$R_\alpha = \frac{1}{h_\alpha}$$

$$= \frac{1}{0.881140 \frac{BTU}{hr\text{-}ft^2\text{-}F^\circ}}$$

$$= 1.13489 \frac{hr\text{-}ft^2\text{-}F^\circ}{BTU}$$

$$Q = \frac{T_1 - T_2}{R_\alpha} \cdot A$$

$$= \frac{(200^\circ F - 68^\circ F)}{\left(1.13489 \frac{hr\text{-}ft^2\text{-}F^\circ}{BTU}\right.} \cdot \left(2400 in \cdot \frac{1}{12}\right)$$

$$= 23262.16 \frac{BTU}{hr}$$

$$Q = 2.33 \times 10^4 \frac{BTU}{hr}$$

$$\dot{Q}_{RAD} = \varepsilon \sigma A \left(T_{PHOSPHATE}^{4} - T_{AIR}^{4} \right)$$

$\varepsilon = 0.95 \rightarrow$ BASED ON WATER ; FROM: ENGINEERING TOOL BOX

$\sigma = 1.714 \times 10^{-9} \dfrac{BTU}{hr\text{-}ft^2\text{-}R^4}$

$A = 16.67\ ft^2$

$$\dot{Q}_{RAD} = (0.95)\left(1.714 \times 10^{-9} \frac{BTU}{hr\text{-}\cancel{ft^2}\text{-}\cancel{R^4}}\right)\left[(200+460)^4 - (75+460)^4\right]\cancel{R^4} \cdot (16.67\ \cancel{ft^2})$$

$$= 2{,}927\ \frac{BTU}{hr}$$

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HEAT TRANSFER INTO THE PHOSPHATE

$$Q_{steel} = \overset{2000\,lb}{15820\ BTU} \rightarrow \overset{500\,lb}{3955\ BTU}$$

$$Q_{Basket} = 2940\ BTU$$

$$Q_{B+S} = \overset{2000\,lb}{18760\ BTU} \rightarrow \overset{500\,lb}{6895\ BTU}$$

- Product gets dipped <u>5</u> times per hr

$$18760\ BTU \cdot 5/hr = 93800\ \frac{BTU}{hr}$$

$$Q_{Air} = 2.33 \times 10^4\ \frac{BTU}{hr}$$

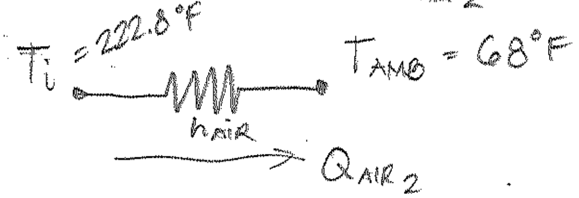
$$Q_{Rad} = 2927\ \frac{BTU}{hr}$$

$$Q_{inp} = 18760\ \frac{BTU}{hr} + 2.33 \times 10^4\ \frac{BTU}{hr} + 2927\ \frac{BTU}{hr}$$

$$= \overset{2000\,lb}{120027\ \frac{BTU}{hr}} \rightarrow \overset{500\,lb}{60702\ \frac{BTU}{hr}}$$

Appendix H: Calculation of Heat Input to Inner Dip Tank and Air Heat Losses

b) CALCULATION OF $Q_{AIR\,2}$



$$A = \left[(40'' \times 96'') - (30'' \times 88'')\right]\left(\frac{1\,ft}{12\,in}\right)^2$$

$$A = 8.333\ ft^2$$

$$Q_{AIR_2} = A \cdot h_{AIR} \cdot (T_i - T_{AMB})$$

$$= (8.333\ \cancel{ft^2})\left(9.69\ \frac{BTU}{hr\text{-}\cancel{ft^2}\text{-}\cancel{°F}}\right)(222.8\cancel{°F} - 68\cancel{°F})$$

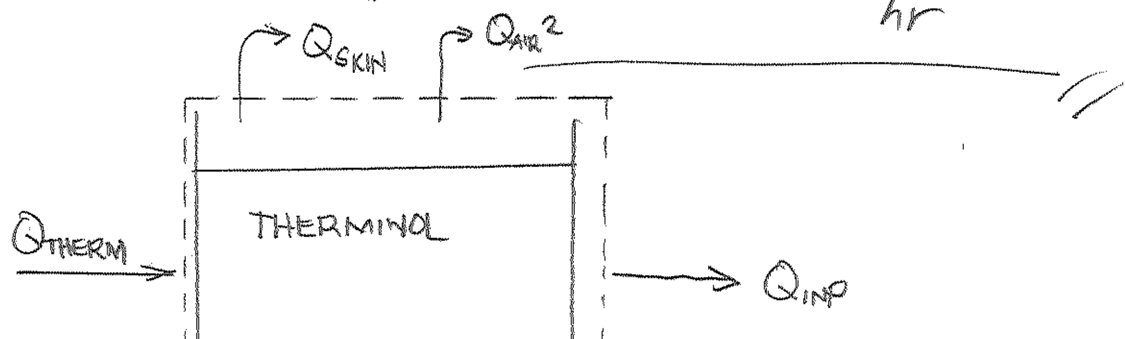
$$Q_{AIR\,2} = 12{,}500\ \frac{BTU}{hr}$$

TOTAL HEAT INPUT TO THERMINOL : (Q_{THERM})

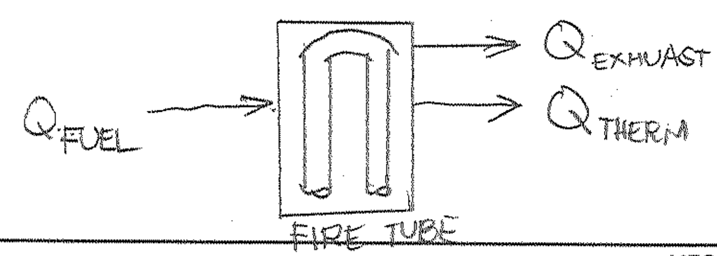
$$Q_{THERM} = Q_{INP} + Q_{SKIN} + Q_{AIR\,2}$$

$$= [120{,}027 + 14{,}681 + 12{,}500]\ \frac{BTU}{hr}$$

$$Q_{THERM} = 147{,}208\ \frac{BTU}{hr} \approx 150{,}000\ \frac{BTU}{hr}$$



HEAT FROM FUEL



Appendix I: Calculation of Heat Transfer Fluid Temperature

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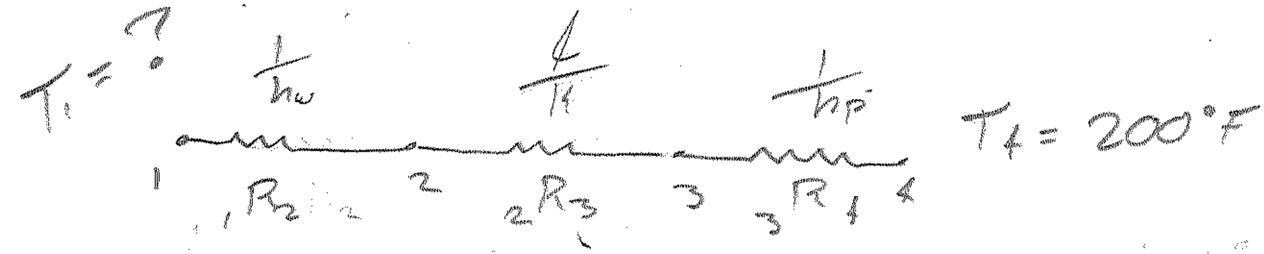
Heat transfer with dirt losses

→ 2000 lb & 500 lb

worst case — best case



$${}_1R_2 = \frac{1}{h_w} = \frac{1}{88.11 \frac{BTU}{hr \cdot ft^2 \cdot F°}} = 0.011349 \frac{hr \cdot ft^2 \cdot F°}{BTU}$$

$${}_2R_3 = \frac{l}{k} = \frac{\left(\frac{3}{16} in\right)\left(\frac{1}{12}\right)}{9.4 \frac{BTU}{ft \cdot hr \cdot F°}} = 0.001662 \frac{hr \cdot ft^2 \cdot F°}{BTU}$$

$${}_3R_4 = \frac{1}{h_p} = \frac{1}{3522.2 \frac{BTU}{ft^2 \cdot hr \cdot F°}} = 2.83 \times 10^{-4} \frac{hr \cdot ft^2 \cdot F°}{BTU}$$

$$\Sigma R = 0.013294 \frac{hr \cdot ft^2 \cdot F°}{BTU}$$

$$\frac{Q}{A} = \frac{T_1 - T_2}{\Sigma R} \qquad \frac{BTU}{hr} \cdot \frac{1}{ft^2} \cdot \frac{hr \cdot ft^2 \cdot F°}{BTU} = \frac{F°}{1}$$

$$T_1 = \left(\frac{Q}{A}\right)(\Sigma R) + T_2$$

$$= \left(\frac{120027 \frac{BTU}{hr}}{63.8 ft^2}\right)\left(0.01329 \frac{hr \cdot ft^2 \cdot F°}{BTU}\right) + (200°F)$$

$$= 224.9\ F° \longrightarrow 2000 lb$$

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$$T_1 = \left(\frac{60702}{63.8ft^2}\right)(0.01329\,C) + 200$$

$$= 212.62\,F^\circ \longrightarrow 300lb$$

Use thermino! 54

↳ boiling point → 664°F

$C = 0.52\,\frac{BTU}{lb \cdot F^\circ}$ at 200°F

$\rho = 54.23\,\frac{lb}{ft^3}$

Heat loss to air only

$$T_1 = \left(\frac{23300}{63.8ft^2}\right)(0.01329) + 200^\circ F$$

$$= 204.84\,F^\circ$$

Appendix J: Calculation of Heat Losses on Outer Tank Skin

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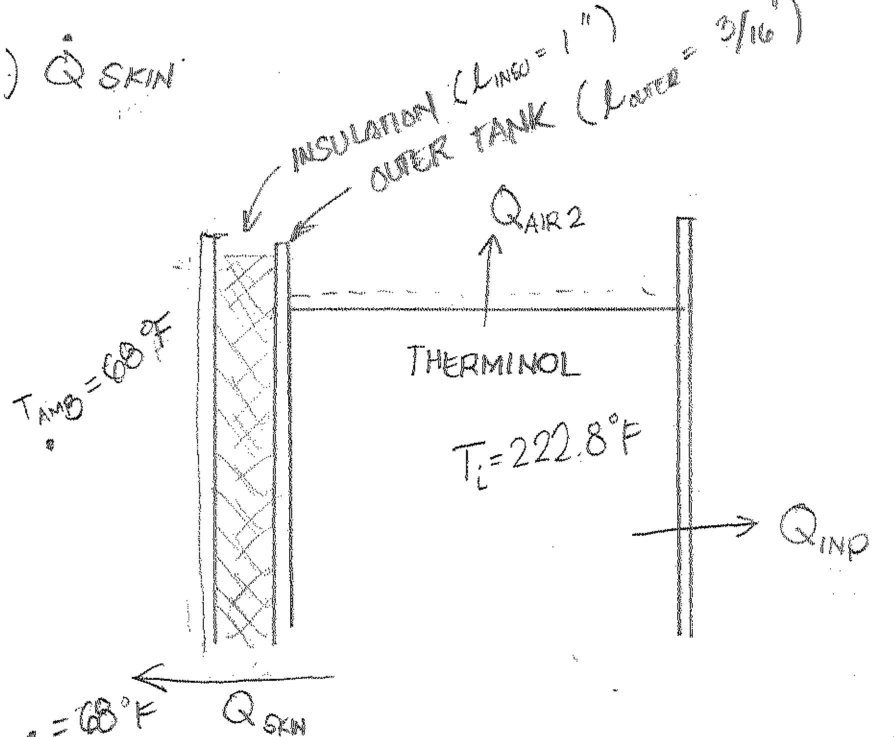
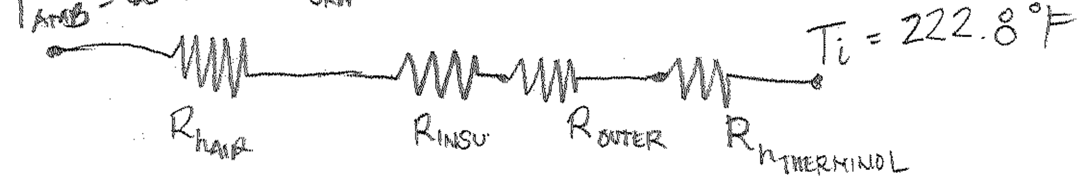
CALCULATION OF HEAT LOSS OF THERMINOL TO OUTSIDE AIR (Q_{SKIN})

9.) $\dot{Q}_{SKIN}$

$K_{INSU} = 0.833 \ \frac{BTU\text{-}in}{hr\text{-}ft^2\text{-}°F}$

$K_{OUTER} = 9.4 \ \frac{BTU}{ft\text{-}hr\text{-}°F}$





$$\frac{\dot{Q}_{SKIN}}{A} = \frac{T_i - T_{AMB}}{\Sigma AR} \ ; \qquad \Sigma AR = \frac{1}{h_A} + \frac{l_{INSU}}{k_{INSU}} + \frac{l_{OUTER}}{K_{OUTER}} + \frac{1}{h_{THERMINOL}}$$

$$\Sigma AR = \frac{1}{9.69 \ \frac{BTU}{hr\text{-}ft^2\text{-}°F}} + \frac{1 \ \cancel{in}}{0.833 \ \frac{BTU\text{-}\cancel{in}}{hr\text{-}ft^2\text{-}°F}} + \frac{\frac{3}{16}\cancel{"} \times \frac{1 \ ft}{12 \ \cancel{in}}}{9.4 \ \frac{BTU}{hr\text{-}ft\text{-}°F}} + \frac{1}{88.11 \ \frac{BTU}{hr\text{-}ft^2\text{-}°F}}$$

$$\Sigma AR = 1.317 \ \frac{hr\text{-}ft^2\text{-}°F}{BTU}$$

$$A = \left[(40" \times 52" \times 2) + (52" \times 96" \times 2) + (40" \times 96")\right]\left(\frac{1 \ ft}{12 \ in}\right)^2$$

$$A = 124.9 \ ft^2$$

$$Q_{SKIN} = \frac{(124.9 \ \cancel{ft^2})(222.8 \ \cancel{°F} - 68 \ \cancel{°F})}{\left(1.317 \ \frac{hr\text{-}\cancel{ft^2}\text{-}\cancel{°F}}{BTU}\right)} = 14,681 \ \frac{BTU}{hr}$$

Appendix K: Calculation of Fire Tube Heat Transfer Area

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SIZING OF FIRE TUBES

→ FIND HEAT TRANSFER AREA (A)

CONSIDERATIONS:

$U = 5\ BTU/hr\text{-}ft^2\text{-}°F$ → FROM ENGINEER'S EDGE (FIRED HEATERS)

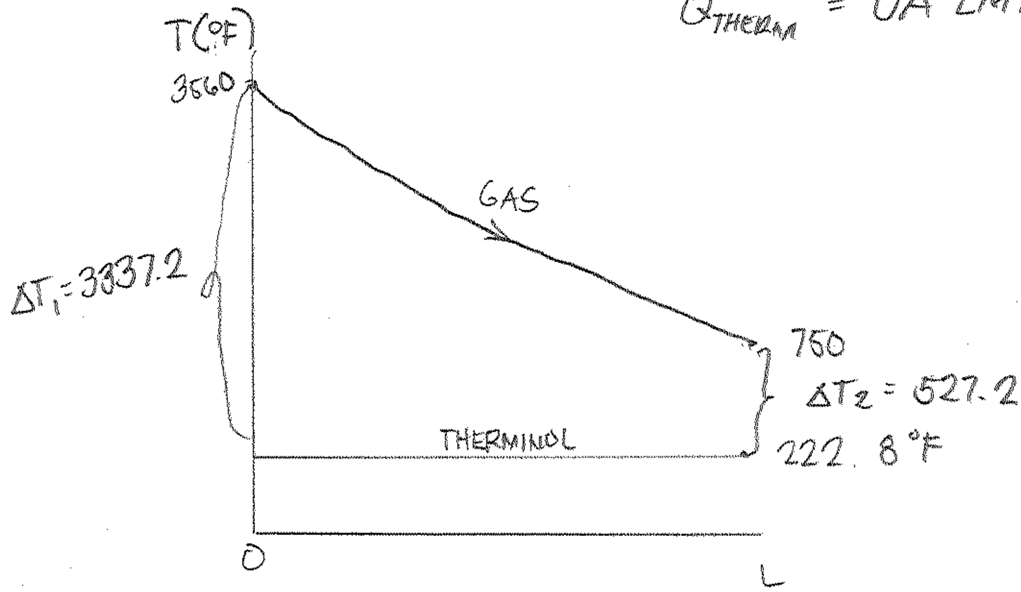
304 SS MAXIMUM SERVICE TEMP ≈ 870°C

→ LIMIT DESIGN TEMP TO ½ ≈ 400°C ∴ $T_{gas\ out} = 400°C$ or 750°F

$T_{gas\ in} = 3560°F$ or 1960°C → FLAME TEMPERATURE

$T_{THERMINOL} = 222.8\ °F$

$\overset{\checkmark}{Q_{THERM}} = \overset{\checkmark}{U}\overset{?}{A}\ \overset{?}{LMTD}$



$$LMTD = \frac{\Delta T_1 - \Delta T_2}{\ln\left(\frac{\Delta T_1}{\Delta T_2}\right)} = \frac{3337.2 - 527.2}{\ln\left(\frac{3337.2}{527.2}\right)} = 1522.8\ °F$$

$$A = \frac{Q_{THERM}}{U \cdot LMTD} = \frac{150{,}000\ \cancel{BTU/hr}}{5\ \frac{\cancel{BTU}}{\cancel{hr\text{-}}ft^2\ \cancel{°F}}\ (1522.8\ \cancel{°F})} = 19.7\ ft^2$$

CONSIDER COMBINATION OF TUBE Ø AND PASSES

$A = \pi \varnothing \times L \times n$

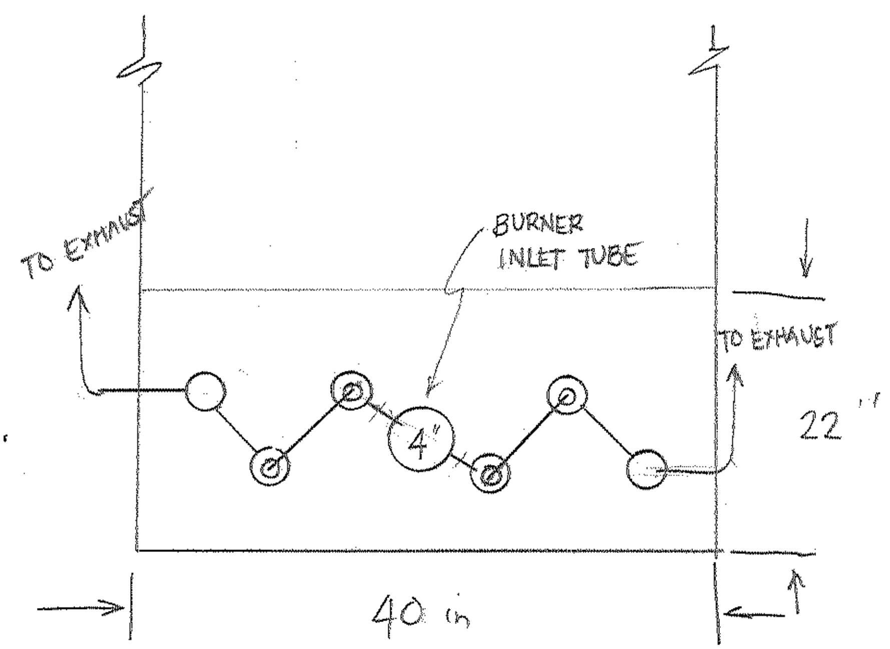
LENGTH OF TUBE (L) = 80 inches

n → # OF PASSES

Ø → TUBE DIA, LIMIT TO 2" DUE TO SPACE CONSTRAINT:

A (ft^2)	n	Ø (INCHES)
19.7	2	5.73
19.7	3	3.82
19.7	4	2.86
19.7	5	2.30
19.7	6	1.91
19.7	7	1.64 → SELECT TO HAVE SOME MARGIN.

PROPOSED CONFIGURATION



Appendix L: Calculation of Buoyant Force onto the Inner Tank

06/03/2024 | MCEN 2474 | ETHAN NOTT

Bouyant Force Calculations
↳ Fully submerged

Mass of Inner Tank → 2340 lb

Density of heating Fluid
↳ $54.23 \frac{lb}{ft^3}$

Volume of displaced Fluid

$$V_d = \frac{(6.25)(30)(88)}{12^3}$$

$$= 9.548 \ ft^3$$

$$F_b = (9.54 \ ft^3)(54.23 \frac{lb}{ft^3})$$

$$= 517.82 \ lb$$

the mass of the inner tank is greater then the bouyant Force

Appendix M: Selection of Heat Transfer Fluid

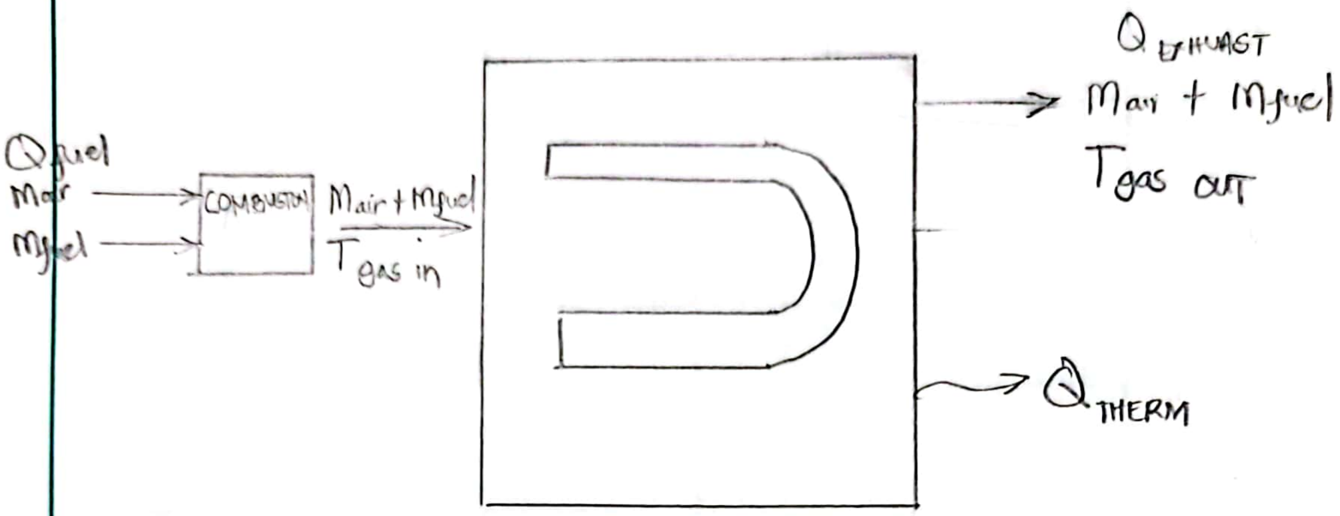
SELECTED HEAT TRANSFER FLUID

English units *Liquid phase heat transfer*	THERMINOL **54** Economical medium-temperature-range fluid	THERMINOL **55** Trusted medium-temperature-range fluid
Typical properties[a]		
Appearance	Clear, yellow liquid	Clear, yellow liquid
Composition	Synthetic hydrocarbon mixture	Synthetic hydrocarbon mixture
Recommended bulk temperature	540°F	570°F[d]
Maximum film temperature	590°F	635°F
Normal boiling point	664°F	664°F
Pumpability: at 300 cSt (mm^2/s) at 2000 cSt (mm^2/s)	 17°F –18°F	 17°F –18°F
Pour point	<–50°F	–65°F
Flash point, COC	>340°F	379°F
Fire point, COC	>410°F	425°F
Autoignition temperature[b]	>625°F	719°F (DIN 51794)
Fully developed turbulent flow (Re = 10,000, 10 ft/s, 1-in. tube)	152°F	152°F
Kinematic viscosity, cSt (mm^2/s)	0°F 683 200°F 4.03 400°F 0.96 540°F 0.56	0°F 683 200°F 4.03 400°F 0.964 550°F 0.536
Density at 75°F (lb/gal)	7.25	7.26
Density, various temperatures	0°F 7.49 lb/gal 56.0 lb/ft^3 200°F 6.86 lb/gal 51.3 lb/ft^3 400°F 6.22 lb/gal 46.5 lb/ft^3 540°F 5.73 lb/gal 42.8 lb/ft^3	0°F 7.49 lb/gal 56.0 lb/ft^3 200°F 6.86 lb/gal 51.3 lb/ft^3 400°F 6.22 lb/gal 46.5 lb/ft^3 550°F 5.69 lb/gal 42.6 lb/ft^3
Heat capacity, Btu/(lb•°F)	0°F 0.42 200°F 0.52 400°F 0.61 540°F 0.68	0°F 0.423 200°F 0.518 400°F 0.612 550°F 0.682
Thermal conductivity, Btu/(h•ft•°F)	0°F 0.077 200°F 0.069 400°F 0.062 540°F 0.057	0°F 0.0768 200°F 0.0693 400°F 0.0618 550°F 0.0561
Vapor pressure	200°F — — 400°F 18.6 mmHg 0.36 psia 540°F 169 mmHg 3.27 psia	200°F 0.16 mmHg 0.003 psia 400°F 18.6 mmHg 0.360 psia 550°F 193 mmHg 3.74 psia
Geographic availability[c]	Europe/Middle East/Africa	Americas/Middle East/Africa

Appendix N: Calculation of Fuel Requirement

MARCH 27, 2024

DETERMINING REQUIRED HEAT INPUT TO FIRE TUBE



KNOWN:

$$Q_{THERM} = 150{,}000 \ BTU/hr$$

$$T_{gas\ IN} = 3560\ °F$$

$$T_{gas\ OUT} = 750\ °F$$

$$E_{IN} = E_{OUT}$$

$$Q_{fuel} = Q_{EXHAUST} + Q_{THERM}$$

$$(M_{air} + M_{fuel}) \cdot C_{p_{air}} \cdot T_{gas_{in}} = (M_{air} + M_{fuel}) \cdot C_{p_{air}} \cdot T_{gas\ out} + Q_{THERM}$$

$$(M_{air} + M_{fuel}) \cdot C_{p_{air}} (T_{gas_{in}} - T_{gas\ out}) = Q_{THERM}$$

NEED AIR & FUEL MASS FLOW RATIO:

LET 20% EXCESS AIR BY VOLUME:

BY STOICH ANALYSIS: $\frac{49.8 \text{ lb-mol AIR}}{1 \text{ lb-mol NATURAL GAS}}$

$$MW_{AIR} = 29 \frac{\text{lb-AIR}}{\text{lb-mol AIR}}$$

$$MW_{NATURAL\ GAS} = \frac{19 \text{ lb-NAT'L GAS}}{\text{lb-mol NAT'L GAS}}$$

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$$\frac{49.8\ \cancel{\text{lb-mol AIR}}}{1\ \cancel{\text{lb-mol NAT'L GAS}}} \times \frac{\dfrac{29\ \text{lb-AIR}}{\cancel{\text{lb-mol AIR}}}}{\dfrac{19\ \text{lb-NAT'L GAS}}{\cancel{\text{lb-mol NAT'L GAS}}}} = 76\ \frac{\text{lb-air}}{\text{lb-NAT'L GAS}}$$

$$\frac{m_{air}}{m_{fuel}} = 76\ \frac{\text{lb air}}{\text{lb-NAT'L GAS}}$$

$$m_{fuel} = \frac{1}{76} m_{air}$$

SUB:

$$\left(m_{air} + \frac{1}{76} m_{air}\right) Cp_{air} \left(T_{gas\,in} - T_{gas\,out}\right) = Q_{THERM}$$

$$Cp_{air} = 0.24\ \frac{BTU}{lb\text{-}°F}$$

$$m_{air} = \frac{Q_{THERM}}{Cp_{air}\left(T_{gas\,IN} - T_{gas\,out}\right)\left(1 + \frac{1}{76}\right)}$$

$$= \frac{150,000\ \cancel{BTU}/hr}{0.24\ \frac{\cancel{BTU}}{lb\text{-}\cancel{°F}}\left(3560\cancel{°F} - 750\cancel{°F}\right)\left(1 + \frac{1}{76}\right)}$$

$$m_{air} = 219.53\ \frac{lb}{hr} \rightarrow Q_{Exhaust} = m_{air}\, Cp \cdot T_{gas\,out}$$

$$m_{fuel} = 2.9\ \frac{lb}{hr}$$

$$= \left(219.53 \frac{lb}{hr}\right)\left(0.24 \frac{BTU}{lb\,F°}\right)\left(750°F\right)$$

$$Q_{Exhaust} = 39,515\ \frac{BTU}{hr}$$

$$\approx 40K\ \frac{BTU}{hr}$$

TOTAL Q NEED

$$Q_{fuel} = Q_{THERM} + Q_{Exhaust}$$

$$= 150,000 \frac{BTU}{hr} + 39515 \frac{BTU}{hr} = 190,000 \frac{BTU}{hr}$$

$$\text{MASS OF FUEL} = \frac{190,000\ \frac{\cancel{BTU}}{hr}}{19800\ \frac{\cancel{BTU}}{lb}} = 9.6\ \frac{lb}{hr} \approx 10\ \frac{lb}{hr}$$

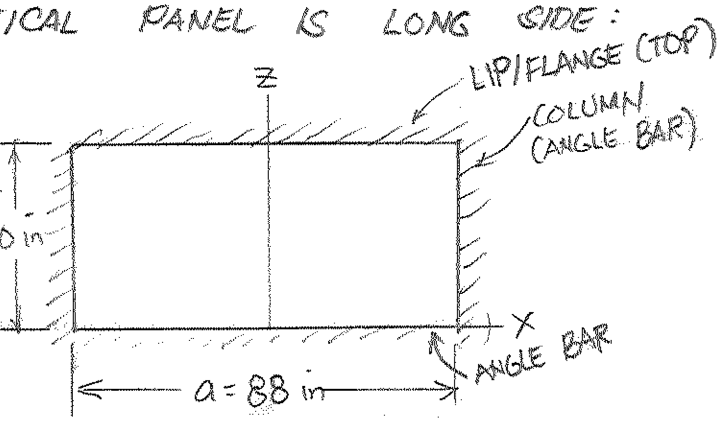
Appendix O: Calculation of Inner Tank Thickness

INSIDE TANK THICKNESS DESIGN:

CASE 1: 4 CORNER COLUMNS, NO OTHER STIFFENERS

USING ROARK'S TABLE 11.4 CASE 8a.

CRITICAL PANEL IS LONG SIDE:



$$\sigma_{MAX} = \frac{\beta_1 \cdot q \cdot b}{t^2}$$

$$\sigma_{MAX} = \sigma_d = \frac{S_y}{N} \quad ; \quad N = 2$$

$$t = \left[\frac{N \cdot \beta_1 \cdot q \cdot b^2}{S_y}\right]^{1/2}$$

$N = 2$; $S_y = 35$ ksi

$q = \gamma h$; $S.G = 1.205$ [HOUGHTO-PHOS → MANGANESE PHOS]

$h = b = 30$ in → CONSERVATIVE, ASSUME WORST CASE

$$q = (1.205)\left(62.4 \frac{lb}{ft^3}\right)(30 \text{ in})\left(\frac{1\ ft}{12 \text{ in}}\right)^3$$

$$q = 1.31 \text{ psi}$$

$a = 88$ in , $b = 30$ in

$$\frac{a}{b} = \frac{88 \text{ in}}{30 \text{ in}} = 2.93 \quad ; \quad \beta_1 = 0.5000$$

$$t = \left[\frac{(2)(0.5000)(1.31 \text{ psi})(30 \text{ in})^2}{(35{,}000 \text{ psi})}\right]^{1/2}$$

$t = 0.1835''$ → USE 3/16" THK SS304 PLATE

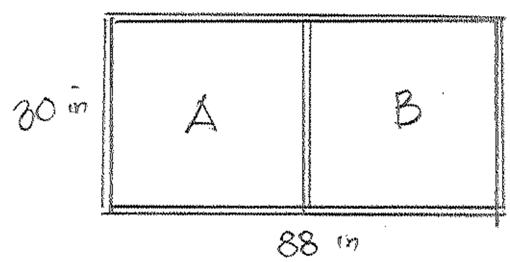
DEFLECTION AT CENTER:

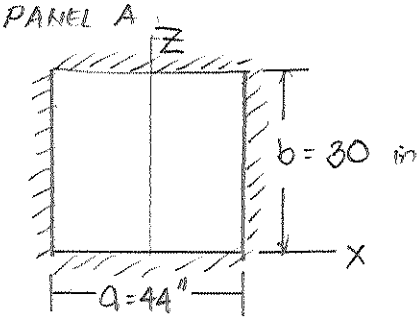
$\alpha = 0.0284$

$$y_{MAX} = \frac{\alpha q b^4}{E t^3} = \frac{(0.0284)(1.31 \text{ psi})(30 \text{ in})^4}{(30 \times 10^6 \text{ psi})(0.1875 \text{ in})^3} = 0.1524 \text{ inches}$$

25-FEB

CASE 2: 1 STIFFENER ADDED TO CASE 1





$\frac{a}{b} = \frac{44}{30} = 1.467$

a/b	β_1	α
1.4	0.4356	0.0226
1.467	β_1	α
1.6	0.4680	0.0251

$\beta_1 = 0.4465$

$\alpha = 0.02344$

$$t = \left[\frac{(2)(0.4465)(1.31 \text{ psi})(30 \text{ in})^2}{35{,}000 \text{ psi}} \right]^{1/2}$$

$t = 0.1734''$ → STILL 3/16" THK PLATE

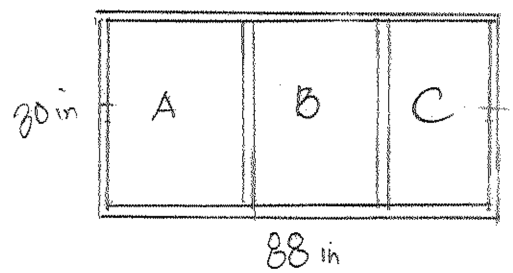
DEFLECTION:

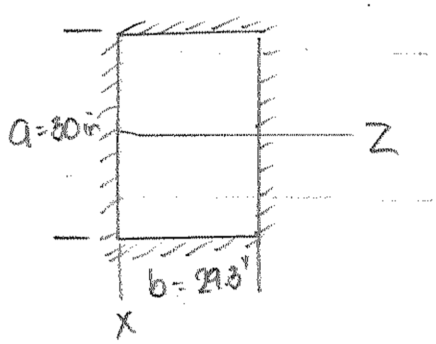
$$u_{MAX} = \frac{(0.02344)(1.31 \cancel{\text{psi}})(30 \text{ in})^4}{(30 \times 10^6 \cancel{\text{psi}})(0.1875 \text{ in})^3} = 0.126 \text{ inches}$$

25-FEB

CASE 3: 2 STIFFENERS ADDED:

PER PANEL:





$$\frac{a}{b} = \frac{30 \text{ in}}{29.3 \text{ in}} \approx 1.0$$

$\beta_1 = 0.3078$

$\alpha = 0.0138$

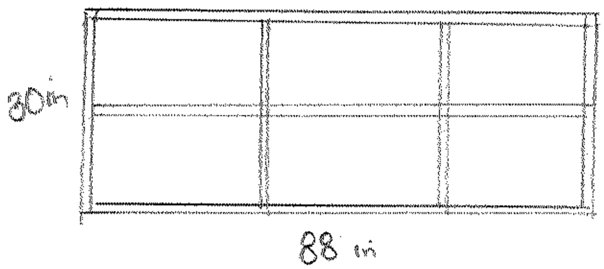
$$t = \left[\frac{(2)(0.3078)(1.31 \text{ psi})(29.3 \text{ in})^2}{35 \times 10^3 \text{ psi}}\right]^{1/2}$$

$t = 0.1406$ in $\rightarrow$ USE GAUGE 9 (5/32) 304 SS

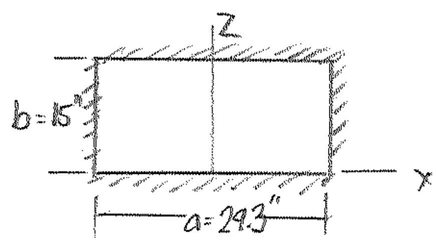
DEFLECTION:

$$y_{MAX} = \frac{(0.0138)(1.31 \text{ psi})(30 \text{ in})^4}{(30 \times 10^6 \text{ psi})(0.1563 \text{ in})^3} = 0.128 \text{ inches}$$

CASE 4: 3 STIFFENERS:



PER PANEL:



$$\frac{a}{b} = \frac{29.3''}{15''} = 1.95'' \approx 2.0$$

$$\beta_1 = 0.4974$$

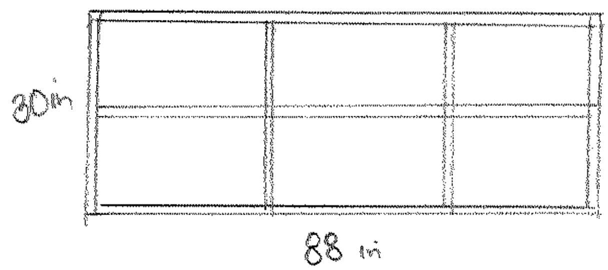
$$\alpha = 0.0277$$

$$t = \left[\frac{(2)(0.4974)(1.31\ psi)(15\ in)^2}{35 \times 10^3\ psi} \right]^{1/2}$$

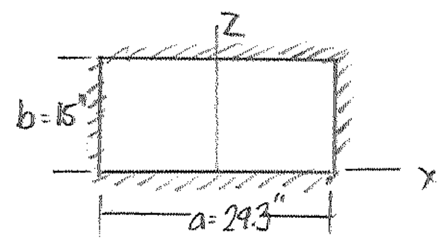
$t = 0.081$ inches $\longrightarrow$ USE GAUGE 12 $(7/64)$ SS 304
$t = 0.1054''$

$$y_{MAX} = \frac{(0.0277)(1.31\ psi)(15\ in)^4}{(30 \times 10^6\ psi)(0.1054\ in)^3} = \underline{0.052\ \text{inches}}$$

CASE 4: 3 STIFFENERS:



PER PANEL:



$$\frac{a}{b} = \frac{29.3''}{15''} = 1.95'' \approx 2.0$$

$$\beta_1 = 0.4974$$

$$\alpha = 0.0277$$

$$t = \left[\frac{(2)(0.4974)(1.31\ psi)(15\ in)^2}{35 \times 10^3\ psi} \right]^{1/2}$$

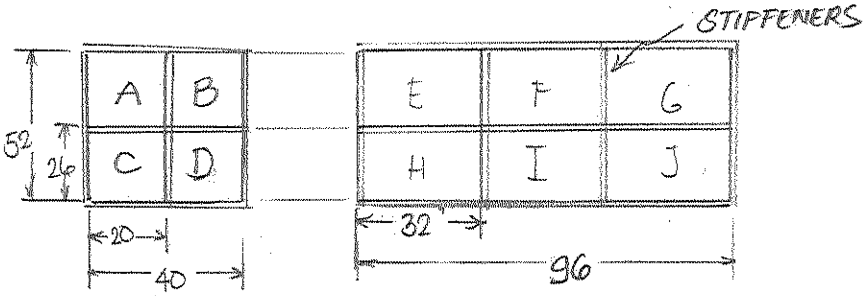
$t = 0.081$ inches $\longrightarrow$ USE GAUGE 12 $t = 0.1054''$ (7/64) SS 304

$$y_{MAX} = \frac{(0.0277)(1.31\ psi)(15\ in)^4}{(30 \times 10^6\ psi)(0.1054\ in)^3} = \underline{0.052\ inches}$$

Appendix P: Calculation of Outer Tank Thickness

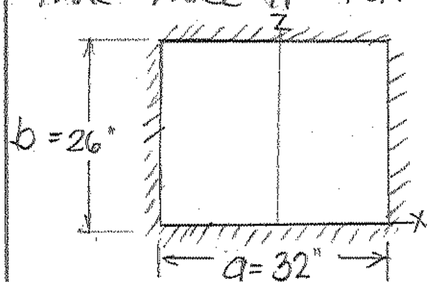
OUTER TANK

DESIGN CASE 1: 6 PARTITIONS ON LONG SIDE
4 PARTITIONS ON SHORT SIDE



WORST CASE PANEL H, I OR J

TAKE PANEL "H" FOR ANALYSIS



CONSIDERATION
- ALL EDGES FIXED (STIFFENER ARE WELDED)
- UNIFORM LOAD (PRESSURE) OVER ENTIRE PLATE

FLAT PLATE THEORY
ROARK'S TABLE 11.4 CASE 8a

$$\sigma_{MAX} = \frac{\underset{\text{COMPRESSIVE}}{-}\beta_1 \cdot q \cdot b^2}{t^2} \longrightarrow \text{EQ. 1}$$

UNIFORM PRESSURE (q) FROM THERMINOL 66: $q = \gamma h$

T	γ [lb/ft³]
50°F	63.4
200°F	γ
300°F	57.5

$$\frac{\gamma - 63.4}{57.5 - 63.4} = \frac{200 - 50}{300 - 50}$$

$$\gamma = 59.86 \ \frac{lb}{ft^3}$$

LET $h = 52"$ → CONSERVATIVE (WORST CASE)

$$q = 59.86 \ \frac{lb}{ft^3} \left(52"\right)\left(\frac{1\,ft}{12\,in}\right)^3 = 1.8 \ \frac{lb}{in^2}$$

$a = 32"$; $b = 26"$

$$\frac{a}{b} = \frac{32}{26} = 1.23$$; INTERPOLATION:

a/b	β_1
1.2	0.3834
1.23	β_1
1.4	0.4356

MIDPOINT

$\therefore \beta_1 = 0.39123$

EQUATE EQ. 1 TO DESIGN STRESS

$$\sigma_{MAX} = \sigma_d = \frac{S_y}{N}, \quad N = 2 \rightarrow \text{STATIC LOAD UNDER BENDING}$$

PLATE MATERIAL: 304 SS, $S_y = 35$ Ksi $\rightarrow$ FROM MOTT

$$\frac{\beta_1 \cdot q \cdot b^2}{t^2} = \frac{S_y}{N}$$

$$t = \sqrt{\frac{N \cdot \beta_1 \cdot q \cdot b^2}{S_y}} =$$

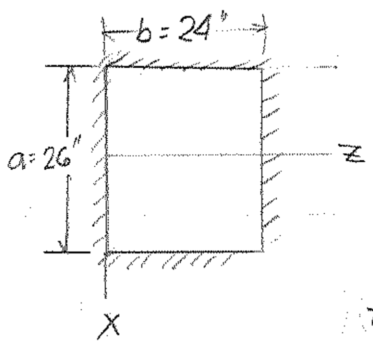
$$= \left[\frac{(2)(0.39123)\left(1.8 \frac{lb}{in^2}\right)(32 \text{ in})^2}{35{,}000 \frac{lb}{in^2}} \right]^{1/2}$$

$t = 0.203''$ $\rightarrow$ MINIMUM THICKNESS

$\therefore$ MUST USE $\underline{1/4'' \text{ SS } 304}$ PLATES

CASE 2:

IF WE INCREASE TO 8 PARTITIONS ON LONG SIDE:



$$a/b = \frac{26''}{24''} = 1.083$$

a/b	β_1
1.0	0.3078
1.083	β_1
1.2	0.3834

$\beta_1 = 0.3392$

$$t = \left[\frac{(2)(0.3392)\left(1.8 \frac{lb}{in^2}\right)(24'')^2}{35{,}000 \frac{lb}{in^2}} \right]^{1/2}$$

$t = 0.1418''$

$\therefore$ MUST USE $3/16''$ 304 PLATES

$\hookrightarrow$ BETTER

23 - FEB

EXPECTED DEFLECTION AT PLATE CENTER: (3/16" THK)

$$y_{MAX} = \frac{\alpha q b^4}{E t^3}$$

a/b	α
1.0	0.0138
1.083	α
1.2	0.0188

$\alpha = 0.01588$

$$y_{MAX} = \frac{(0.01588)(1.8\ lb/in^2)(24\ in)^4}{(30\times10^6)\frac{lb}{in^2}\left(\frac{3}{16}\ in\right)^3} = 0.048\ in$$

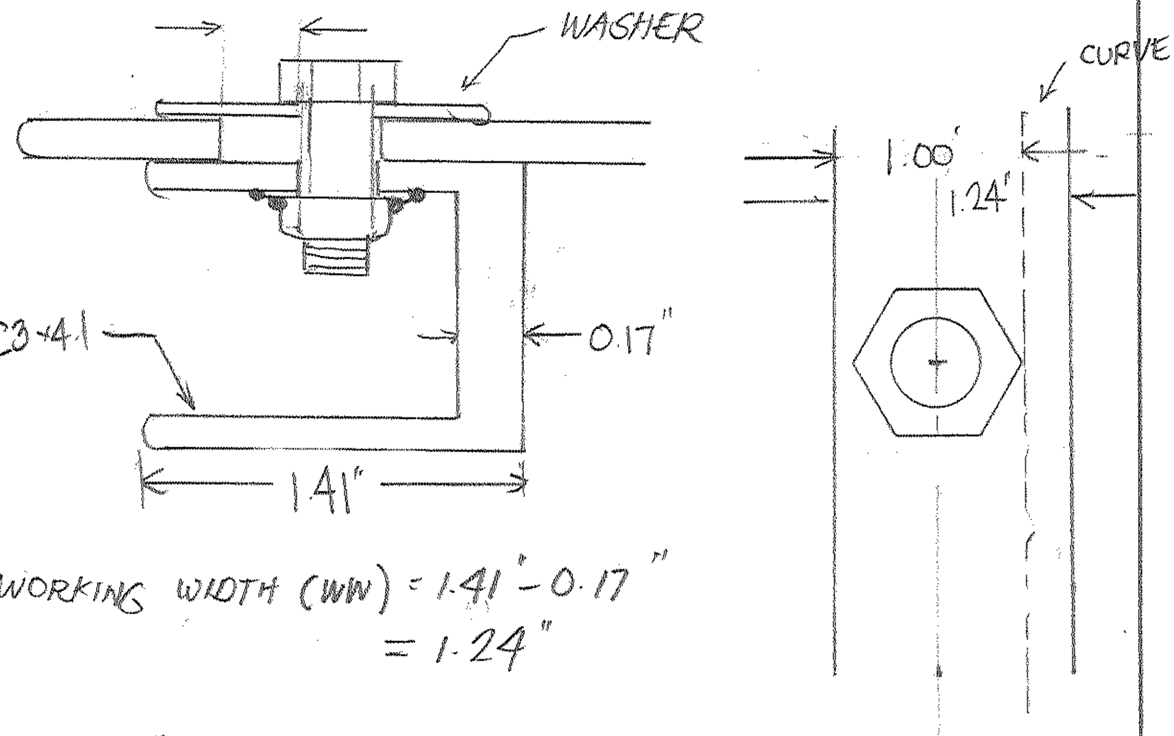
EFUNDA CHECK

$\left.\begin{array}{l} p = 1.8\ psi \\ L_x = 26\ in \\ L_y = 24\ in \\ t = 0.1875" \\ E = 200\ GPa \end{array}\right\}$ $\left.\begin{array}{l} \sigma_{MAX} = 69.6\ MPa \\ \text{DEFLECTION } y_{MAX} = 0.049\ in \end{array}\right\}$ OK!

$\nu = 0.3$

Appendix Q: Calculation of Inner Tank Bolt Size

SIZING OF CLAMPING BOLTS FOR INNER TANK MOUNTING



WORKING WIDTH (WW) = 1.41" − 0.17"
= 1.24"

BOLT ½" − 13 UNC
UPPER LIP HOLE 0.625" (CLEARANCE HOLE)
UPPER WASHER : CUP WASHER FOR OVERSIZED HOLE
½" ID : 0.531"
OD : 3.50

Appendix R: Calculation of Inner Tank Lifting Eyebolt Size

MECSA

SIZING OF LIFTING EYE & SLINGS FOR INNER TANK

WEIGHT OF INNER TANK: (W) = 2340 lb

CONSIDERATIONS:

SLING ANGLE : 45°

OF EYE BOLTS : 4

FACTOR OF SAFETY : 2

MIN. EYEBOLT RATING = $\frac{W}{(\text{\# OF EYEBOLTS})} \cdot N$

$= \frac{2340\text{ lb}\,(2)}{4} = 1170\text{ lb}$

FROM CATALOGUE:

CHOOSE: $\frac{3}{4}$" - 10 UNC - 2A

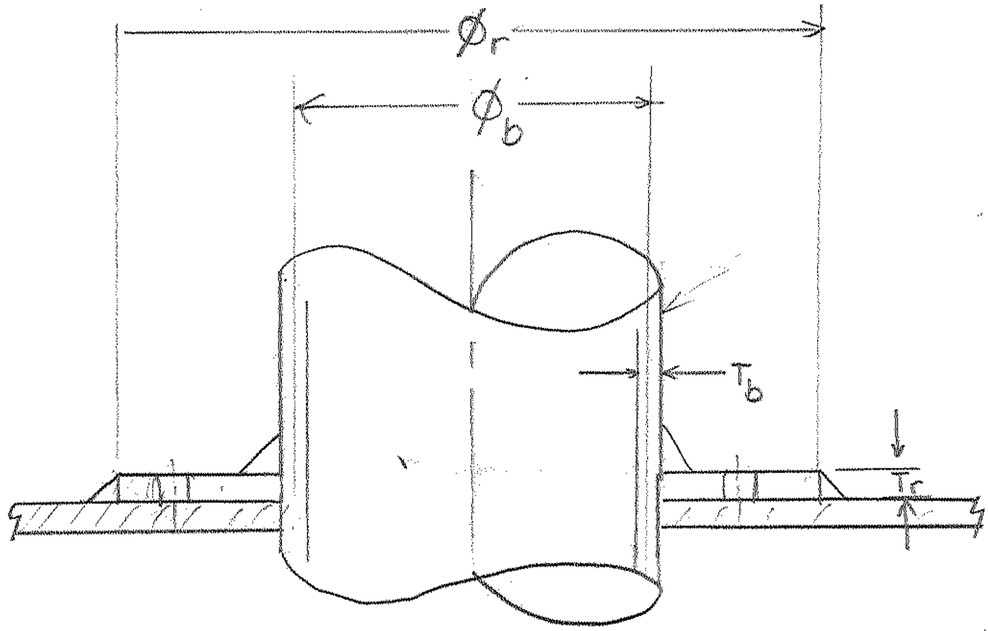
MIN. LENGTH OF ENGAGEMENT = 1.62" (TOTAL)

3/4" - 10 UNC NUT HEIGHT = 0.64"

NUT HEIGHT × 4 = 0.64" (4) = 2.56" > 1.62" ok!

Appendix S: Calculation of Fire Tube Reinforcing Pad Design

REINFORCING PAD DESIGN:



$T_r = 0.7\, T_b \rightarrow$ MINIMUM :

$\phi_r = 2 \times \phi_b \rightarrow$ MINIMUM .

FROM ASME B31.3
Para 325.5.4

2" SCH 10

$T_b = 0.109"$

$T_r = 0.0763"$

$\rightarrow$ GAUGE 12 (0.1046")

$\phi_b = 2.375"$

$\phi_r = 4.75"$

4" SCH 10

$T_b = 0.120"$

$T_r = 0.084$

$\rightarrow$ GAUGE 12(0.1046")

$\phi_b = 4.500"$

$\phi_r = 9"$

SUMMARY :

2" SCH 10 PIPE

GAUGE 12, PLATE
O.D = 4.75"
I.D = 2.375"

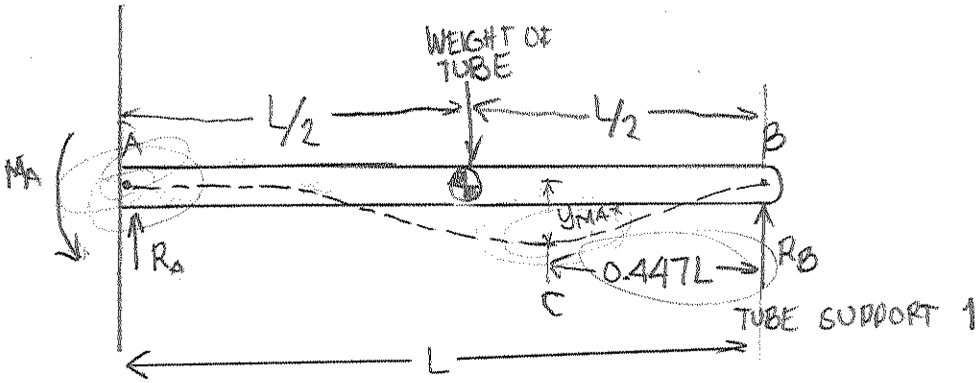
4" SCH 10 PIPE

GAUGE 12 PLATE
O.D. = 9"
I.D. = 4.500"

Appendix T: Calculation of Tube Support Spacing

TUBE SUPPORT SPACING:

FROM MOTT (APPLIED STRENGTH OF MATERIALS) APX. A21



POINT OF MAXIMUM DEFLECTION IS AT 0.447L FROM FREE END

IF L = 80"

TUBE SUPPORT 2 LOCATION:

$$0.447(80") \approx \underline{36" \text{ FROM FREE END}}$$

Appendix U: Calculation of C-channel Column Size

27/02/2024 | MCEN 2471 | ETHAN NOTT

12 - C chanels

↳ do column analysis
to size the C chanel

Mass of Imortals model → 487.68 lb

Density of phosphate → 75.192 $\frac{lb}{ft^3}$

Mass of phosphate

↳ $m = \rho V$

$= (75.192)\left(\frac{(20in)(30in)(80in)}{12^3}\right)$

$= 2088.\overline{6}$ lb

baskets + materials

$m = m_t + m_p$

$= 2340$ lb $+ 2088.\overline{6}$ lb $+ 2500$ lb

$= 6928$ lb

USE safety factor of 2

6928 lb · 2

= 13856 lb

28/02/2024 | MCEN 2471 | ETHAN NOTT

C - Channel Sizing

$E = 29 \times 10^6$ psi $\quad S_y = 36$ ksi

the y-axis is the weakest so I will size the c-chanel based on that value

the c-chanel is welded at the top and bottom so it is a Fixed column

$K = 0.65 \quad L = 52$ in

Start with C 3×4.1

$A = 1.21 \text{ in}^2 \quad I_y = 0.20 \text{ in}^4$

$r_{min} = (0.20 \text{ in}^4 / 1.21 \text{ in}^2)^{\frac{1}{2}}$

$= 0.406557$ in

$S_r = \dfrac{KL}{r_{min}} = \dfrac{(0.65)(52 \text{ in})}{0.406557 \text{ in}}$

$= 83.137$

28/02/2024 | MCEN 2471 | ETHAN NOTT

$$C_c = \left(\frac{2\pi^2 E}{S_y}\right)^{\frac{1}{2}}$$

$$= \left(\frac{2\pi^2(29\times10^6 psi)}{36000 psi}\right)^{\frac{1}{2}}$$

$$= 126.099$$

$S_r < C_c \longrightarrow$ short column

$$P_{cr} = A S_y \left(1 - \frac{S_y (KL/r_{min})^2}{4\pi^2 E}\right)$$

$$= (1.26 in^2)(36000 psi)\left(1 - \frac{(36000 psi)\left(\frac{0.65(52 in)}{0.406557}\right)^2}{4\pi^2(29\times10^6 psi)}\right)$$

$$= 34092.7616$$

$P_{cr} > P_a$

$\hookrightarrow$ C channel size C3×4.1 is suitable for the load

Appendix V: Direct Material Cost Estimate

PART NO.	QTY	DWG DESCRIPTION	MATERIAL DESCRIPTION		PRICE (in CAD)	VENDOR	OEM NO.	LINKS FOR PRICING
3001	1	OUTER TANK - U-PROFILE	7 GA, 304 SS SHEET METAL 4' x 12'	per attached Quote	$ 927.00	RYERSON HOLDING	304SH7X48X144	Stainless Steel Sheet - Ryerson
3002	1	OUTER TANK - U-PROFILE (NO-HOLE)	7 GA, 304 SS SHEET METAL 4' x 12'	per attached Quote	$ 927.00	RYERSON HOLDING	304SH7X48X144	Stainless Steel Sheet - Ryerson
3003	1	REAR OUTER TANK PROFILE SHEET	7 GA, 304 SS SHEET METAL 5' x 10'	per attached Quote	$ 1,440.39	RYERSON HOLDING	304SH7X60X120	Stainless Steel Sheet - Ryerson
3004		FRONT OUTER TANK PROFILE SHEET						
3005	2	INNER TANK - U-PROFILE	12 GA, 304 SS SHEET METAL 4' x 8'	per attached Quote	$ 1,182.90	RYERSON HOLDING	304SH12X48X96X4	Stainless Steel Sheet - Ryerson
3006	1	REAR AND FRONT INNER TANK PROFILE SHEET	12 GA, 304 SS SHEET METAL 3' x 3'	per attached Quote	$ 794.10	RYERSON HOLDING		Stainless Steel Sheet - Ryerson
3007	1	EXHAUST FIRE TUBE SUPPORT	304 SS, 3' x 3' x 3/16" PLATE	$8.579/ sqft	$ 77.21	RUSSEL METALS		Plate – Russel Metals
3008		INLET FIRE TUBE SUPPORT						
3009		GAS BURNER FLANGE						
4001	1	THREADED THERMOCOUPLE PROBE	TYPE T, 32º TO 900ºF, 0.5 s RESPONSE TIME		$ 96.61	MCMASTER-CARR	1245N32	Thermocouple Probe
4002	1	1/2" NPT HALF COUPLING THREADED	304 SS		$ 5.11	MCMASTER-CARR	4452K212	Half Coupling Threaded
4003	1	1/2" NPT FEMALE x 1 3/8" LG. THREADED PIPE FITTING	304 SS		$ 6.95	MCMASTER-CARR	4464K354	Pipe Fitting
4004	1	1/2" NPT x 3" LG. PIPE NIPPLE	304 SS		$ 7.00		4830K175	Pipe Nipple
4005	10	304 SS, C 3 x 4.1 x 52" LG.	C-CHANNEL, 3" x 4.1 x 44' LG.	$ 1559.21/ 20 ft	$ 3,430.26	METAL SUPERMARKET or RYERSON HOLDING	304LCH3X1.41X17	MetalsDepot® - Buy Stainless Steel Channel Online
4006	1	304 SS, C 3 x 4.1 x 21 1/2" LG.	C-CHANNEL, 3" x 4.1 x 2' LG.		$ 155.92			
4007	24	304 SS, C 3 x 4.1 x 20 1/4" LG.	C-CHANNEL, 3" x 4.1 x 41' LG.		$ 3,196.38			
4008	6	304 SS, C 3 x 4.1 x 42 3/4" LG.	C-CHANNEL, 3" x 4.1 x 22' LG.		$ 1,715.13			
4009	2	304 SS, C 3 x 4.1 x 21 1/2" LG.	C-CHANNEL, 3" x 4.1 x 4' LG.		$ 311.84			
4010	3	304 SS, C 3 x 4.1 x 98 7/8" LG.	C-CHANNEL, 3" x 4.1 x 25' LG.		$ 1,949.00			
4011	10	304 SS, C 3 x 4.1 x 39 3/4" LG.	C-CHANNEL, 3" x 4.1 x 34' LG.		$ 2,650.66			
4012	2	304 SS, ANGLE BAR, 6 x 6 x 1/2 x 88" LG.	ANGLE, 6" x 6" x 15' LG.	$4982.53 / 20 FT	$ 3,736.90	METAL SUPERMARKET		Metals Depot® - 304 Stainless Steel Angle | Shop Online!
4013	2	304 SS, ANGLE BAR, 6 x 6 x 1/2 x 42" LG.	ANGLE, 6" x 6" x 7' LG.		$ 1,743.89	METAL SUPERMARKET		
4014	3	304 SS, C 3 x 4.1 x 90 13/16" LG.	C-CHANNEL, 3" x 4.1 x 23' LG.	$ 1559.21/ 20 ft	$ 1,793.00	METAL SUPERMARKET or RYERSON HOLDING		MetalsDepot® - Buy Stainless Steel Channel Online
4015	8	304 SS, C 3 x 4.1 x 11 29/32" LG.	C-CHANNEL, 3" x 4.1 x 8' LG.		$ 623.68			
4016	2	304 SS, C 3 x 4.1 x 32 13/16" LG.	C-CHANNEL, 3" x 4.1 x 6' LG.		$ 467.76			
4017	4	304 SS, C 3 x 4.1 x 21" LG.	C-CHANNEL, 3" x 4.1 x 7' LG.		$ 545.72			
4018	8	304 SS, C 3 x 4.1 x 24" LG.	C-CHANNEL, 3" x 4.1 x 16' LG.		$ 1,247.37			
4019	6	304 SS, C 3 x 4.1 x 25 11/32" LG.	C-CHANNEL, 3" x 4.1 x 13' LG.		$ 1,013.50			
4020	1	TEE, 4" SCH 10 PIPE, BUTTWELD	304 SS		$ 156.43	GRAINGER CANADA	4381011680	Tee, 304L SS, 4 in Pipe Size, Buttweld
4021	2	OFFSET REDUCER, 4" SCH 10 PIPE, BUTTWELD	304 SS	$202.4 / pc	$ 404.84	MCMASTER-CARR	45735K639	Offset Reducer
4022	2	90◦ SHORT ELBOW, 2" SCH 10 PIPE, BUTTWELD	304 SS	$69.60 / pc	$ 139.20	MCMASTER-CARR	45735K324	Short Elbow - 2 Pipe Size
4023	8	90◦ LONG ELBOW, 2" SCH 10 PIPE, BUTTWELD	304 SS	$17.00 / pc	$ 136.00	MCMASTER-CARR	45735K216	Long Elbow - 2 Pipe Size
4024	4	2" SCH 10 PIPE, SEAMLESS x 78" LG.	304 SS x 26' LG.	$ 653.87/ 20 ft	$ 850.00	RUSSEL METALS		Russel Metals - Pipe
4025	1	4" SCH 10 PIPE, SEAMLESS x 96" LG.	304 SS x 7' LG.	$ 905/ 8 ft	$ 905.00	RUSSEL METALS		
4026	2	2" SCH 10 PIPE, SEAMLESS (EXHAUST) x 96" LG.	304 SS x 16' LG.	$ 653.87/ 20 ft	$ 523.00	RUSSEL METALS		
4027	2	90º ELBOW, 4" SCH 10 PIPE, BUTT-WELD	304 SS	$139.24 / pc	$ 278.48	MCMASTER-CARR	45735K327	90deg Elbow, 4 Pipe Size
4028	2	ANGLE BAR SUPPORT - HORIZONTAL (INNER TANK)	304 SS, ANGLE 1 1/2" x 1 1/2" x 1/4" x 60" LG.	$67.07 / 30 in	$ 134.14	RUSSEL METALS		Stainless Steel Angle 304 | Metal Supermarkets
4029	1	ANGLE BAR SUPPORT - VERTICAL (INNER TANK)	304 SS, ANGLE 1 1/2" x 1 1/2" x 1/4" x 30" LG.	$67.07 / 30 in	$ 67.07	RUSSEL METALS		
4030	2	ANGLE BAR SUPPORT - HORIZONTAL (OUTER TANK)	304 SS, ANGLE 1 1/2" x 1 1/2" x 1/4" x 104" LG.	$98.98 / 52in	$ 197.96	RUSSEL METALS		
4031	1	ANGLE BAR SUPPORT - VERTICAL (OUTER TANK)	304 SS, ANGLE 1 1/2" x 1 1/2" x 1/4" x 40" LG.	$88.71 / 40 in	$ 88.71	RUSSEL METALS		
4032	2	THREADED ONE END NIPPLE, 1/2" NPT	304 SS	$8.05 / pc	$ 16.10	MCMASTER-CARR	9157K53	Nipple
4033	20	WELD STUD, 1/2"-13 x 2" LG.	18-8 SS	$431.84 / pack (100/pack)	$ 431.84	GRAINGER CANADA	WWG12A902	Weld Stud
4034	20	HEX NUT, 1/2"-13 UNC	18-8 SS	$3.21 / pack (10/pack)	$ 6.42	MCMASTER-CARR	92673A137	Hex Nuts
4035	6	2" SCH 10 PIPE SADDLE SUPPORT	T304 SS	$270.77 / pc	$ 1,624.62	EMPIRE INDUSTRIES INC.	429KTU	Pipe Support
4036	1	2" SCH 10 PIPE SADDLE SUPPORT	T304 SS	$334.63	$ 334.63	EMPIRE INDUSTRIES INC.	429KTU	Pipe Stanchion (for Pricing Only)
4037	4	LIFTING EYEBOLT c/w NUT, 3/4"-10 x 3" LG.	304 SS	$95.27 / pc	$ 381.08	MCMASTER-CARR	3069T37	Lifting Eye Bolts
4038	1	BREATHER VENT c/w CAP	304 SS	$55.12 / pc	$ 55.12	MCMASTER-CARR	3853N13	Breather Vent with Cap
4039	12	1/2"-13 x 1 3/4" LG. HEX HEAD SCREW	18-8 SS	$4.77 / pack (5/pack)	$ 14.31		92198A127	1/2"-13 UNC Hex Head Screw
4040	12	RECTANGULAR WASHER FOR 1/2" SCREW	18-8 SS	$18.83 / pack (5/pack)	$ 56.49	MCMASTER-CARR	92516A220	Rectangular Washer
4041	1	24" SIGHT GLASS	304 SS	(NOTE: PREFERRED VENDOR	$ 1,129.66	MCMASTER-CARR		Level Indicator (For Pricing Only)
4042	8	5/8"-11 x 1 1/2" LG. BUTTON HEAD SCREW	18-8 SS	$3.78 / pc	$ 30.24		92949A765	Button Head Hex Screw
4043	8	5/8"-11 HEX NUT	18-8 SS	$3.16 / pack (5/pack)	$ 6.32		92673A144	5/8"-11 Hex Nut
4044	2	CERAMIC FIBER INSULATION, 1" TH.	ALUMINUM SILICATE FIBER x 24" x 25' x 1" TH.	$483.51 / pc	$ 967.02	GRAINGER CANADA	WWG23AR50	Ceramic Insulation
4045	12	SHEET INSULATION, 250F	HALOGEN-FREE NBR, 36" x 48" x 1/2" TH.	$66.39 / pc	$ 796.68	GRAINGER CANADA	WWG4NPW8	Cladding
				TOTAL PRICE	**$ 39,776.65**			

RYERSON

SALES QUOTATION ACKNOWLEDGEMENT

Joseph T. Ryerson & Son, Inc.

Quote Nbr: IQ51812230   Cust. Nbr: 10325062

04/17/2024

CURRENCY: CAD

ATTENTION: Aicel - Argus Machine

REFERENCE:
PHONE NO: NA

SALES OFFICE:

Edmonton
7945 Coronet Road
Edmonton, AB T6E 4N7

FROM: Alaniss Benavides

Email: Alaniss.Benavides@ryerson.com
Phone No: +1-780-490-2103   Fax No: 780-469-6971

SOLD TO:

CASH SALES EDM/SK EXEMPT
7945 CORONET RD NW
EDMONTON AB T6E 4N7
Canada

SHIP TO:

Customer-Pick Up

ADDITIONAL COMMENTS:

Thank you for the opportunity to meet your metal needs. Due to extreme market volatility, quotes are valid for 24 hours. Please let me know if you have any questions.

Need to review your quote or place your order? Click here, sign into your Ryerson.com account to view your quotes.

SHIPPING CONDITION: Will Call

Requested Delivery Date: TBD

PURCHASE ORDER #:

TERMS: Payment by Credit Card

AUTHORIZED SIGNATURE: ______________________________

Quote Line No.	Order Qty	Order UOM	Item Description	Estimated Weight (lbs)	Quantity in Pricing Uom	Price	Price UOM
000010	1	PC	Plt 304/304l Hrap .1875 X 48 X 144 161000366	412	1	$1,215.00	PC
Pieces: 1			P/N PURCHASE ORDER #:	EXTENDED AMOUNT LEAD TIME: 8 BUSINESS DAYS REQUESTED DELIVERY DATE: TBD		$1,215.00	
000020	2	PC	Plt 304/304l Hrap .1875 X 48 X 144 161000366	824	2	$927.00	PC
Pieces: 2			P/N PURCHASE ORDER #:	EXTENDED AMOUNT LEAD TIME: 8 BUSINESS DAYS REQUESTED DELIVERY DATE: TBD		$1,854.00	
000030	3	PC	Plt 304/304l Hrap .1875 X 48 X 144 161000366	1,235	3	$824.00	PC
Pieces: 3			P/N PURCHASE ORDER #:	EXTENDED AMOUNT LEAD TIME: 12 BUSINESS DAYS REQUESTED DELIVERY DATE: TBD		$2,472.00	

Energy & Distribution Charge: $0.00 CAD

Total Weight: 2,471 LB

Material Total (without taxes)* $5,541.00 CAD

*Material Total does not include applicable taxes. Applicable taxes will be calculated when the order is placed.

Ryerson's standard conditions and terms of sale apply without exception to the sale of all product(s) referenced herein, and no other terms or conditions including, without limitation, the buyer's standard printed terms and conditions, whether included or referenced on the buyer's purchase order or otherwise, will have any application to any transaction between Ryerson and the buyer unless specifically agreed in writing by Ryerson. No terms of any document, purchase order or form submitted by buyer in any manner shall be effective to alter or add to Ryerson's standard conditions and terms of sale even where

Review Cart

1 PART IN CART

PURCHASE ORDER NUMBER * Enter PO Number

CHECK PRICING & AVAILABILITY

COLLAPSE ALL

EXPAND ALL

304SH12X48X120X4
ALT: 160009748

QUANTITY	2 PC(S)
WEIGHT	354.16 LBS
NET PRICE	591.45
PRICE UOM	PC
CUT TO SIZE	Define Cut
DELIVERY DATE	See Below
TOTAL PRICE	$1182.90

We'll get what you need, but we can't display the stock availability online right now. We will confirm details after you submit your order.[Reference Code 2038]

Stainless Steel | Sheet | SHT 304 #4 B/W FLM 12GA X 48 X 120

Primary Grade
304
Thickness
0.1054 IN
Length
120.0 IN
Protection
B/W FLM

Gauge Thickness
12GA
Width
48.0 IN
Finish
#4

+ Customer Reference Number + Line Item Notes + Line Level PO

CUT TO SIZE + Add

AVAILABLE TO SHIP + Future Date

- TBD PRICE NOT GUARANTEED

RYERSON

ADD TO LIST +

DELETE SELECTED

CREATE E-QUOTE

CHECK PRICING & AVAILABILITY

Please Note - If you update your cart, you will need to update Pricing and Availability.

Add More To Cart

Download Pricing Result

APPROXIMATE ORDER WEIGHT:	354.16
SUBTOTAL:	$1182.90 CAD
FUEL SURCHARGE:	$90.00 CAD
TAXES:	$63.65 CAD
TOTAL NET PRICE:	**$1336.55 CAD**

PROCEED TO SHIP AND PAYMENT

RYERSON

Review Cart

1 PART IN CART

PURCHASE ORDER NUMBER * Enter PO Number

CHECK PRICING & AVAILABILITY

COLLAPSE ALL

EXPAND ALL

304SH12X36X120X4
ALT: 160009746

QUANTITY	30 S...
WEIGHT	132.81 LBS
NET PRICE	26.47
PRICE UOM	S...
CUT TO SIZE	NA
DELIVERY DATE	See Below
TOTAL PRICE	$794.10

We'll get what you need, but we can't display the stock availability online right now. We will confirm details after you submit your order.[Reference Code 2038]

Values have been updated.

Stainless Steel | Sheet | SHT 304 #4 B/W FLM 12GA X 36 X 120

Primary Grade
304
Thickness
0.1054 IN
Length
120.0 IN
Protection
B/W FLM

Gauge Thickness
12GA
Width
36.0 IN
Finish
#4

+ Customer Reference Number + Line Item Notes + Line Level PO

AVAILABLE TO SHIP
- TBD PRICE NOT GUARANTEED

+ Future Date

HIDE DETAILS

(1)

RYERSON

ADD TO LIST +

DELETE SELECTED

CREATE E-QUOTE

CHECK PRICING & AVAILABILITY

Please Note - If you update your cart, you will need to update Pricing and Availability.

Add More To Cart

Download Pricing Result

APPROXIMATE ORDER WEIGHT:	132.81
SUBTOTAL:	$794.10 CAD
FUEL SURCHARGE:	$90.00 CAD
TAXES:	$44.21 CAD
TOTAL NET PRICE:	**$928.31 CAD**

PROCEED TO SHIP AND PAYMENT

RYERSON

Review Cart

1 PART IN CART

PURCHASE ORDER NUMBER * Enter PO Number

CHECK PRICING & AVAILABILITY

COLLAPSE ALL

EXPAND ALL

RYERSON

304SH7X60X120
ALT: 100013663

QUANTITY	1 PC(S)
WEIGHT	393.55 LBS
NET PRICE	1440.39
PRICE UOM	PC
CUT TO SIZE	Define Cut
DELIVERY DATE	See Below
TOTAL PRICE	$1440.39

We'll get what you need, but we can't display the stock availability online right now. We will confirm details after you submit your order.[Reference Code 2038]

Stainless Steel | Sheet | SHT 304 2B FBR LZR 7GA X 60 X 120

Primary Grade
304

Gauge Thickness
7GA

Thickness
0.1874 IN

Width
60.0 IN

Length
120.0 IN

Finish
2B

Protection
FBR LZR

+ Customer Reference Number + Line Item Notes + Line Level PO

CUT TO SIZE + Add

AVAILABLE TO SHIP + Future Date

- TBD PRICE NOT GUARANTEED

Back to Top

SHOW DETAILS

(1)

RYERSON

ADD TO LIST +

DELETE SELECTED

CREATE E-QUOTE

CHECK PRICING & AVAILABILITY

Please Note - If you update your cart, you will need to update Pricing and Availability.

Add More To Cart

Download Pricing Result

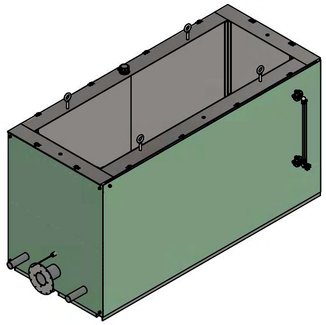
APPROXIMATE ORDER WEIGHT:	393.55
SUBTOTAL:	$1440.39 CAD
FUEL SURCHARGE:	$90.00 CAD
TAXES:	$76.52 CAD
TOTAL NET PRICE:	**$1606.91 CAD**

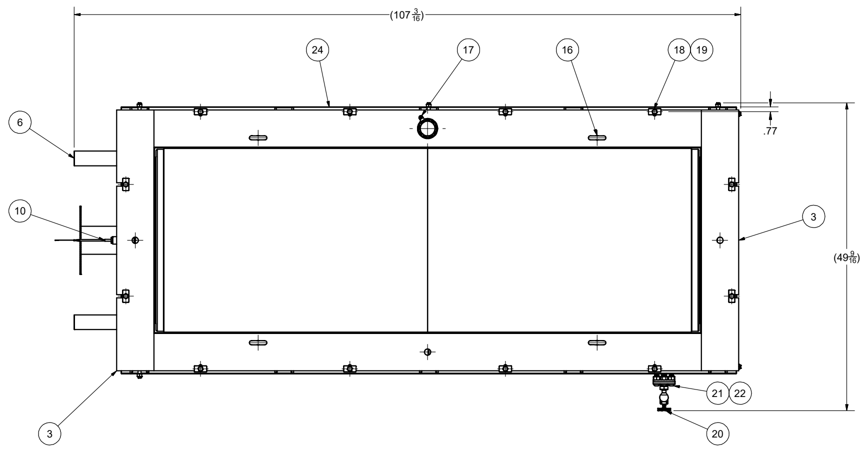
PROCEED TO SHIP AND PAYMENT

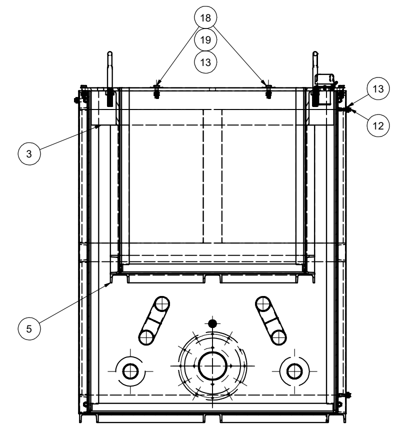
Appendix W: Assembly Drawings

ASSEMBLY PARTS LIST					
ITEM	QTY	DESCRIPTION	PART NO.	VENDOR	VENDOR - OEM PN
1	1	OUTER TANK WELDMENT	2001		
2	1	INNER TANK WELDMENT	2002		
3	1	INNER TANK LIP WELDMENT	2006	METAL SUPERMARKETS	
4	1	OUTER TANK STRUCTURAL SUPPORT	2007	METAL SUPERMARKETS	
5	1	INNER TANK STRUCTURAL SUPPORT	2008		
6	1	FIRE TUBE WELDMENT	2010		
7	2	EXHAUST FIRE TUBE SUPPORT	3007	RUSSEL METALS	
8	1	INLET FIRE TUBE SUPPORT	3008	RUSSEL METALS	
9	1	GAS BURNER FLANGE	3009	RUSSEL METALS	
10	1	THREADED THERMOCOUPLE PROBE	4001	MCMASTER-CARR	1245N32
11	2	THREADED ONE END NIPPLE, 1/2" NPT	4032	MCMASTER-CARR	9157K53
12	15	18-8 SS, WELD STUD, 1/2"-13 x 2" LG.	4033		WWG12A902

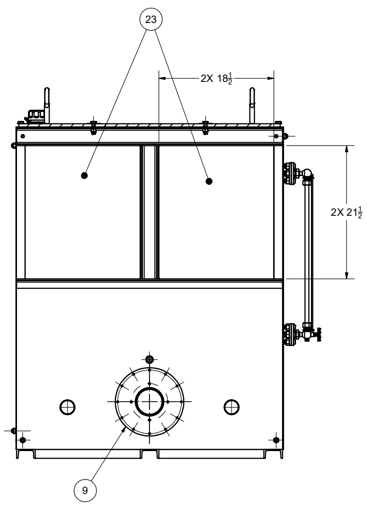
ASSEMBLY PARTS LIST					
ITEM	QTY	DESCRIPTION	PART NO.	VENDOR	VENDOR - OEM PN
13	12	18-8 SS, WELD STUD, 1/2"-13 HEX NUT	4034		92673A137
14	6	2" SCH 10 PIPE SADDLE SUPPORT	4035	EMPIRE INDUSTRIES INC.	429KTU
15	1	4" SCH 10 PIPE SADDLE SUPPORT	4036	EMPIRE INDUSTRIES INC.	429KTU-4"
16	4	LIFTING EYEBOLT c/w NUT, 3/4"-10 x 3" LG., 304 SS	4037	MCMASTER-CARR	3069T37
17	1	BREATHER VENT c/w CAP	4038	MCMASTER-CARR	3853N13
18	12	18-8 SS, 1/2"-13 x 1 3/4" LG. HEX HEAD SCREW	4039		92198A127
19	12	18-8 SS, RECTANGULAR WASHER FOR 1/2" SCREW	4040	MCMASTER-CARR	92516A220
20	1	24" SIGHT GLASS	4041	MCMASTER-CARR	
21	8	18-8 SS, 5/8"-11 x 1 1/2" LG. BUTTON HEAD SCREW	4042		92949A765
22	8	18-8 SS, 5/8"-11 HEX NUT	4043		92673A144
23	22	CERAMIC FIBER INSULATION, 1" TH.	4044	GRAINGER CANADA	WWG23AR50
24	4	SHEET INSULATION, 250F, HALOGEN-FREE NBR	4045	GRAINGER CANADA	WWG4NPW8

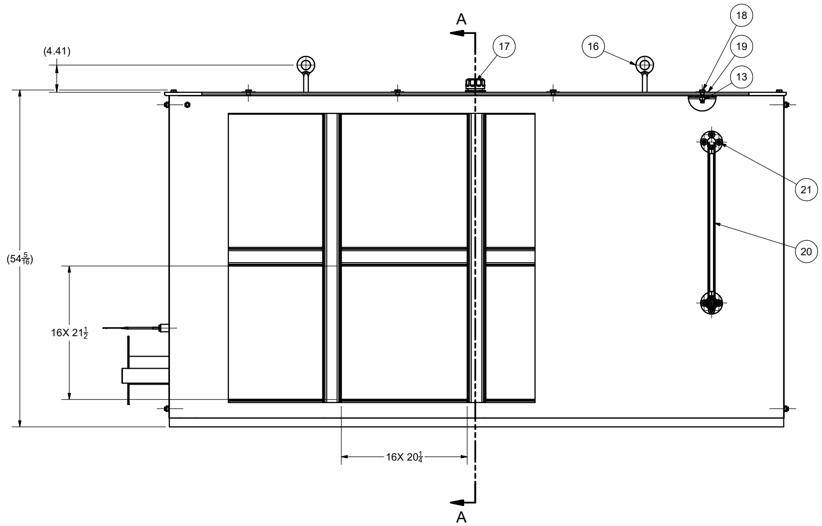


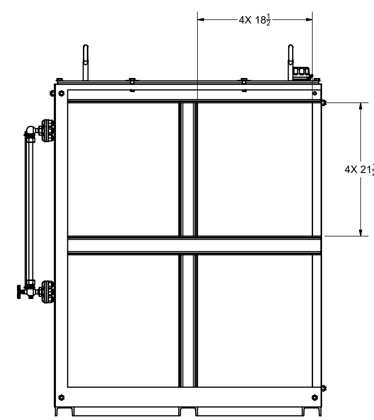




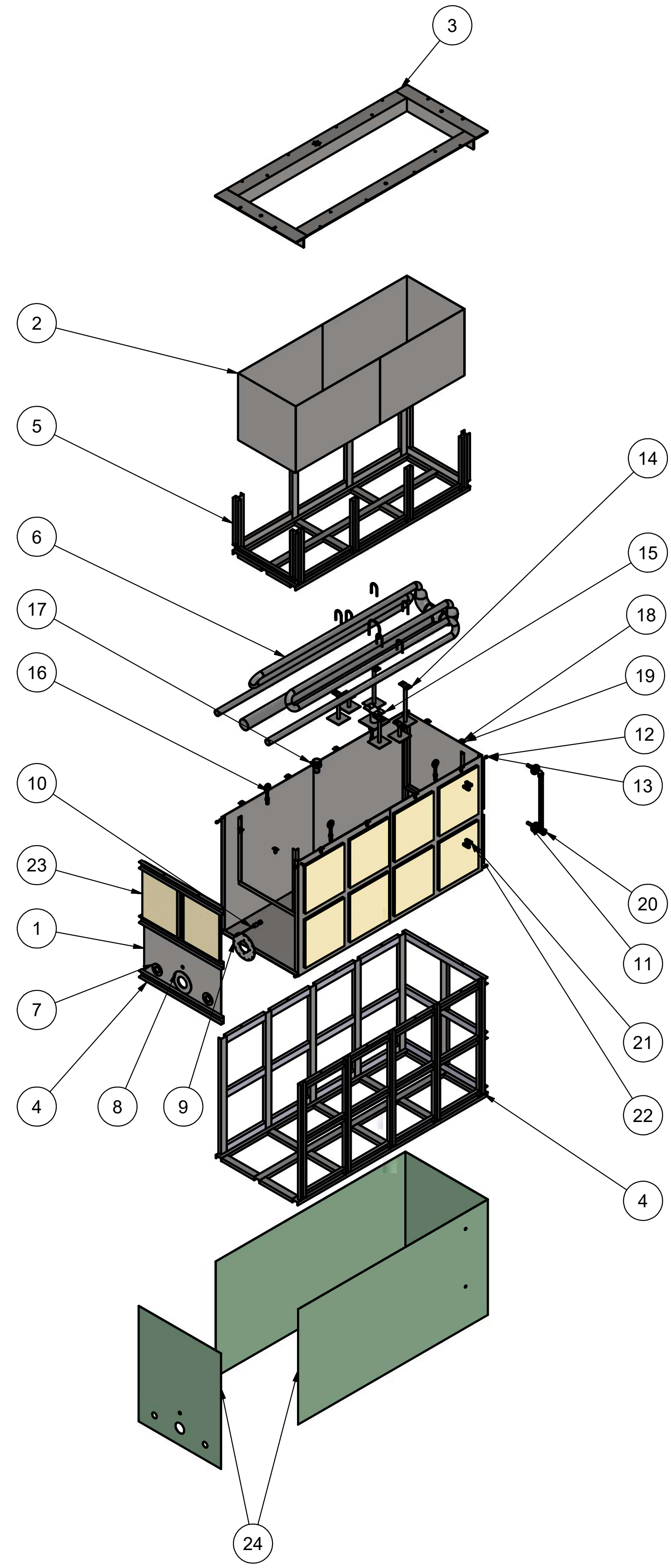
SECTION A-A
SCALE 1 : 10





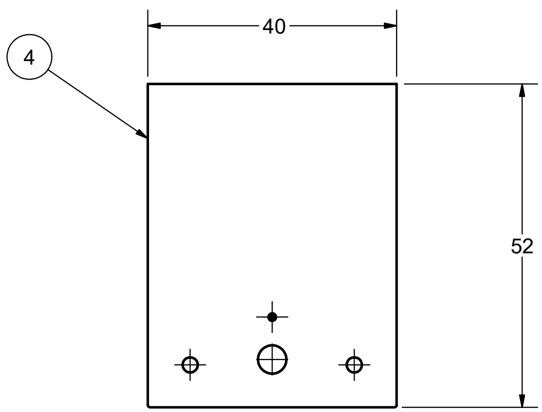


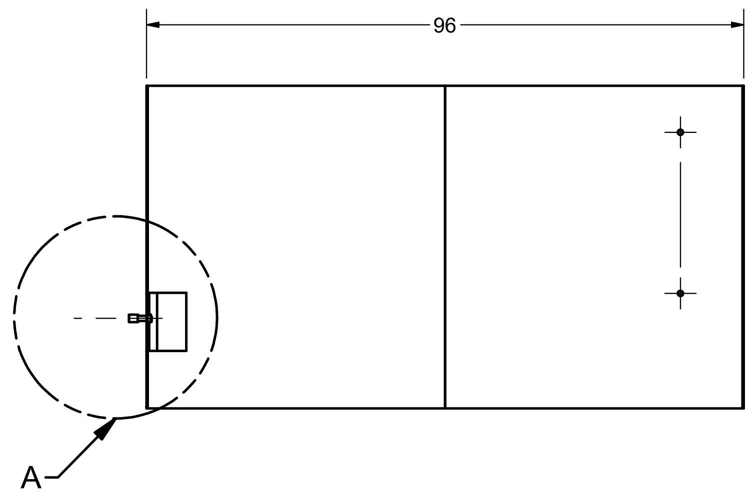
TOLERANCES UNLESS OTHERWISE SPECIFIED	DWN BY: M.D.V.	MECHANICAL ENGINEERING TECHNOLOGY
.X ± .015 FRACTIONS ± 1/32	DATE: 2024-04-13	HOT-FLUID JACKETED PHOSPHATE TANK
.XX ± .010 ANGLES ± 1/2°	CHK BY: E.N.	DWG TYPE: ASSEMBLY / DWG NO: 1001 - 1
.XXX ± .005	COURSE: MCEN 2471	SCALE: N.T.S. / SIZE: D / REV: 0 / 1 OF 42
ALL DIMENSIONS IN INCHES	THIRD ANGLE PROJECTION DO NOT SCALE DRAWING!	II-1192.0

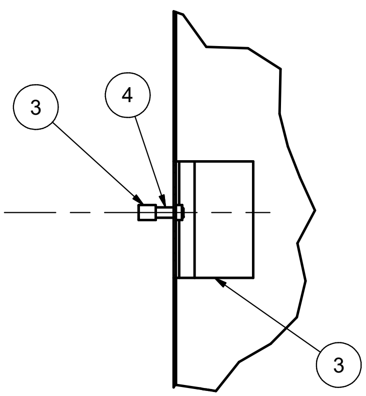


TOLERANCES UNLESS OTHERWISE SPECIFIED	DWN BY: M.D.V.	MECHANICAL ENGINEERING TECHNOLOGY	
.X ± .015 FRACTIONS ± $\frac{1}{32}$	DATE: 13-04-2024	HOT-FLUID JACKETED PHOSPHATE TANK	II-1192.0
.XX ± .010 ANGLES ± $\frac{1}{2}$°	CHK BY: E.N.	DWG TYPE: ASSEMBLY	DWG NO: 1001 - 1
.XXX ± .005		THIRD ANGLE PROJECTION DO NOT SCALE DRAWING!	
ALL DIMENSIONS IN INCHES	COURSE: MCEN 2471	SCALE: N.T.S. SIZE: B REV: 0	2 OF 42

ASSEMBLY PARTS LIST						
ITEM	QTY	DESCRIPTION	PART NO.	VENDOR	VENDOR - OEM PN	MATERIAL
1	1	OUTER TANK WELDMENT ASSY	2001			
3	1	1/2" NPT FEMALE x 1 3/8" LG. THREADED PIPE FITTING	4003	MCMASTER-CARR	4464K354	Stainless Steel, Austenitic
4	1	1/2" NPT x 3" LG. PIPE NIPPLE	4004	MCMASTER-CARR	4830K175	Stainless Steel, Austenitic





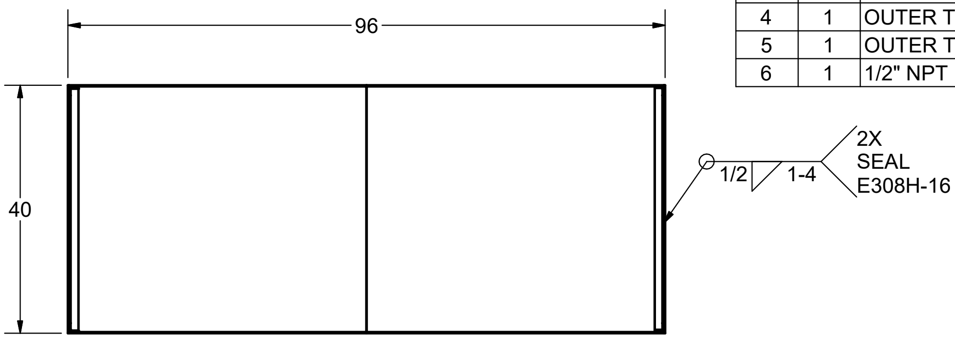


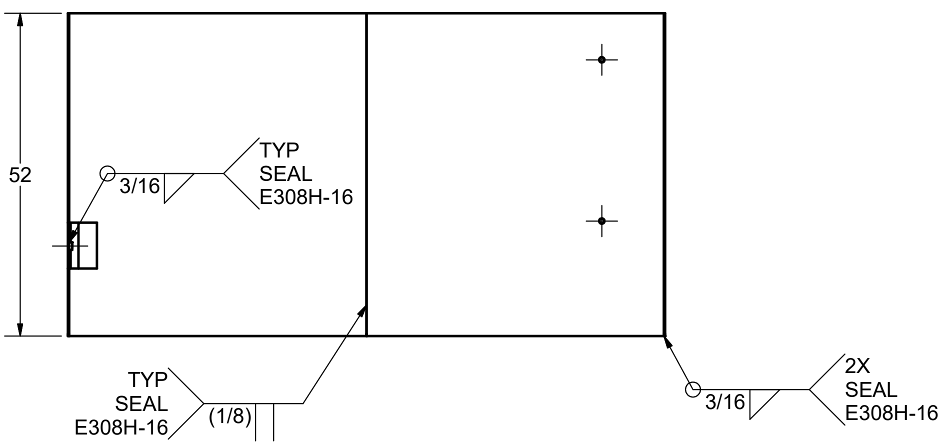
DETAIL A
SCALE 1:10

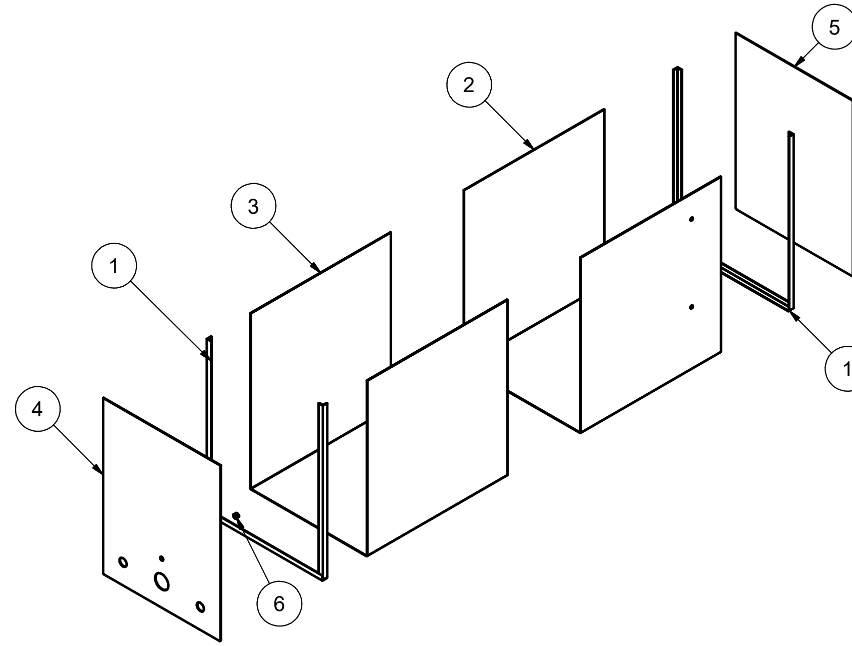
TOLERANCES UNLESS OTHERWISE SPECIFIED			
.X ± .015 FRACTIONS ± $\frac{1}{32}$	DWN BY: M.D.V.	MECHANICAL ENGINEERING TECHNOLOGY	
.XX ± .010 ANGLES ± $\frac{1}{2}$°	DATE: 27-MAR-2024	OUTER TANK WELDMENT	II-1192.0
.XXX ± .005	CHK BY: E.N.	DWG TYPE: ASSEMBLY	DWG NO: 1002 - 1
ALL DIMENSIONS IN INCHES	COURSE: MCEN 2471	THIRD ANGLE PROJECTION DO NOT SCALE DRAWING!	SCALE: N.T.S. SIZE: B REV: 0 3 OF 42

Appendix X: Weldment Drawings

ASSEMBLY PARTS LIST					
ITEM	QTY	DESCRIPTION	PART NO.	VENDOR	VENDOR - OEM PN
1	1	OUTER TANK - STRUCTURAL ID	2004	METAL SUPERMARKETS	
2	1	OUTER TANK - U-PROFILE	3001	RYERSON HOLDING	304SH7X48X144
3	1	OUTER TANK - U PROFILE (NO HOLE)	3002	RYERSON HOLDING	
4	1	OUTER TANK - REAR PROFILE SHEET	3003	RYERSON HOLDING	304SH7X48X120X4
5	1	OUTER TANK - FRONT PROFILE SHEET	3004	RYERSON HOLDING	
6	1	1/2" NPT HALF COUPLING THREADED	4002	MCMASTER-CARR	4452K212

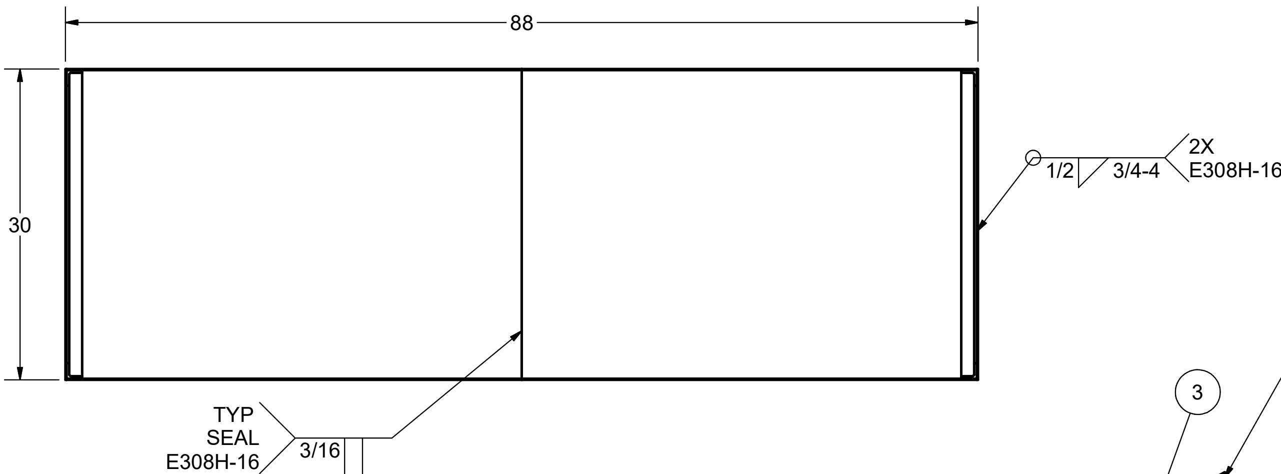


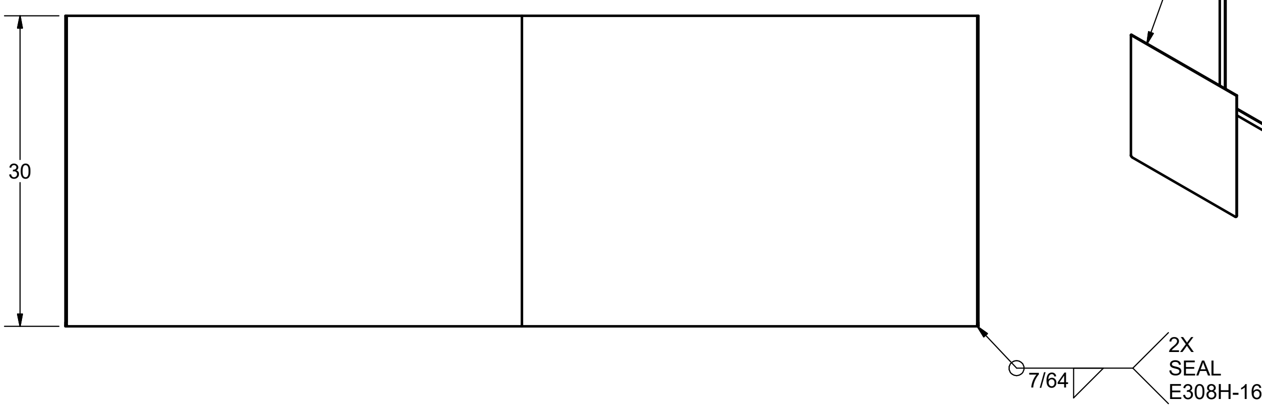


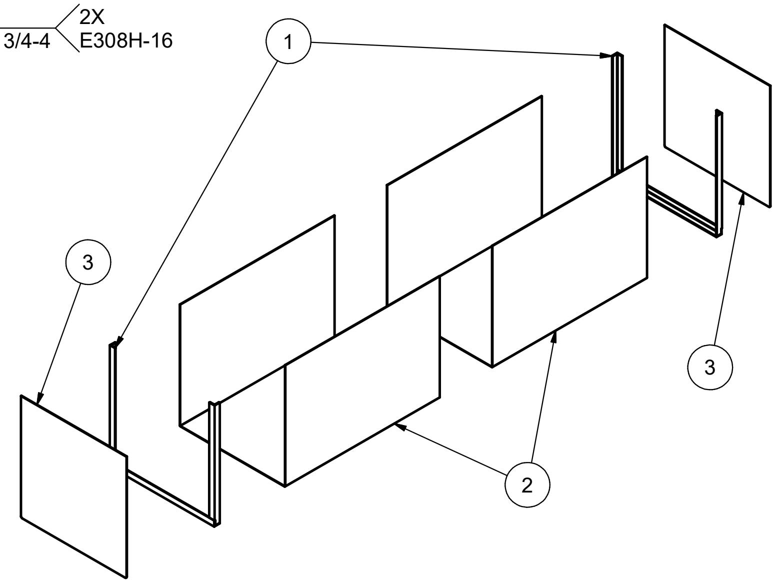


TOLERANCES UNLESS OTHERWISE SPECIFIED	DWN BY: M.D.V.	MECHANICAL ENGINEERING TECHNOLOGY	II-1192.0
.X ± .015 FRACTIONS ± 1/32	DATE: 27-MAR-2024	OUTER TANK WELDMENT	
.XX ± .010 ANGLES ± 1/2°	CHK BY: E.N.	DWG TYPE: WELDMENT	DWG NO: 2001 - 1
.XXX ± .005	COURSE: MCEN 2471	SCALE: N.T.S. SIZE: B REV: 0	4 OF 42
ALL DIMENSIONS IN INCHES	THIRD ANGLE PROJECTION DO NOT SCALE DRAWING!		

ASSEMBLY PARTS LIST					
ITEM	QTY	DESCRIPTION	PART NO.	VENDOR	MATERIAL
2	2	INNER TANK - U-PROFILE	3005	RYERSON HOLDING	Stainless Steel, Austenitic
3	2	INNER TANK - FRONT AND REAR PROFILE SHEET	3006	RYERSON HOLDING	Stainless Steel, Austenitic
1	1	INNER TANK - STRUCTURAL ID	2005	METAL SUPERMARKETS	Welded Aluminum-6061



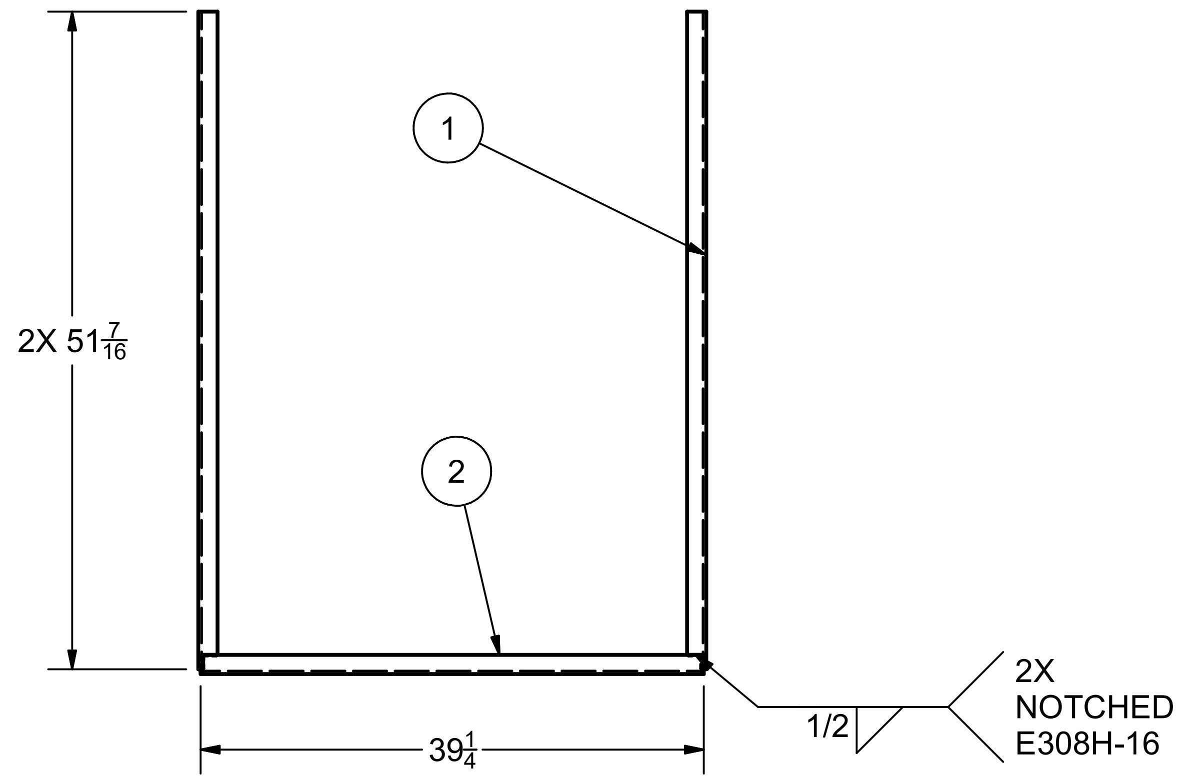




TOLERANCES UNLESS OTHERWISE SPECIFIED	DWN BY: M.D.V.	NAIT	MECHANICAL ENGINEERING TECHNOLOGY
.X ± .015 FRACTIONS ± $\frac{1}{32}$	DATE: 27-MAR-2024		INNER TANK WELDMENT
.XX ± .010 ANGLES ± $\frac{1}{2}$°	CHK BY: E.N.	THIRD ANGLE PROJECTION	DWG TYPE: WELDMENT — DWG NO: 2002 - 1
.XXX ± .005 ALL DIMENSIONS IN INCHES	COURSE: MCEN 2471	DO NOT SCALE DRAWING!	SCALE: N.T.S. — SIZE: B — REV: 0 — 5 OF 42

II-1192.0

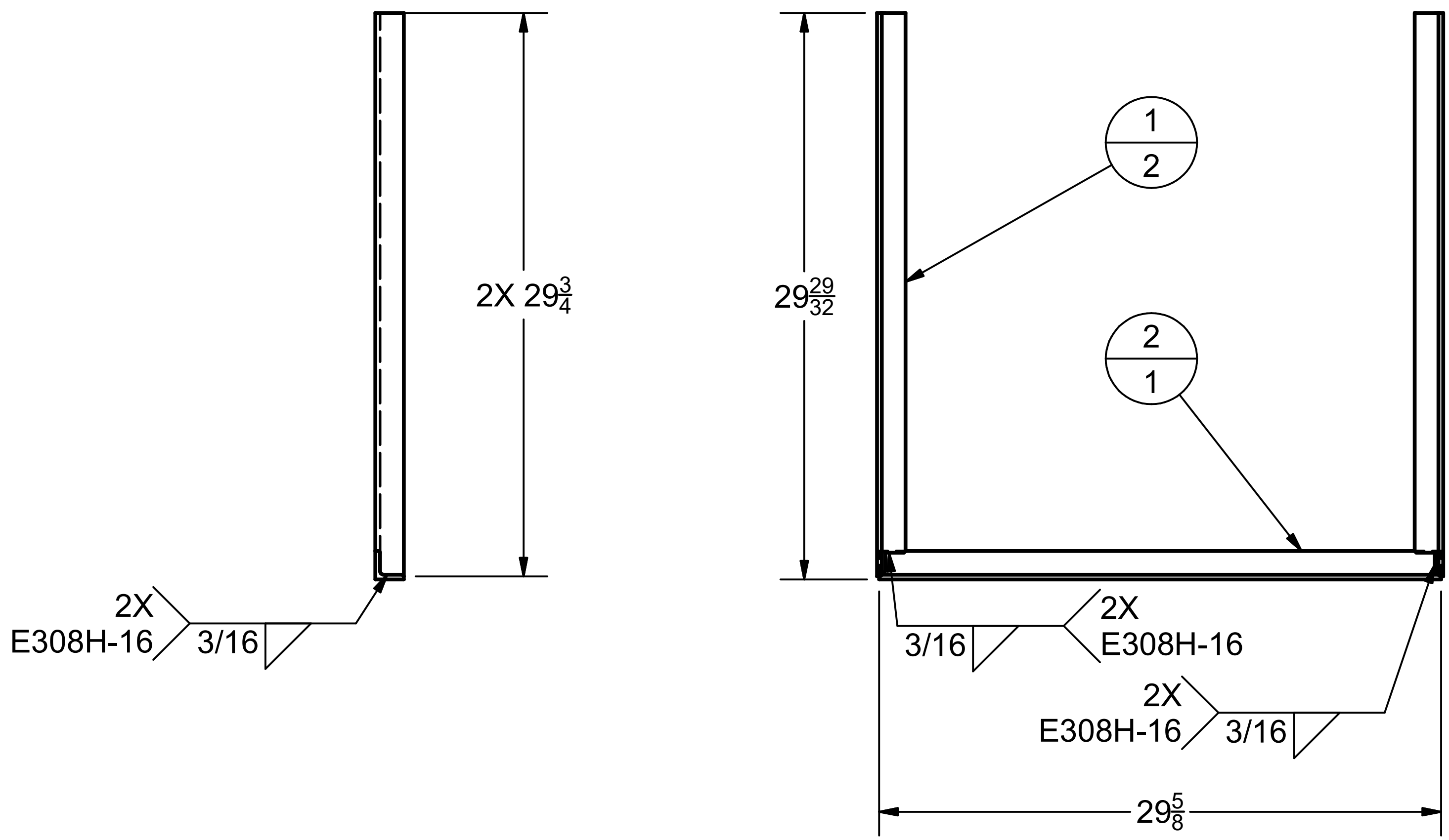
ASSEMBLY PARTS LIST						
ITEM	QTY	DESCRIPTION	PART NO.	VENDOR	MATERIAL	LENGTH
1	2	ANGLE BAR SUPPORT - HORIZONTAL	4030	RUSSEL METALS	Stainless Steel, Austenitic	51 $\frac{3}{8}$ in
2	1	ANGLEBAR SUPPORT- VERTICAL	4031	RUSSEL METALS	Stainless Steel, Austenitic	39 in



TOLERANCES UNLESS OTHERWISE SPECIFIED .X ± .015 FRACTIONS ± $\frac{1}{32}$ .XX ± .010 ANGLES ± $\frac{1}{2}$° .XXX ± .005 ALL DIMENSIONS IN INCHES	DWN BY: M.D.V. DATE: 27-MAR-2024 CHK BY: E.N. COURSE: MCEN 2471	NAIT THIRD ANGLE PROJECTION DO NOT SCALE DRAWING!	MECHANICAL ENGINEERING TECHNOLOGY OUTER TANK - STRUCTURAL ID DWG TYPE: WELDMENT DWG NO: 2004 - 1 SCALE: 1 : 15 SIZE: A REV: 0 6 OF 42

II-1192.0

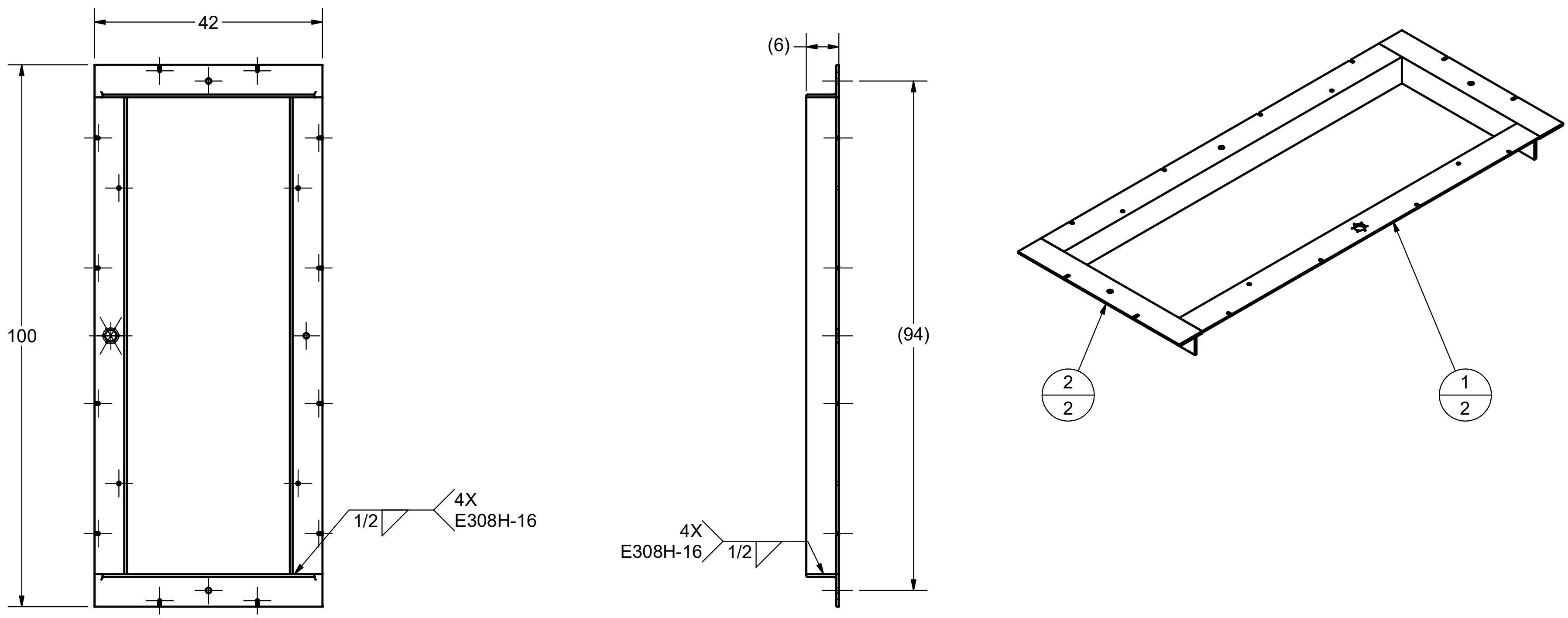
ASSEMBLY PARTS LIST						
ITEM	QTY	DESCRIPTION	PART NO.	VENDOR	MATERIAL	UNIT QTY
1	2	ANGLE BAR SUPPORT - VERTICAL	4028	METAL SUPERMARKETS	Stainless Steel, Austenitic	29 $\frac{3}{4}$ in
2	1	ANGLE BAR SUPPORT - HORIZONTAL	4029	METAL SUPERMARKETS	Stainless Steel, Austenitic	29 $\frac{5}{8}$ in



TOLERANCES UNLESS OTHERWISE SPECIFIED	DWN BY: M.D.V.	NAIT	MECHANICAL ENGINEERING TECHNOLOGY
.X ± .015 FRACTIONS ± $\frac{1}{32}$	DATE: 27-MAR-2024		INNER TANK - STRUCTURAL ID
.XX ± .010 ANGLES ± $\frac{1}{2}$°	CHK BY: E.N.	THIRD ANGLE PROJECTION	DWG TYPE: WELDMENT / DWG NO: 2005 - 1
.XXX ± .005 ALL DIMENSIONS IN INCHES	COURSE: MCEN 2471	DO NOT SCALE DRAWING!	SCALE: 1 : 10 / SIZE: A / REV: 0 / 7 OF 42

II-1192.0

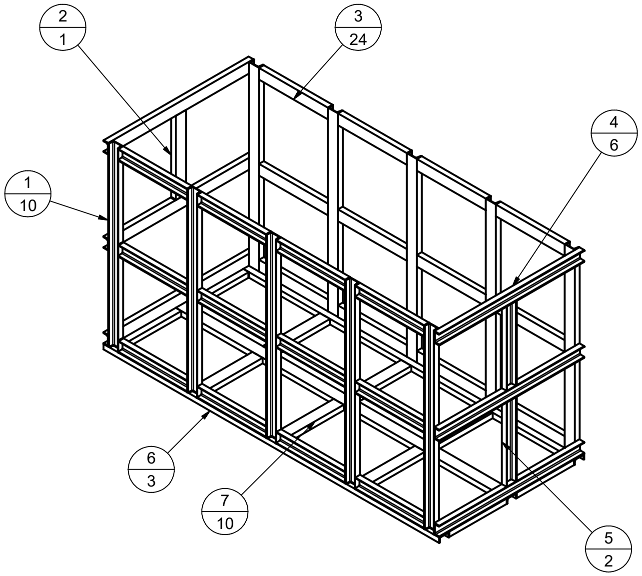
ASSEMBLY PARTS LIST						
ITEM	QTY	DESCRIPTION	PART NO.	VENDOR	MATERIAL	LENGTH
1	2	INNER TANK LIP - LONG BAR	4012	METAL SUPERMARKETS	Stainless Steel, Austenitic	88 in
2	2	INNER TANK LIP - SHORT BAR	4013	METAL SUPERMARKETS	Stainless Steel, Austenitic	42 in

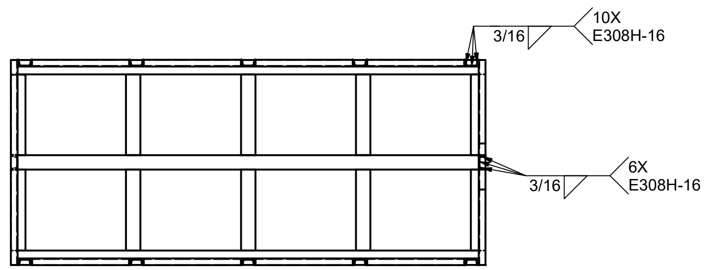


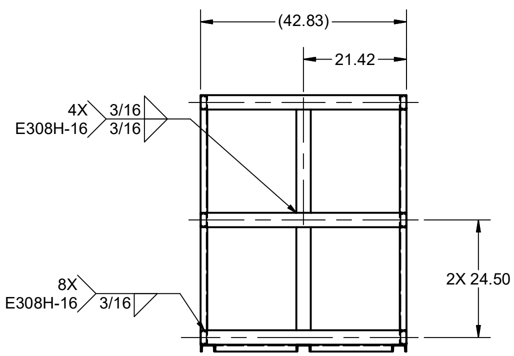
TOLERANCES UNLESS OTHERWISE SPECIFIED .X ± .015 FRACTIONS ± $\frac{1}{32}$ .XX ± .010 ANGLES ± $\frac{1}{2}$° .XXX ± .005 ALL DIMENSIONS IN INCHES	DWN BY: M.D.V. DATE: 27-MAR-2024 CHK BY: E.N. COURSE: MCEN 2471	NAIT THIRD ANGLE PROJECTION DO NOT SCALE DRAWING!	MECHANICAL ENGINEERING TECHNOLOGY INNER TANK LIP WELDMENT DWG TYPE: WELDMENT DWG NO: 2006 - 1 SCALE: N.T.S. SIZE: B REV: 0 8 OF 42

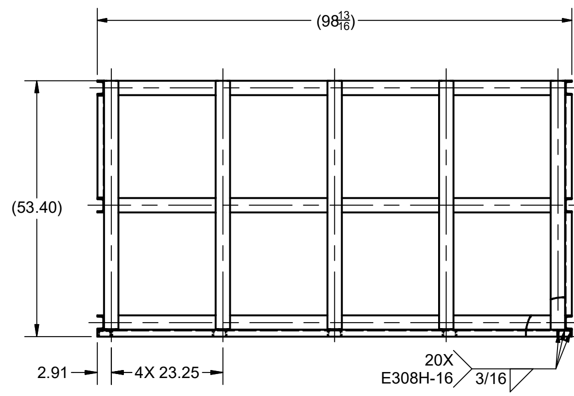
II-1192.0

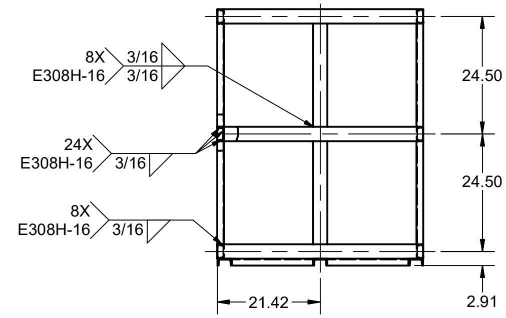
ASSEMBLY PARTS LIST						
ITEM	QTY	DESCRIPTION	PART NO.	VENDOR	MATERIAL	LENGTH
1	10	OUTER TANK SS - SIDE VERTICAL	4005	METAL SUPERMARKETS	Stainless Steel, Austenitic	52 in
2	1	OUTER TANK SS - REAR VERTICAL	4006	METAL SUPERMARKETS	Stainless Steel, Austenitic	21 $\frac{1}{2}$ in
3	24	OUTER TANK SS - SIDE HORIZONTAL	4007	METAL SUPERMARKETS	Stainless Steel, Austenitic	20 $\frac{1}{4}$ in
4	6	OUTER TANK SS - REAR HORIZONTAL	4008	METAL SUPERMARKETS	Stainless Steel, Austenitic	42 $\frac{3}{4}$ in
5	2	OUTER TANK SS - REAR VERTICAL	4009	METAL SUPERMARKETS	Stainless Steel, Austenitic	21 $\frac{1}{2}$ in
6	3	OUTER TANK SS - BOTTOM LONG	4010	METAL SUPERMARKETS	Stainless Steel, Austenitic	98 $\frac{7}{8}$ in
7	10	OUTER TANK SS - BOTTOM SHORT	4011	METAL SUPERMARKETS	Stainless Steel, Austenitic	39 $\frac{3}{4}$ in

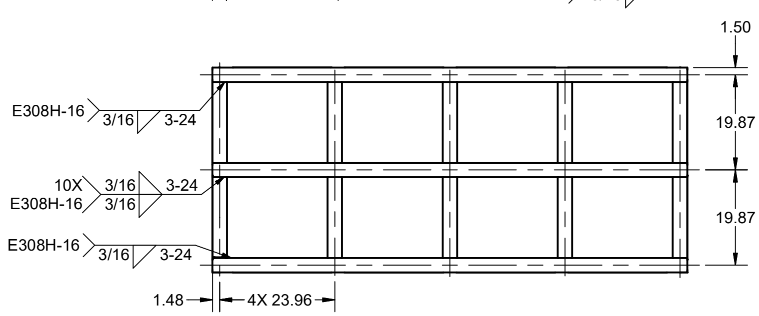












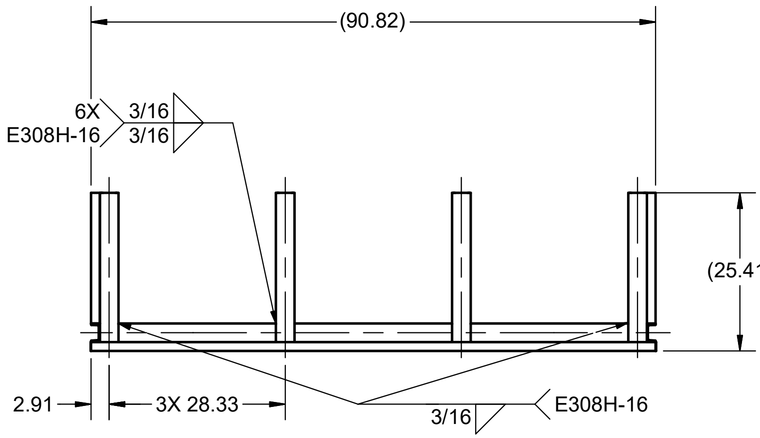
TOLERANCES UNLESS OTHERWISE SPECIFIED		DWN BY:	M.D.V.	MECHANICAL ENGINEERING TECHNOLOGY		
.X ± .015	FRACTIONS ± $\frac{1}{32}$	DATE:	27-MAR-2024	OUTER TANK STRUCTURAL SUPPORT		
.XX ± .010	ANGLES ± $\frac{1}{2}$°	CHK BY:	E.N.	DWG TYPE: DETAIL	DWG NO: 2007 - 1	
.XXX ± .005						
ALL DIMENSIONS IN INCHES		COURSE:	MCEN 2471	SCALE: 1:20	SIZE: C	REV: 0

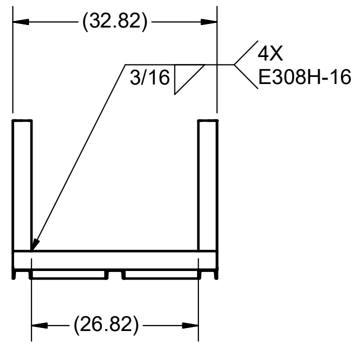
THIRD ANGLE PROJECTION
DO NOT SCALE DRAWING!

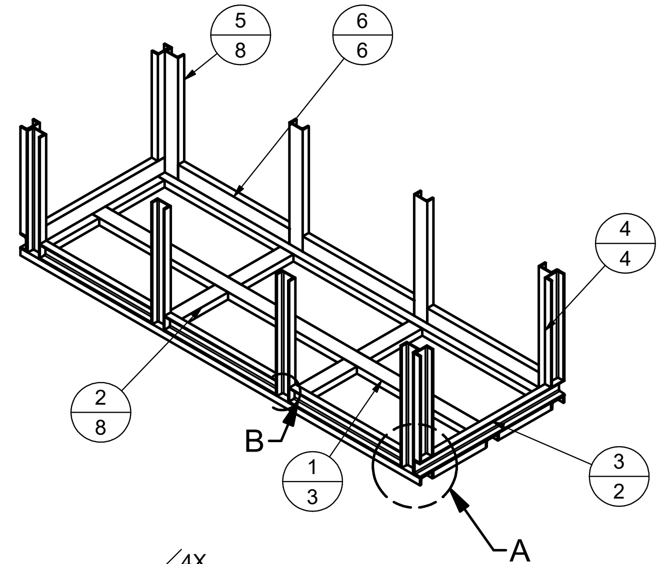
NAIT

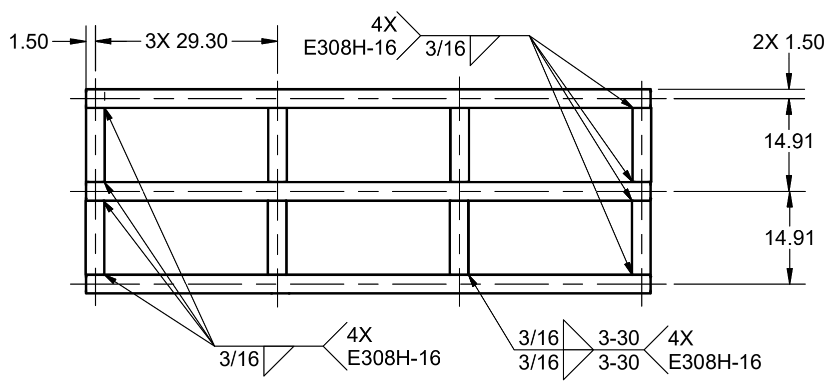
II-1192.0

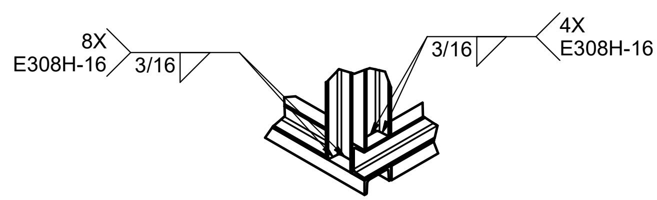
ASSEMBLY PARTS LIST						
ITEM	QTY	DESCRIPTION	PART NO.	VENDOR	MATERIAL	LENGTH
1	3	INNER TANK SS - BOTTOM LONG	4014	METAL SUPERMARKETS	Stainless Steel, Austenitic	272 $\frac{1}{2}$ in
2	8	INNER TANK SS - BOTTOM SHORT	4015	METAL SUPERMARKETS	Stainless Steel, Austenitic	95 $\frac{1}{4}$ in
3	2	INNER TANK SS - FRONT HORIZONTAL	4016	METAL SUPERMARKETS	Stainless Steel, Austenitic	65 $\frac{5}{8}$ in
4	4	INNER TANK SS - FRONT/REAR VERTICAL	4017	METAL SUPERMARKETS	Stainless Steel, Austenitic	84 in
5	8	INNER TANK SS - SIDE VERTICAL	4018	METAL SUPERMARKETS	Stainless Steel, Austenitic	192 in
6	6	INNER TANK SS - SIDE HORIZONTAL	4019	METAL SUPERMARKETS	Stainless Steel, Austenitic	152 in



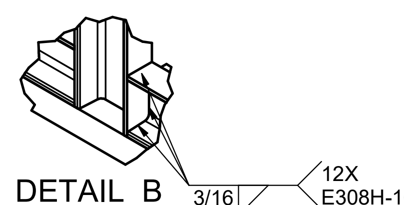








DETAIL A
SCALE 1 : 10

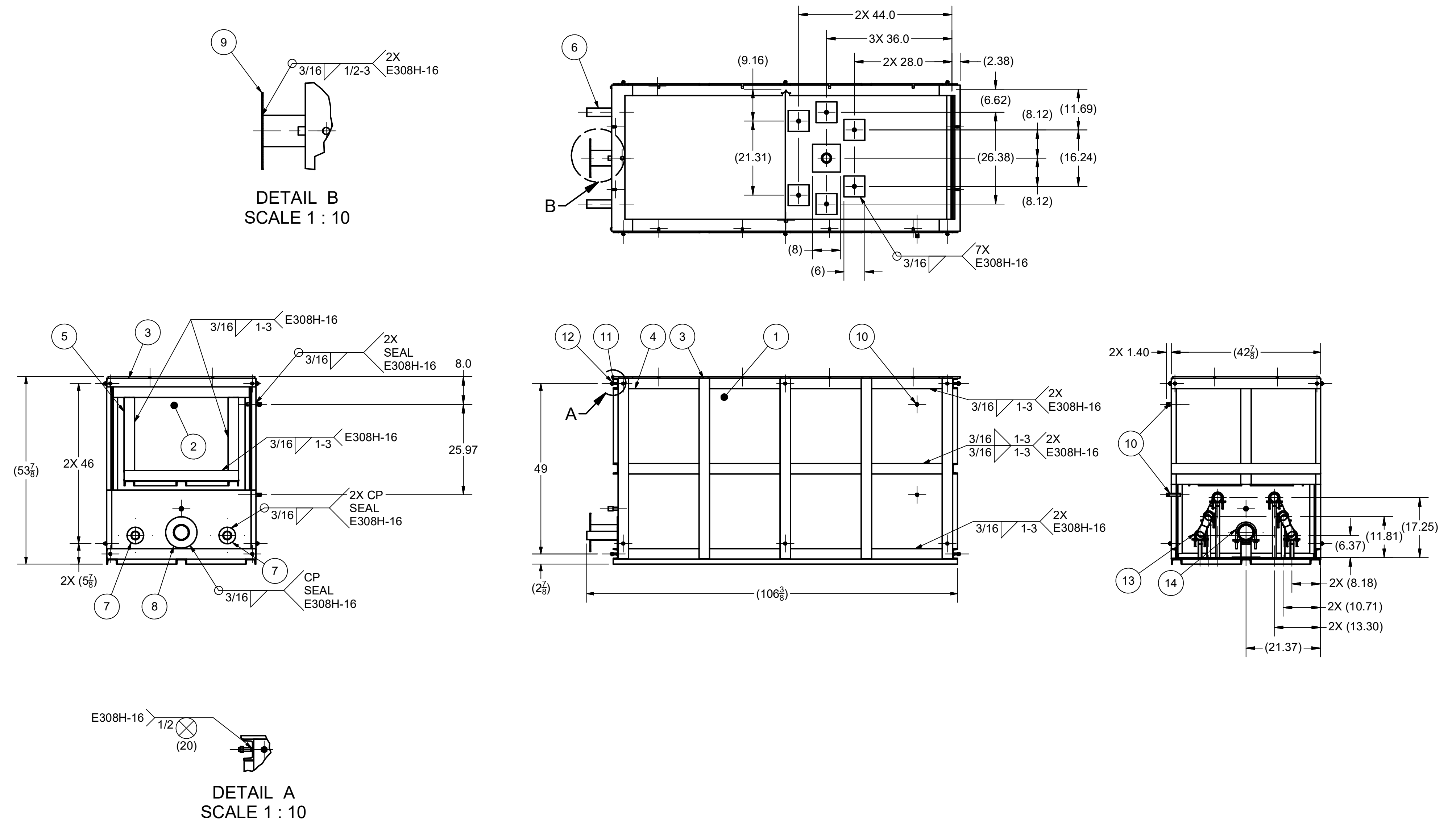


DETAIL B
SCALE 1 : 5

TOLERANCES UNLESS OTHERWISE SPECIFIED .X ± .015 FRACTIONS ± $\frac{1}{32}$ .XX ± .010 ANGLES ± $\frac{1}{2}$· .XXX ± .005 ALL DIMENSIONS IN INCHES	DWN BY: M.D.V. DATE: 27-MAR-2024 CHK BY: E.N. COURSE: MCEN 2471	NAIT THIRD ANGLE PROJECTION DO NOT SCALE DRAWING!	MECHANICAL ENGINEERING TECHNOLOGY INNER TANK STRUCTURAL SUPPORT DWG TYPE: WELDMENT · DWG NO: 2008 - 1 SCALE: N.T.S. · SIZE: B · REV: 0 · 10 OF 42 II-1192.0

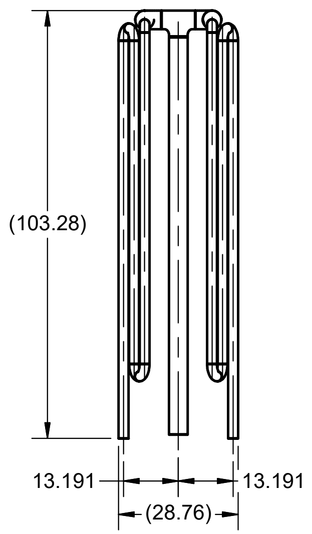
ASSEMBLY PARTS LIST						
ITEM	QTY	DESCRIPTION	PART NO.	VENDOR	VENDOR - OEM PN	MATERIAL
1	1	OUTER TANK ASSEMBLY	2001			
2	1	INNER TANK ASSEMBLY	2002			
3	1	INNER TANK LIP	2006			
4	1	OUTER TANK STRUCTURAL SUPPORT	2007			
5	1	INNER TANK STRUCTURAL SUPPORT	2008			
6	1	FIRE TUBE WELDMENT	2010			
7	2	EXHAUST FIRE TUBE SUPPORT	3007	RUSSEL METALS		Stainless Steel

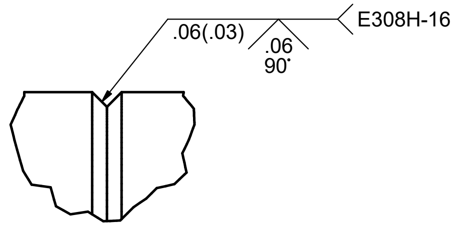
ASSEMBLY PARTS LIST						
ITEM	QTY	DESCRIPTION	PART NO.	VENDOR	VENDOR - OEM PN	MATERIAL
8	1	INLET FIRE TUBE SUPPORT	3008	RUSSEL METALS		Stainless Steel
9	1	GAS BURNER FLANGE	3009	RUSSEL METALS		Stainless Steel
10	2	THREADED ONE END NIPPLE, 1/2" NPT	4032	MCMASTER-CARR	9157K53	304 Stainless Steel
11	20	WELD STUD, 1/2"-13 x 2" LG., 18-8 SS	4033	GRAINGER CANADA	WWG12A902	18-8 Stainless Steel
12	20	1/2"-13 HEX NUT, 18-8 SS	4034		92673A137	18-8 Stainless Steel
13	6	2" SCH 10 PIPE SADDLE SUPPORT	4035	EMPIRE INDUSTRIES INC.	429KTU	T304 Stainless Steel
14	1	4" SCH 10 PIPE SADDLE SUPPORT	4036	EMPIRE INDUSTRIES INC.	429KTU-4"	T304 Stainless Steel



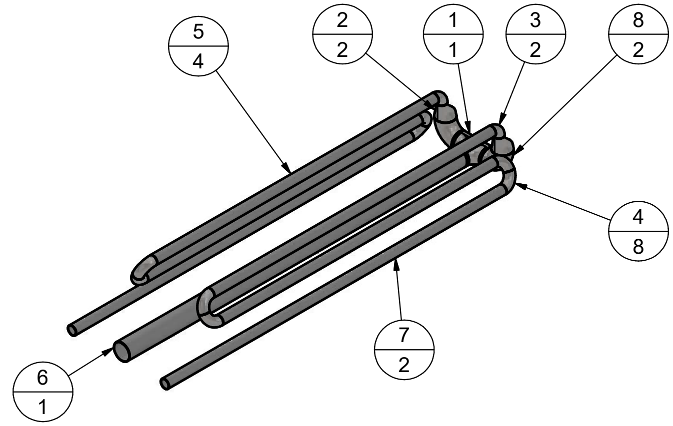
TOLERANCES UNLESS OTHERWISE SPECIFIED: .X ±.015, .XX ±.010, .XXX ±.005; FRACTIONS ± 1/32; ANGLES ± 1/2°; ALL DIMENSIONS IN INCHES	DWN BY: M.D.V.	MECHANICAL ENGINEERING TECHNOLOGY	
	DATE: 11-APR-2027	PHOSPHATE TANK WELDMENT	
	CHK BY: E.N.	DWG TYPE: WELDMENT	DWG NO: 2009 - 1
	COURSE: MCEN 2471	THIRD ANGLE PROJECTION DO NOT SCALE DRAWING! SCALE: N.T.S. SIZE: C	REV: 0 11 OF 42

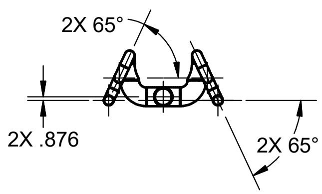
ASSEMBLY PARTS LIST						
ITEM	QTY	DESCRIPTION	SNO / PN	VENDOR	VENDOR - OEM PN	MATERIAL
1	1	TEE, 4" SCH 10 PIPE, BUTTWELD, 304 SS	4020	GRAINGER CANADA	4381011680	Stainless Steel
2	2	OFFSET REDUCER, 4" SCH 10 PIPE, BUTTWELD, 304 SS	4021	MCMASTER-CARR	45735K639	Stainless Steel
3	2	90◦ SHORT ELBOW, 2" SCH 10 PIPE, BUTTWELD, 304 SS	4022	MCMASTER-CARR	45735K324	Stainless Steel
4	8	90◦ LONG ELBOW, 2" SCH 10 PIPE, BUTTWELD, 304 SS	4023	MCMASTER-CARR	45735K216	Stainless Steel
5	4	2" SCH 10 PIPE, SEAMLESS	4024	RUSSEL METALS		Stainless Steel, Austenitic
6	1	4" SCH 10 PIPE, SEAMLESS	4025	RUSSEL METALS		Stainless Steel, Austenitic
7	2	2" SCH 10 PIPE, SEAMLESS (EXHAUST)	4026	RUSSEL METALS		Stainless Steel, Austenitic
8	2	90º ELBOW, 4" SCH 10 PIPE, BUTT-WELD, 304 SS	4027	MCMASTER-CARR	45735K327	Stainless Steel

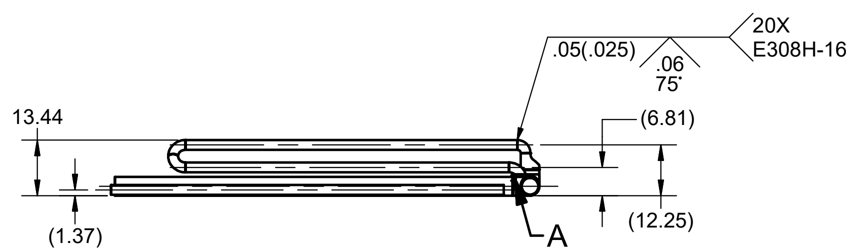


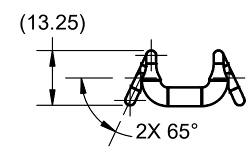


DETAIL A
SCALE 1 : 1



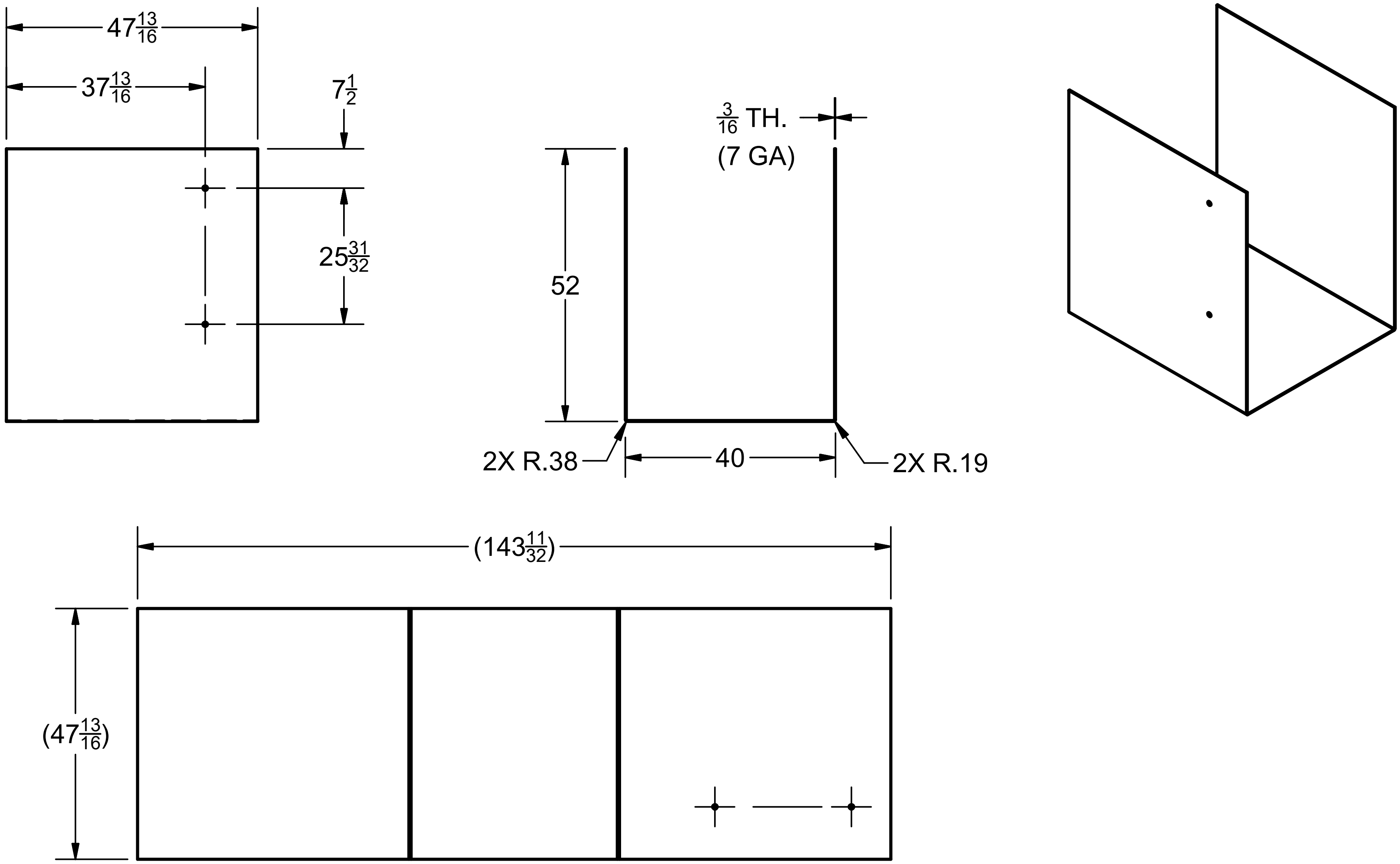






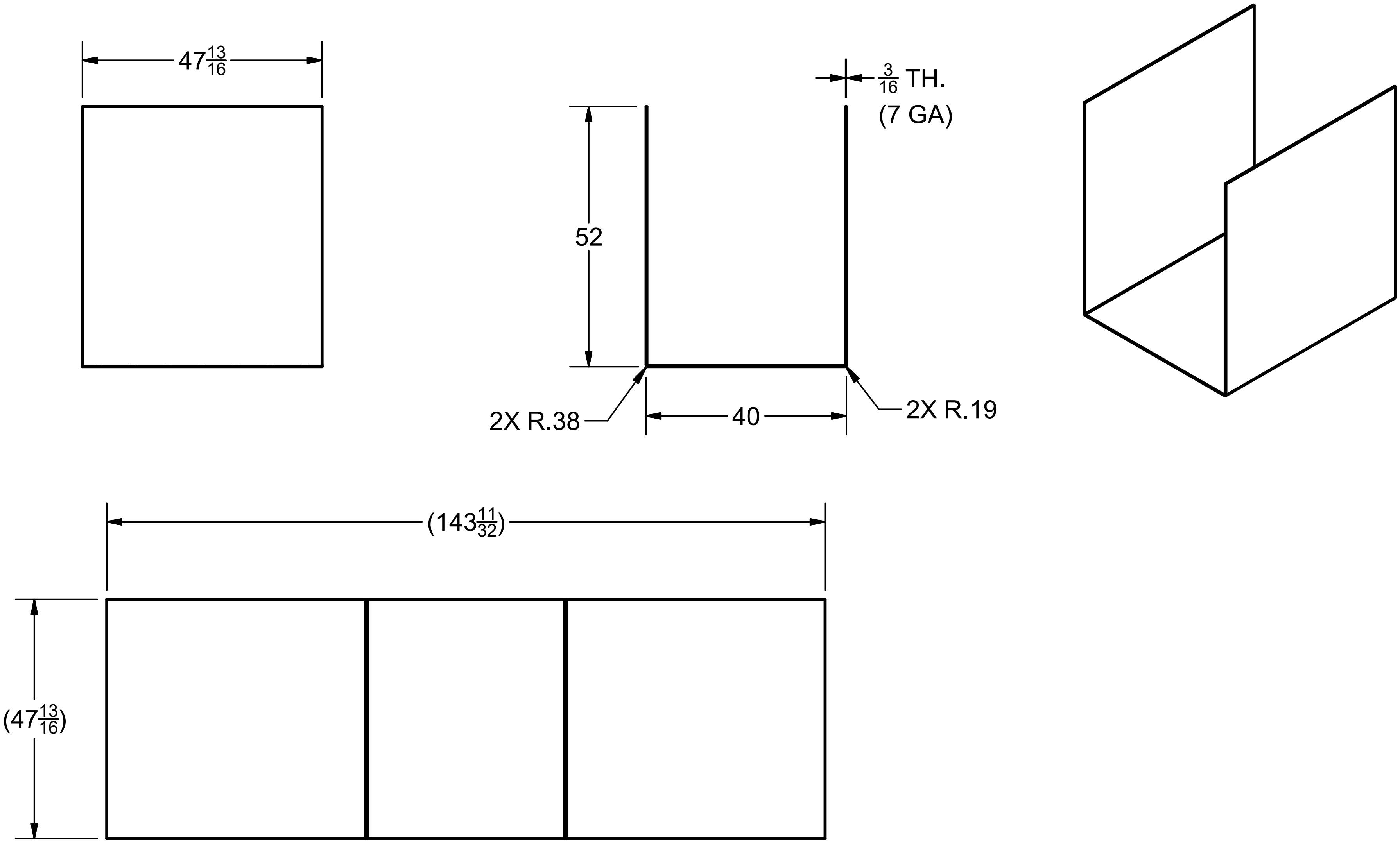
TOLERANCES UNLESS OTHERWISE SPECIFIED .X ± .015 .XX ± .010 .XXX ± .005 FRACTIONS ± 1/32 ANGLES ± 1/2° ALL DIMENSIONS IN INCHES	DWN BY: M.D.V.	MECHANICAL ENGINEERING TECHNOLOGY	
	DATE: 06-APR-2024	FIRE TUBE WELDMENT	II-1192.0
	CHK BY: E.N.	DWG TYPE: WELDMENT	DWG NO: 2010 - 1
	COURSE: MCEN 2471	THIRD ANGLE PROJECTION DO NOT SCALE DRAWING! SCALE: N.T.S. SIZE: B REV: 0	12 OF 42

Appendix Y: Manufactured Parts Drawings



Stainless Steel, Austenitic	7 GA 304 SS SHEET METAL
MATERIAL	DESCRIPTION

TOLERANCES UNLESS OTHERWISE SPECIFIED	DWN BY: M.D.V.	NAIT	MECHANICAL ENGINEERING TECHNOLOGY OUTER TANK - U-PROFILE
.X ± .015 FRACTIONS ± 1/32	DATE: 27-MAR-2024		II-1192.0
.XX ± .010 ANGLES ± 1/2°	CHK BY: E.N.	THIRD ANGLE PROJECTION	DWG TYPE: DETAIL — DWG NO: 3001 - 1
.XXX ± .005		DO NOT SCALE DRAWING!	
ALL DIMENSIONS IN INCHES	COURSE: MCEN 2471		SCALE: 1 : 30 — SIZE: A — REV: 0 — 13 OF 42



Stainless Steel, Austenitic	7 GA 304 SS SHEET METAL
MATERIAL	DESCRIPTION

TOLERANCES UNLESS OTHERWISE SPECIFIED

.X ± .015 FRACTIONS ± 1/32

.XX ± .010 ANGLES ± 1/2°

.XXX ± .005

ALL DIMENSIONS IN INCHES

DWN BY:	M.D.V.
DATE:	27-MAR-2024
CHK BY:	E.N.
COURSE:	MCEN 2471

NAIT

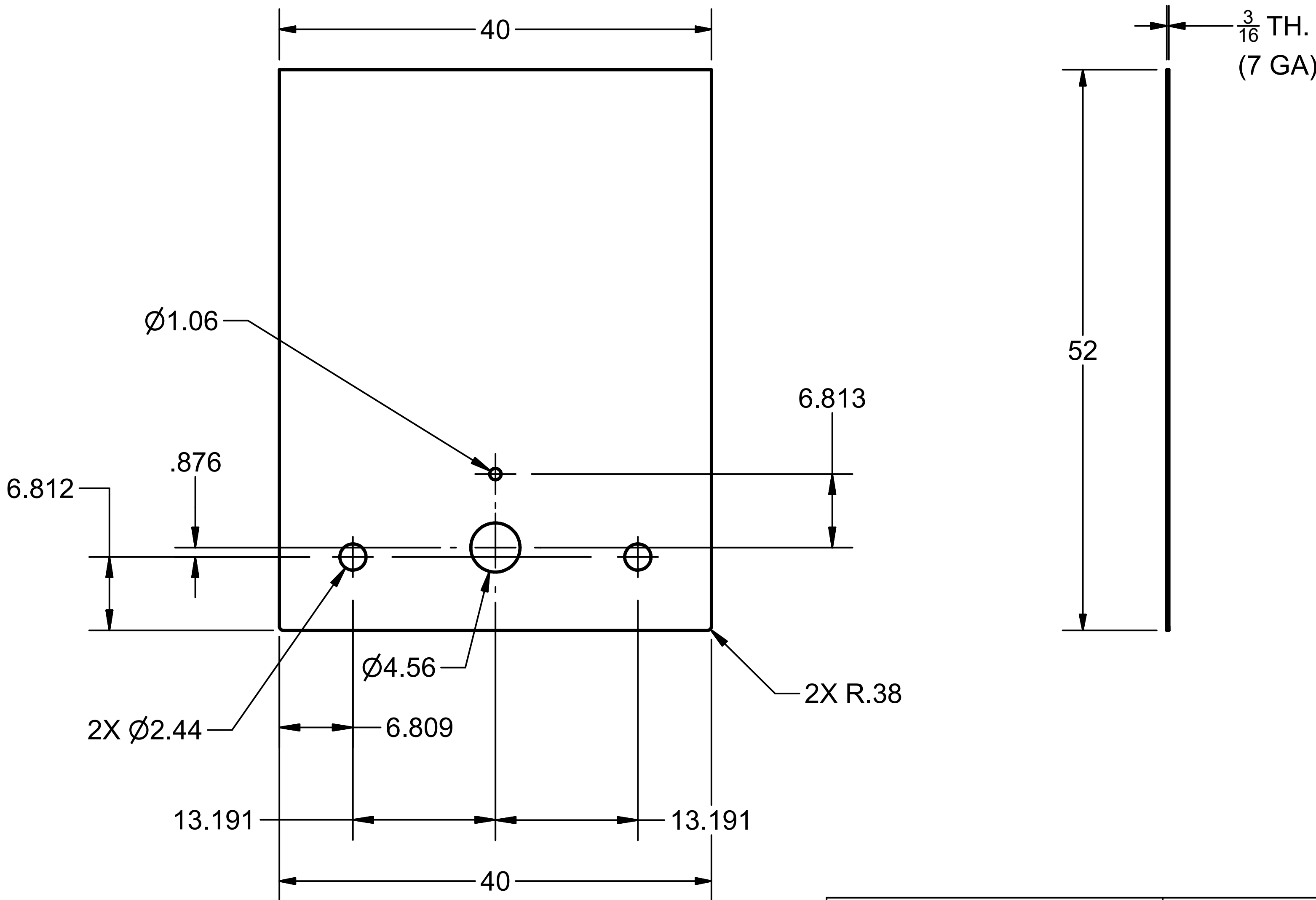
MECHANICAL ENGINEERING TECHNOLOGY

OUTER TANK - U PROFILE (NO HOLE)

II-1192.0

THIRD ANGLE PROJECTION
DO NOT SCALE DRAWING!

DWG TYPE: DETAIL		DWG NO: 3002 - 1	
SCALE: 1 : 20	SIZE: A	REV: 0	14 OF 42



Stainless Steel, Austenitic	7 GA 304 SS SHEET METAL
MATERIAL	DESCRIPTION

TOLERANCES UNLESS OTHERWISE SPECIFIED

.X ± .015 FRACTIONS ± $\frac{1}{32}$

.XX ± .010 ANGLES ± $\frac{1}{2}$°

.XXX ± .005

ALL DIMENSIONS IN INCHES

DWN BY:	M.D.V.
DATE:	27-MAR-2024
CHK BY:	E.N.
COURSE:	MCEN 2471

NAIT

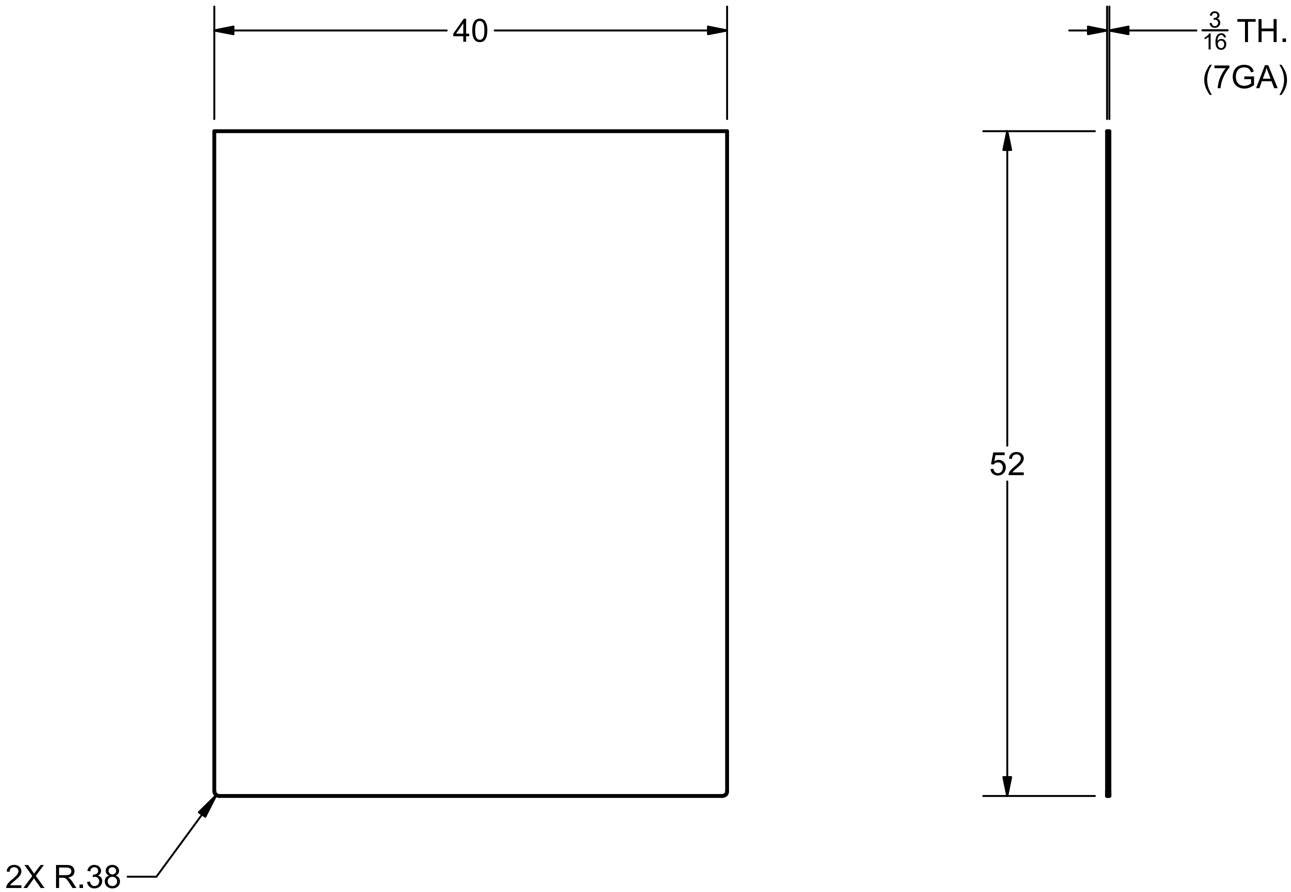
MECHANICAL ENGINEERING TECHNOLOGY

OUTER TANK - REAR PROFILE SHEET

II-1192.0

THIRD ANGLE PROJECTION
DO NOT SCALE DRAWING!

DWG TYPE: DETAIL		DWG NO: 3003 - 1	
SCALE: 1 : 15	SIZE: A	REV: 0	15 OF 42



Stainless Steel, Austenitic	7 GA 304 SS SHEET METAL
MATERIAL	DESCRIPTION

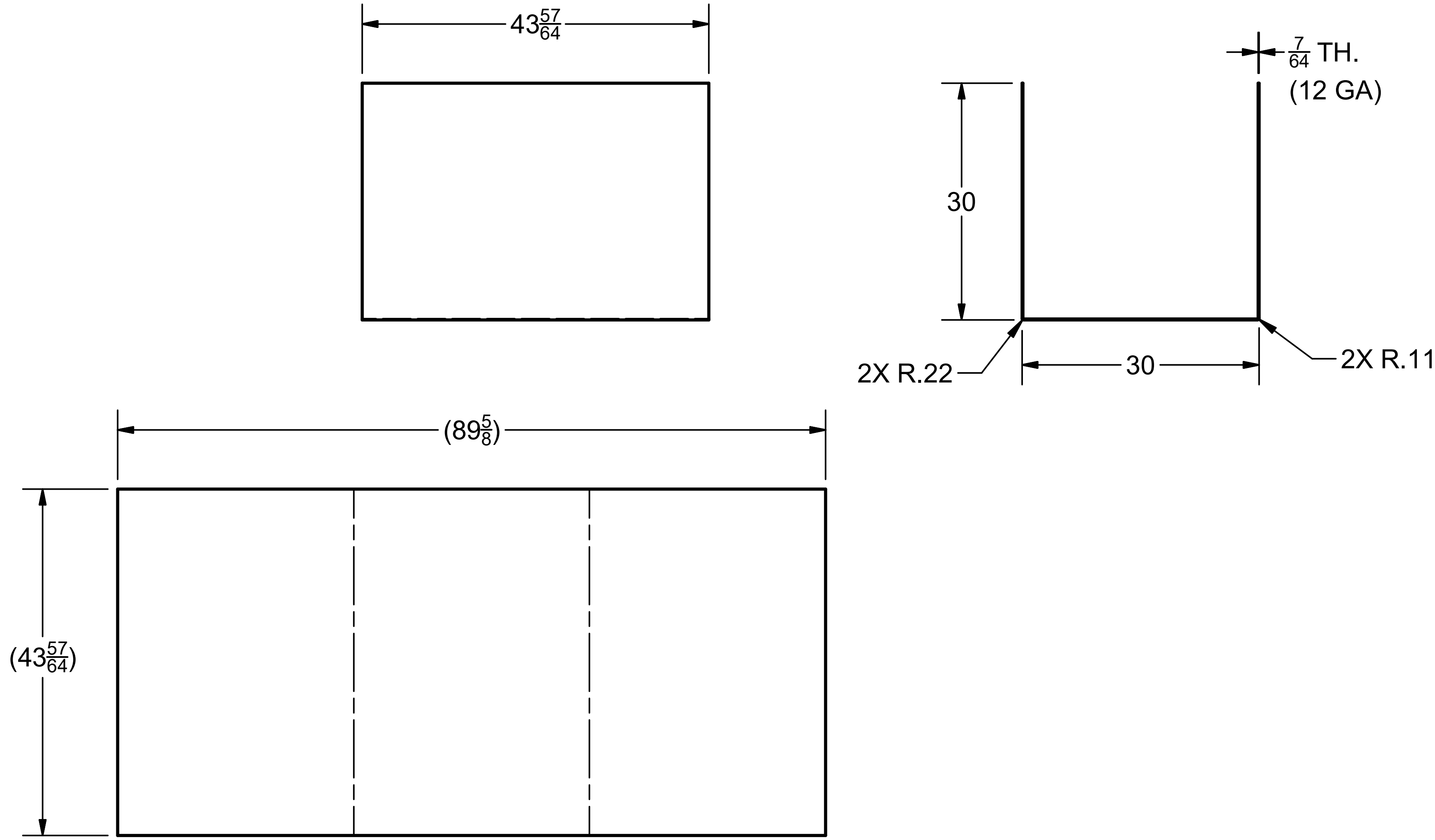
TOLERANCES UNLESS OTHERWISE SPECIFIED
.X ± .015 FRACTIONS ± $\frac{1}{32}$
.XX ± .010 ANGLES ± $\frac{1}{2}$°
.XXX ± .005
ALL DIMENSIONS IN INCHES

DWN BY:	M.D.V.
DATE:	27-MAR-2024
CHK BY:	E.N.
COURSE:	MCEN 2471

NAIT
MECHANICAL ENGINEERING TECHNOLOGY
OUTER TANK - FRONT PROFILE SHEET
II-1192.0

THIRD ANGLE PROJECTION
DO NOT SCALE DRAWING!

DWG TYPE: DETAIL		DWG NO: 3004 - 1	
SCALE: 1 : 15	SIZE: A	REV: 0	16 OF 42



Stainless Steel, Austenitic	12 GA 304 SS SHEET METAL
MATERIAL	DESCRIPTION

TOLERANCES UNLESS OTHERWISE SPECIFIED
.X ± .015 FRACTIONS ± 1/32
.XX ± .010 ANGLES ± 1/2°
.XXX ± .005
ALL DIMENSIONS IN INCHES

DWN BY:	M.D.V.
DATE:	27-MAR-2024
CHK BY:	E.N.
COURSE:	MCEN 2471

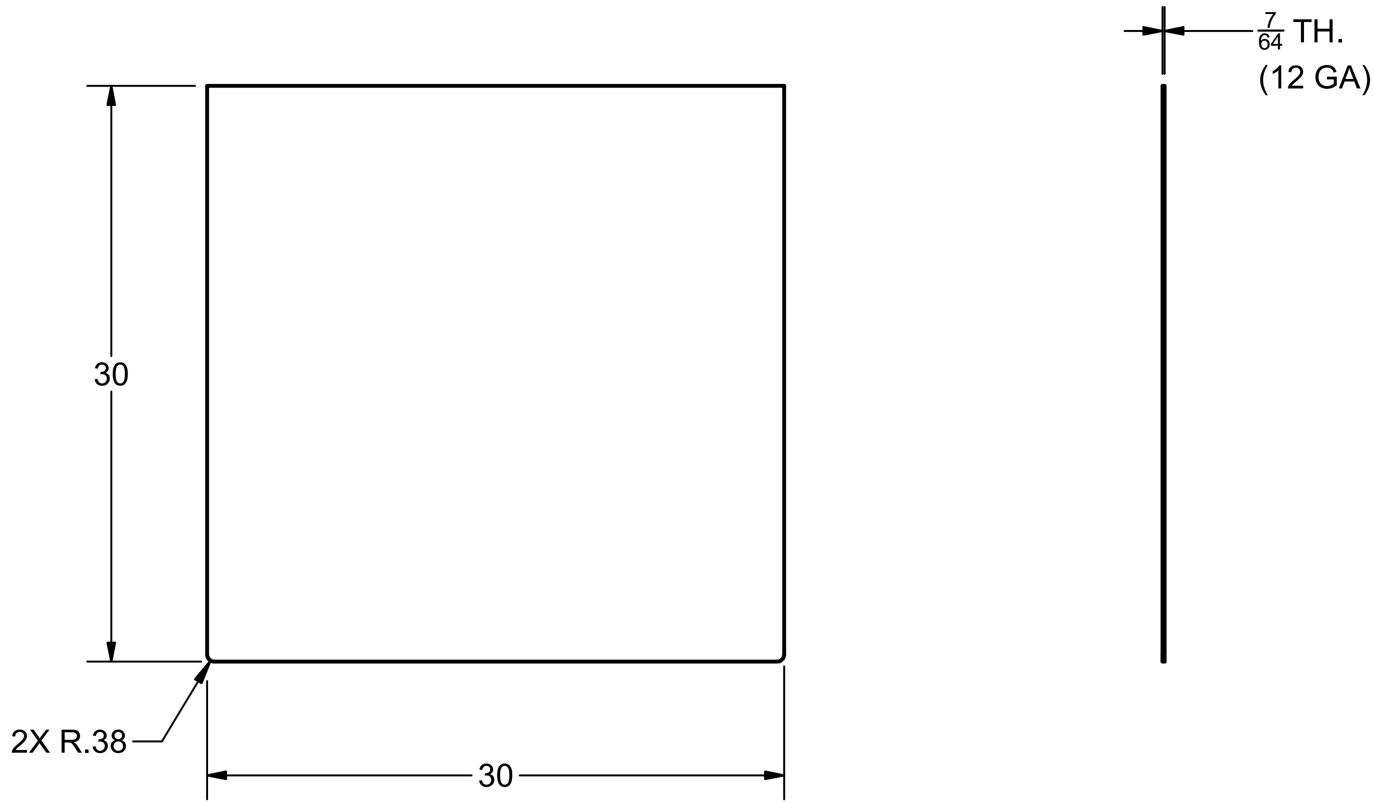
NAIT

THIRD ANGLE PROJECTION
DO NOT SCALE DRAWING!

MECHANICAL ENGINEERING TECHNOLOGY
INNER TANK - U-PROFILE

II-1192.0

DWG TYPE: DETAIL		DWG NO: 3005 - 1	
SCALE: 1 : 20	SIZE: A	REV: 0	17 OF 42



Stainless Steel, Austenitic	12 GA 304 SS SHEET METAL
MATERIAL	DESCRIPTION

TOLERANCES UNLESS OTHERWISE SPECIFIED

.X ± .015 FRACTIONS ± $\frac{1}{32}$

.XX ± .010 ANGLES ± $\frac{1}{2}$°

.XXX ± .005

ALL DIMENSIONS IN INCHES

DWN BY:	M.D.V.
DATE:	27-MAR-2024
CHK BY:	E.N.
COURSE:	MCEN 2471

NAIT

MECHANICAL ENGINEERING TECHNOLOGY

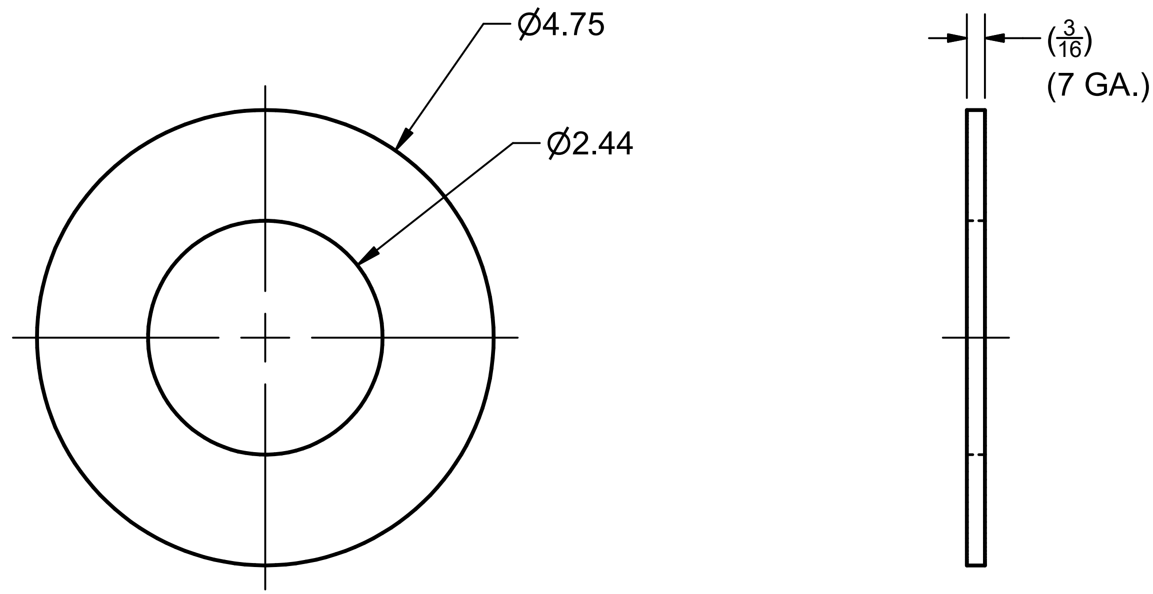
INNER TANK - FRONT AND REAR PROFILE SHEET

II-1192.0

THIRD ANGLE PROJECTION

DO NOT SCALE DRAWING!

DWG TYPE: DETAIL	DWG NO: 3006 - 1		
SCALE: 1 : 20	SIZE: A	REV: 0	18 OF 42



Stainless Steel	304 SS PLATE, EXHAUST FIRE TUBE SUPPORT
MATERIAL	DESCRIPTION

TOLERANCES UNLESS OTHERWISE SPECIFIED

.X ± .015 FRACTIONS ± $\frac{1}{32}$

.XX ± .010 ANGLES ± $\frac{1}{2}$°

.XXX ± .005

ALL DIMENSIONS IN INCHES

DWN BY:	M.D.V.
DATE:	13-APR-2024
CHK BY:	E.N.
COURSE:	MCEN 2471

NAIT

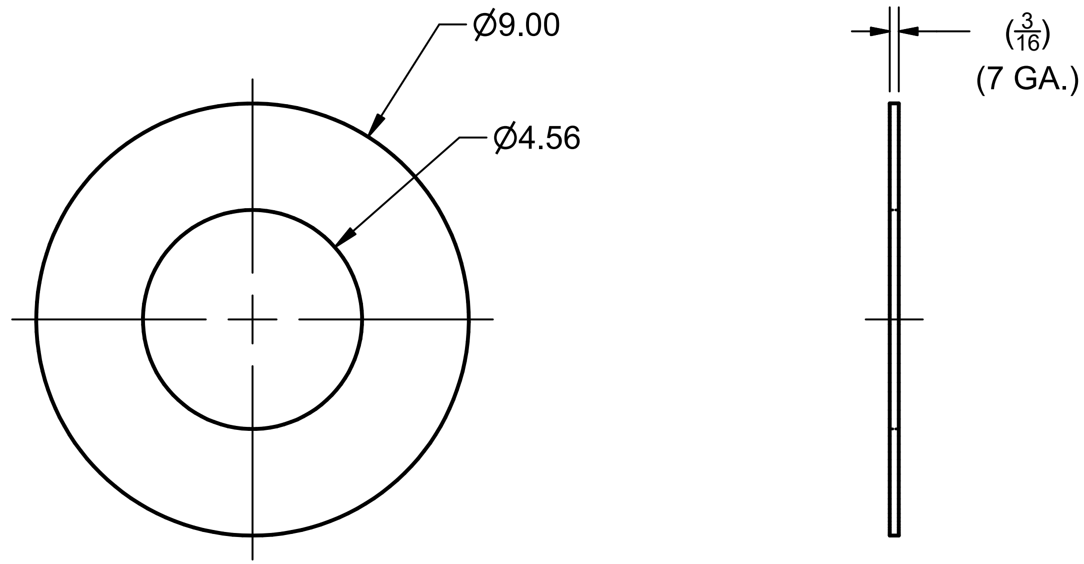
MECHANICAL ENGINEERING TECHNOLOGY

EXHAUST FIRE TUBE SUPPORT

II-1192.0

THIRD ANGLE PROJECTION
DO NOT SCALE DRAWING!

DWG TYPE: DETAIL		DWG NO: 3007 - 1	
SCALE: 1 : 2	SIZE: A	REV: 0	19 OF 42



Stainless Steel	304 SS PLATE, INLET FIRE TUBE SUPPORT
MATERIAL	DESCRIPTION

TOLERANCES UNLESS OTHERWISE SPECIFIED

.X ± .015 FRACTIONS ± $\frac{1}{32}$

.XX ± .010 ANGLES ± $\frac{1}{2}$°

.XXX ± .005

ALL DIMENSIONS IN INCHES

DWN BY:	M.D.V.
DATE:	13-APR-2024
CHK BY:	E.N.
COURSE:	MCEN 2471

NAIT

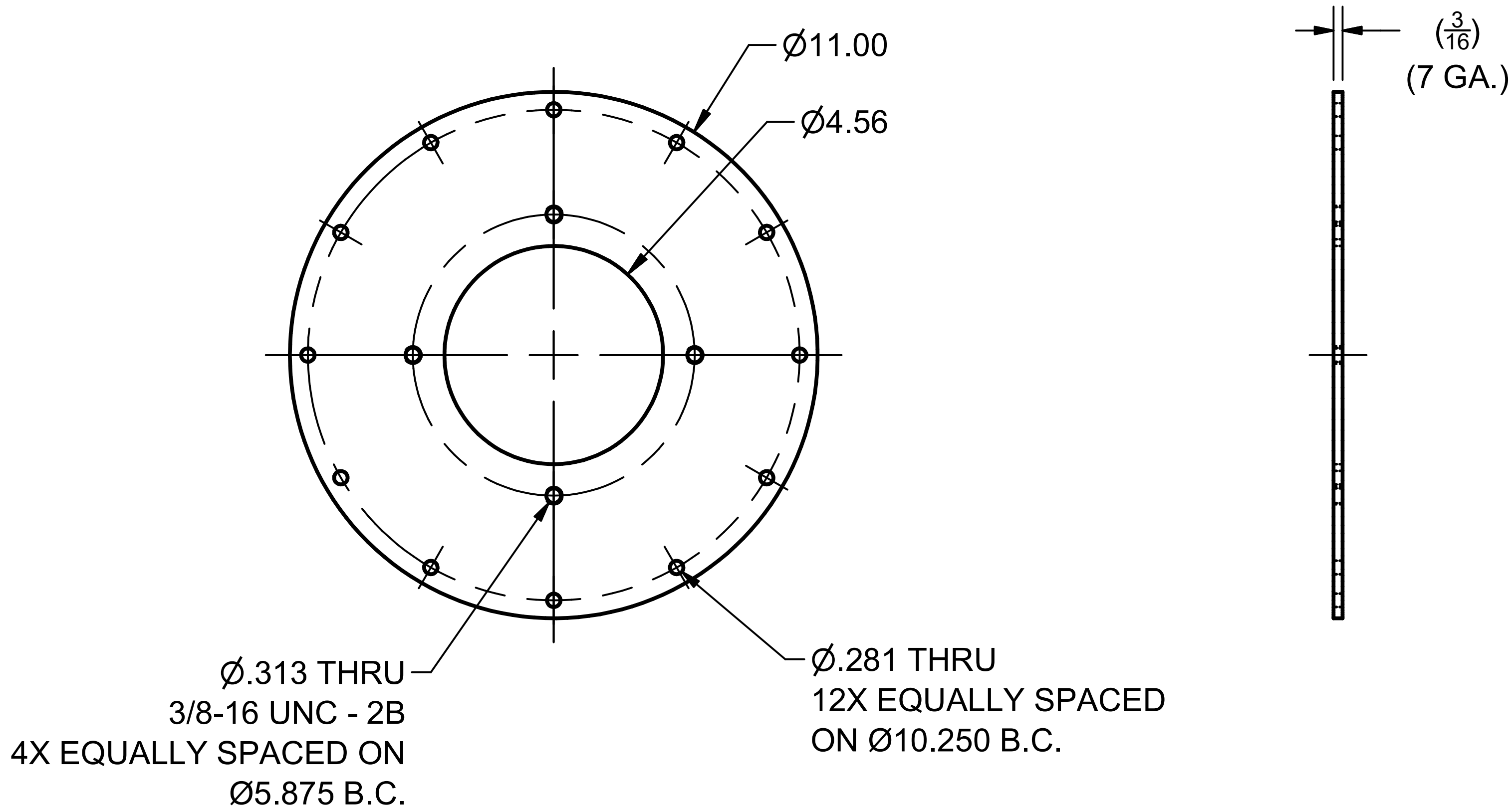
THIRD ANGLE PROJECTION
DO NOT SCALE DRAWING!

MECHANICAL ENGINEERING TECHNOLOGY

INLET FIRE TUBE SUPPORT

II-1192.0

DWG TYPE: DETAIL	DWG NO: 3008 - 1		
SCALE: 1 : 4	SIZE: A	REV: 0	20 OF 42



MATERIAL	DESCRIPTION
Stainless Steel	304 SS PLATE, GAS BURNER FLANGE

TOLERANCES UNLESS OTHERWISE SPECIFIED

.X ± .015 FRACTIONS ± $\frac{1}{32}$

.XX ± .010 ANGLES ± $\frac{1}{2}$°

.XXX ± .005

ALL DIMENSIONS IN INCHES

DWN BY:	M.D.V.
DATE:	13-APR-2024
CHK BY:	E.N.
COURSE:	MCEN 2471

NAIT

THIRD ANGLE PROJECTION
DO NOT SCALE DRAWING!

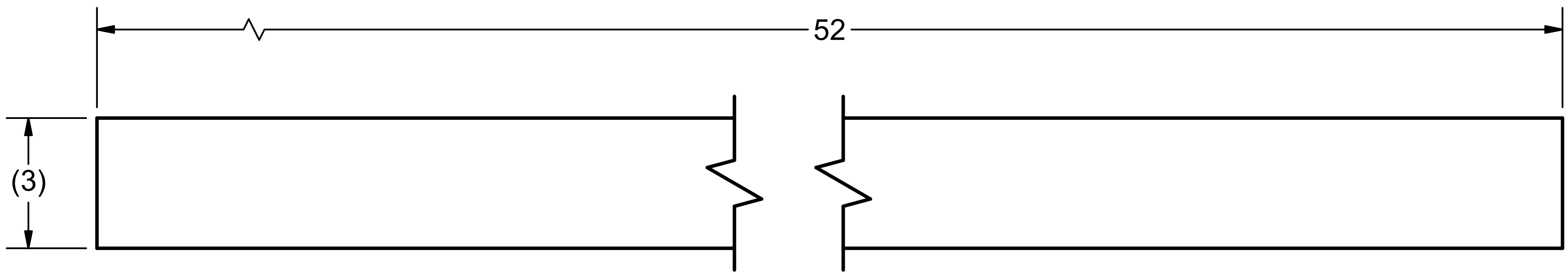
MECHANICAL ENGINEERING TECHNOLOGY

GAS BURNER FLANGE

II-1192.0

DWG TYPE: DETAIL		DWG NO: 3009 - 1	
SCALE: 1 : 4	SIZE: A	REV: 0	21 OF 42

Appendix Z: Buyout Parts List



Stainless Steel, Austenitic	304 SS, C 3 x 4.1 x 52" LG.
MATERIAL	DESCRIPTION

TOLERANCES UNLESS OTHERWISE SPECIFIED			
.X ± .015	FRACTIONS ± $\frac{1}{32}$	DWN BY:	M.D.V.
.XX ± .010	ANGLES ± $\frac{1}{2}$°	DATE:	29-MAR-2024
.XXX ± .005		CHK BY:	E.N.
ALL DIMENSIONS IN INCHES		COURSE:	MCEN 2471

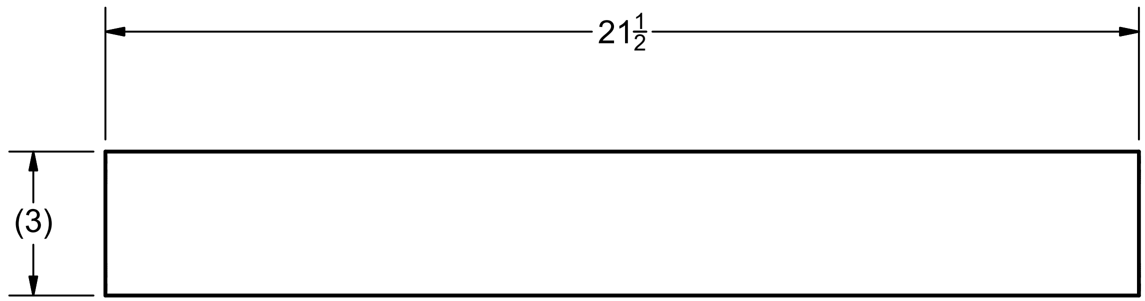
MECHANICAL ENGINEERING TECHNOLOGY

OUTER TANK SS - SIDE VERTICAL

II-1192.0

THIRD ANGLE PROJECTION
DO NOT SCALE DRAWING!

DWG TYPE: DETAIL	DWG NO: 4005 - 1		
SCALE: 1 : 4	SIZE: A	REV: 0	22 OF 42



Stainless Steel, Austenitic	304 SS, C 3 x 4.1 x 21 1/2" LG.
MATERIAL	DESCRIPTION

TOLERANCES UNLESS OTHERWISE SPECIFIED

.X ± .015 FRACTIONS ± $\frac{1}{32}$

.XX ± .010 ANGLES ± $\frac{1}{2}°$

.XXX ± .005

ALL DIMENSIONS IN INCHES

DWN BY:	M.D.V.
DATE:	29-MAR-2024
CHK BY:	E.N.
COURSE:	MCEN 2471

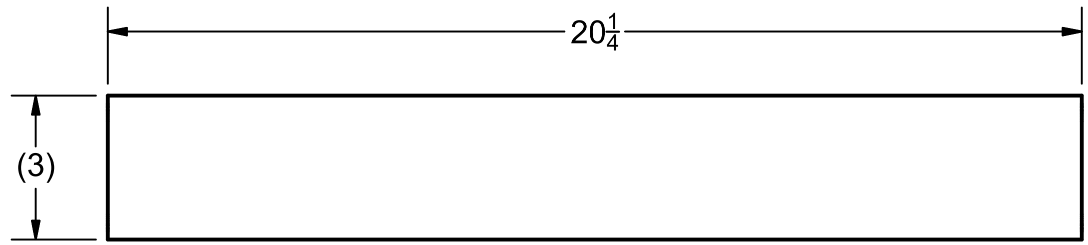
THIRD ANGLE PROJECTION
DO NOT SCALE DRAWING!

MECHANICAL ENGINEERING TECHNOLOGY

OUTER TANK SS - REAR VERTICAL

II-1192.0

DWG TYPE: DETAIL		DWG NO: 4006 - 1	
SCALE: 1 : 4	SIZE: A	REV: 0	23 OF 42



Stainless Steel, Austenitic	304 SS, C 3 x 4.1 x 20 1/4" LG.
MATERIAL	DESCRIPTION

TOLERANCES UNLESS OTHERWISE SPECIFIED

.X ± .015 FRACTIONS ± $\frac{1}{32}$

.XX ± .010 ANGLES ± $\frac{1}{2}$°

.XXX ± .005

ALL DIMENSIONS IN INCHES

DWN BY:	M.D.V.
DATE:	29-MAR-2024
CHK BY:	E.N.
COURSE:	MCEN 2471

NAIT

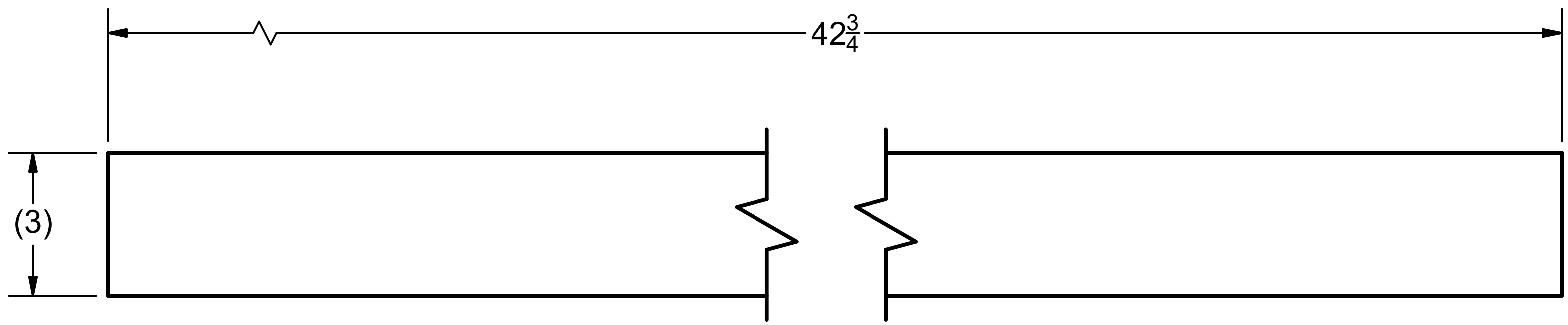
THIRD ANGLE PROJECTION
DO NOT SCALE DRAWING!

MECHANICAL ENGINEERING TECHNOLOGY

OUTER TANK SS - SIDE HORIZONTAL

II-1192.0

DWG TYPE: DETAIL		DWG NO: 4007 - 1	
SCALE: 1 : 4	SIZE: A	REV: 0	24 OF 42



Stainless Steel, Austenitic	304 SS, C 3 x 4.1 x 42 3/4" LG.
MATERIAL	DESCRIPTION

TOLERANCES UNLESS OTHERWISE SPECIFIED

.X ± .015 FRACTIONS ± $\frac{1}{32}$

.XX ± .010 ANGLES ± $\frac{1}{2}$°

.XXX ± .005

ALL DIMENSIONS IN INCHES

DWN BY:	M.D.V.
DATE:	29-MAR-2024
CHK BY:	E.N.
COURSE:	MCEN 2471

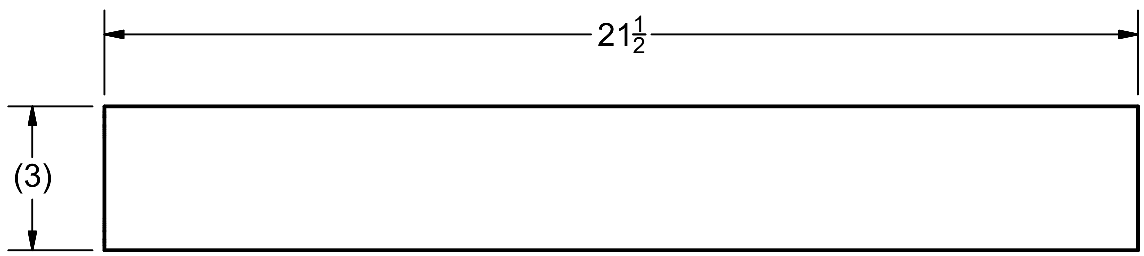
THIRD ANGLE PROJECTION
DO NOT SCALE DRAWING!

MECHANICAL ENGINEERING TECHNOLOGY

OUTER TANK SS - REAR HORIZONTAL

II-1192.0

DWG TYPE: DETAIL		DWG NO: 4008 - 1	
SCALE: 1 : 4	SIZE: A	REV: 0	25 OF 42



Stainless Steel, Austenitic	304 SS, C 3 x 4.1 x 21 1/2" LG.
MATERIAL	DESCRIPTION

TOLERANCES UNLESS OTHERWISE SPECIFIED

.X ± .015 FRACTIONS ± $\frac{1}{32}$

.XX ± .010 ANGLES ± $\frac{1}{2}$°

.XXX ± .005

ALL DIMENSIONS IN INCHES

DWN BY:	M.D.V.
DATE:	29-MAR-2024
CHK BY:	E.N.
COURSE:	MCEN 2471

NAIT

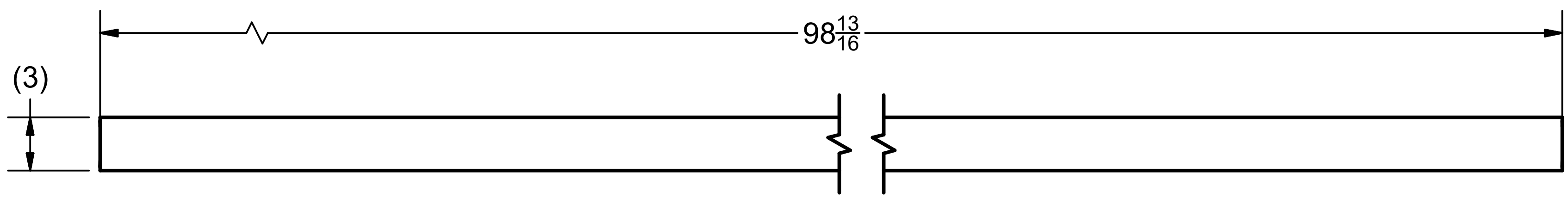
MECHANICAL ENGINEERING TECHNOLOGY

OUTER TANK SS - REAR VERTICAL

II-1192.0

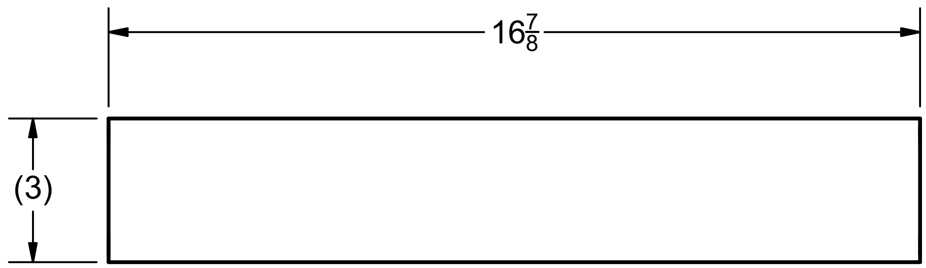
THIRD ANGLE PROJECTION
DO NOT SCALE DRAWING!

DWG TYPE: DETAIL		DWG NO: 4009 - 1	
SCALE: 1 : 4	SIZE: A	REV: 0	26 OF 42



Stainless Steel, Austenitic	304 SS, C 3 x 4.1 x 98 13/16" LG.
MATERIAL	DESCRIPTION

TOLERANCES UNLESS OTHERWISE SPECIFIED .X ± .015 FRACTIONS ± $\frac{1}{32}$ .XX ± .010 ANGLES ± $\frac{1}{2}$° .XXX ± .005 ALL DIMENSIONS IN INCHES	DWN BY: M.D.V.	NAIT	MECHANICAL ENGINEERING TECHNOLOGY OUTER TANK SS - BOTTOM LONG	II-1192.0
	DATE: 29-MAR-2024			
	CHK BY: E.N.	THIRD ANGLE PROJECTION DO NOT SCALE DRAWING!	DWG TYPE: DETAIL	DWG NO: 4010 - 1
	COURSE: MCEN 2471		SCALE: 1 : 10 SIZE: A REV: 0	27 OF 42



Stainless Steel, Austenitic	304 SS, C 3 x 4.1 x 16 7/8" LG.
MATERIAL	DESCRIPTION

TOLERANCES UNLESS OTHERWISE SPECIFIED

.X ± .015 FRACTIONS ± $\frac{1}{32}$

.XX ± .010 ANGLES ± $\frac{1}{2}$°

.XXX ± .005

ALL DIMENSIONS IN INCHES

DWN BY:	M.D.V.
DATE:	29-MAR-2024
CHK BY:	E.N.
COURSE:	MCEN 2471

NAIT

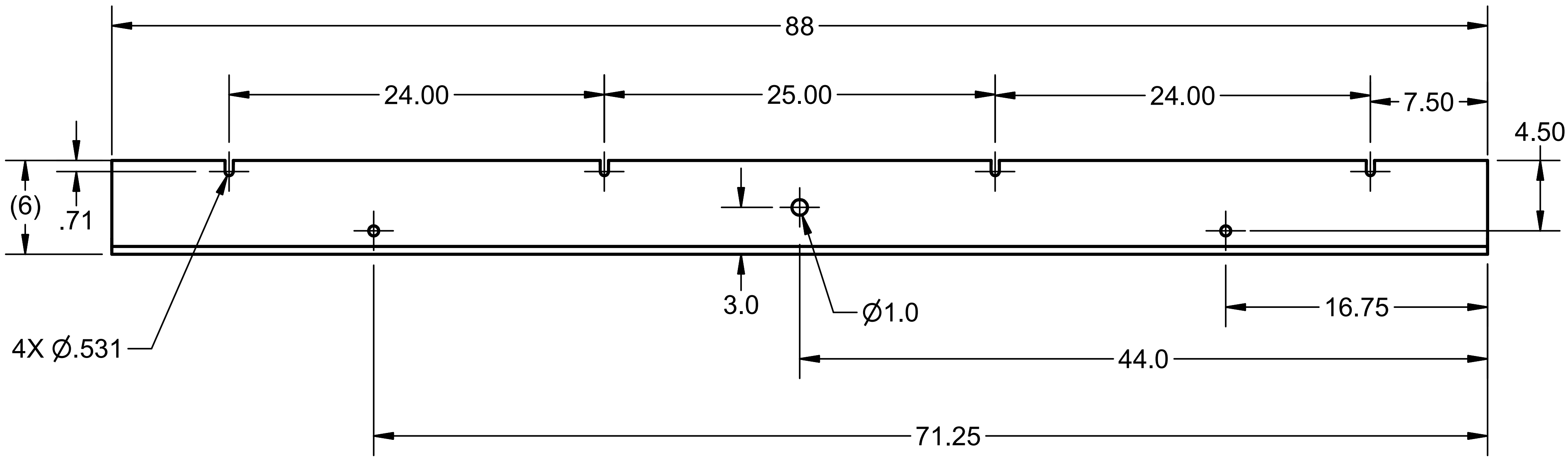
THIRD ANGLE PROJECTION
DO NOT SCALE DRAWING!

MECHANICAL ENGINEERING TECHNOLOGY

OUTER TANK SS - BOTTOM SHORT

II-1192.0

DWG TYPE: DETAIL		DWG NO: 4011 - 1	
SCALE: 1 : 4	SIZE: A	REV: 0	28 OF 42



MATERIAL	DESCRIPTION
Stainless Steel, Austenitic	304 SS, ANGLE BAR, 6 x 6 x 1/2 x 88" LG.

TOLERANCES UNLESS OTHERWISE SPECIFIED

.X ± .015 FRACTIONS ± $\frac{1}{32}$

.XX ± .010 ANGLES ± $\frac{1}{2}°$

.XXX ± .005

ALL DIMENSIONS IN INCHES

DWN BY:	M.D.V.
DATE:	27-MAR-2024
CHK BY:	E.N.
COURSE:	MCEN 2471

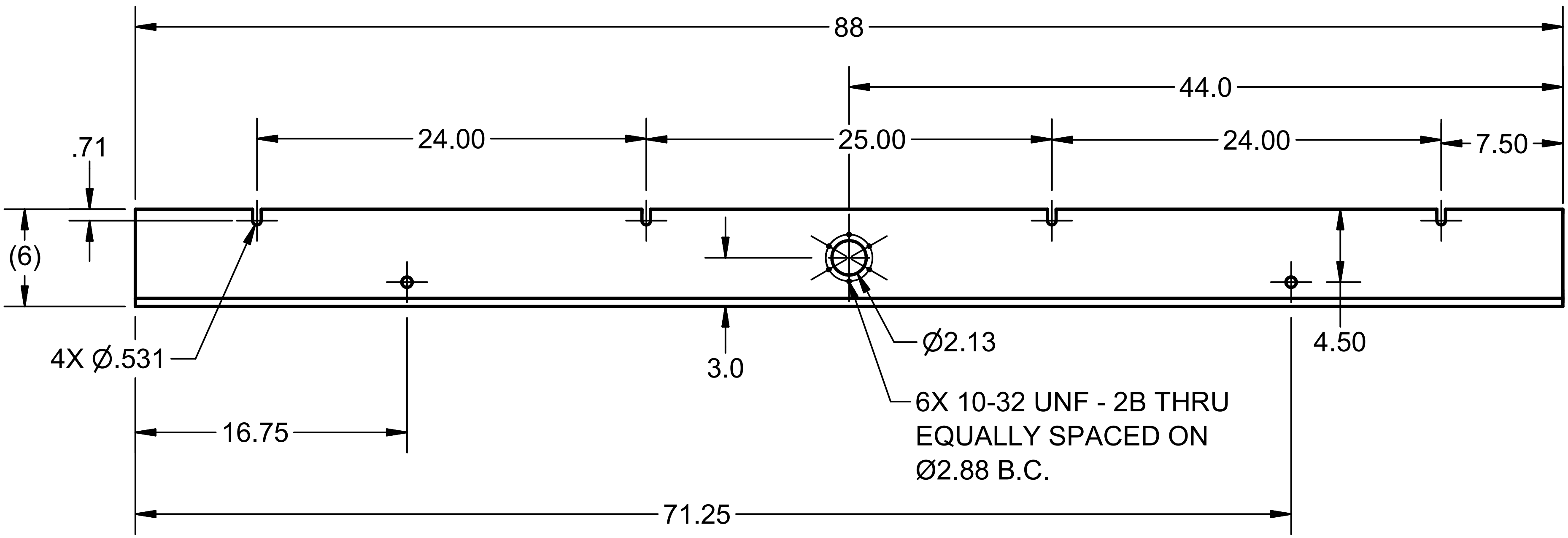
THIRD ANGLE PROJECTION
DO NOT SCALE DRAWING!

MECHANICAL ENGINEERING TECHNOLOGY

INNER TANK LIP - LONG BAR

II-1192.0

DWG TYPE: DETAIL		DWG NO: 4012 - 1	
SCALE: 1 : 10	SIZE: A	REV: 0	29 OF 42



Stainless Steel, Austenitic	304 SS, ANGLE BAR, 6 x 6 x 1/2 x 88" LG.
MATERIAL	DESCRIPTION

TOLERANCES UNLESS OTHERWISE SPECIFIED

.X ± .015 FRACTIONS ± $\frac{1}{32}$

.XX ± .010 ANGLES ± $\frac{1}{2}$°

.XXX ± .005

ALL DIMENSIONS IN INCHES

DWN BY:	M.D.V.
DATE:	27-MAR-2024
CHK BY:	E.N.
COURSE:	MCEN 2471

NAIT

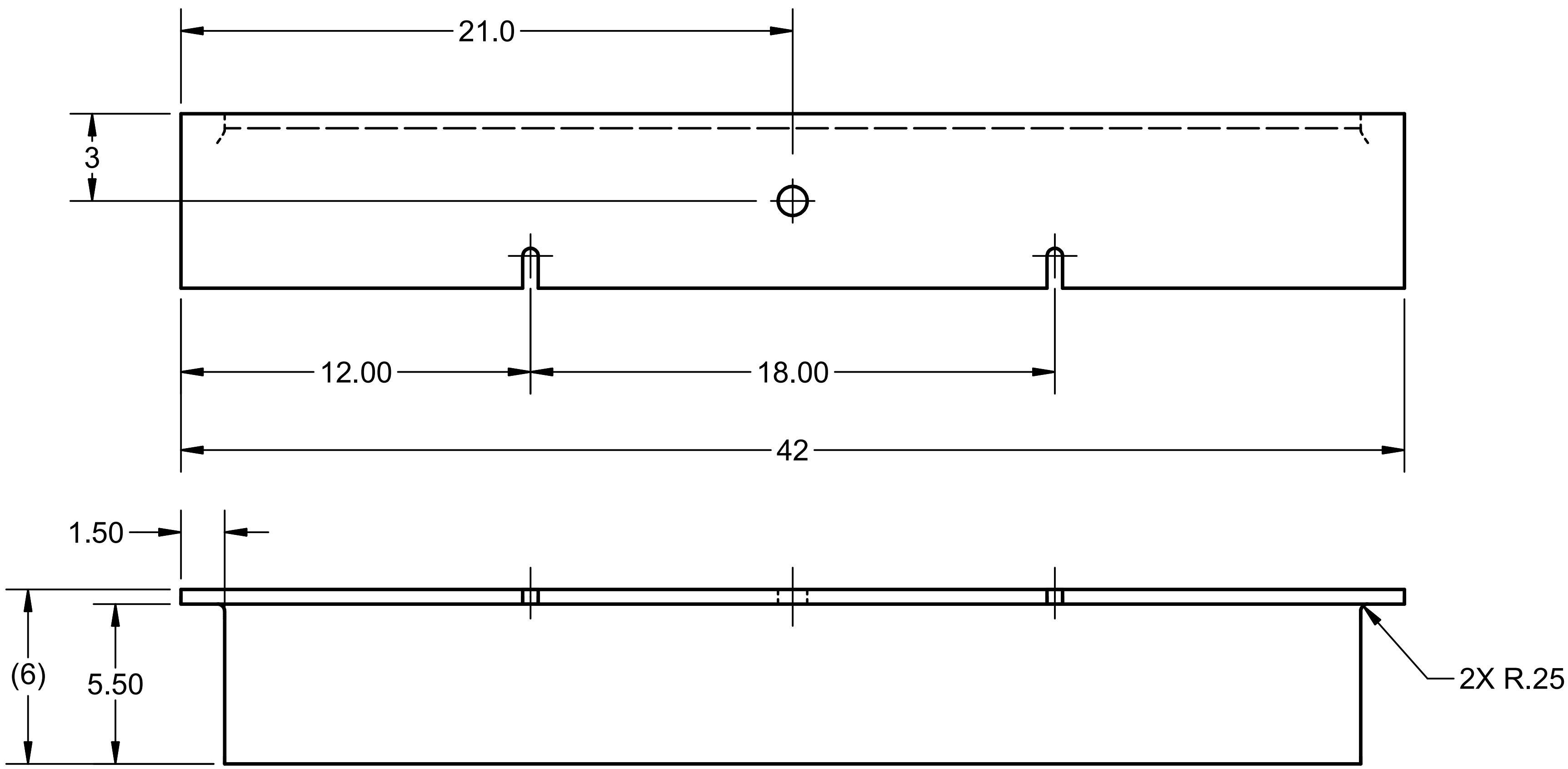
THIRD ANGLE PROJECTION
DO NOT SCALE DRAWING!

MECHANICAL ENGINEERING TECHNOLOGY

INNER TANK LIP - LONG BAR

II-1192.0

DWG TYPE: DETAIL		DWG NO: 4012 - 1	
SCALE: 1 : 10	SIZE: A	REV:	30 OF 42



Stainless Steel, Austenitic	304 SS, ANGLE BAR, 6 x 6 x 1/2 x 42" LG.
MATERIAL	DESCRIPTION

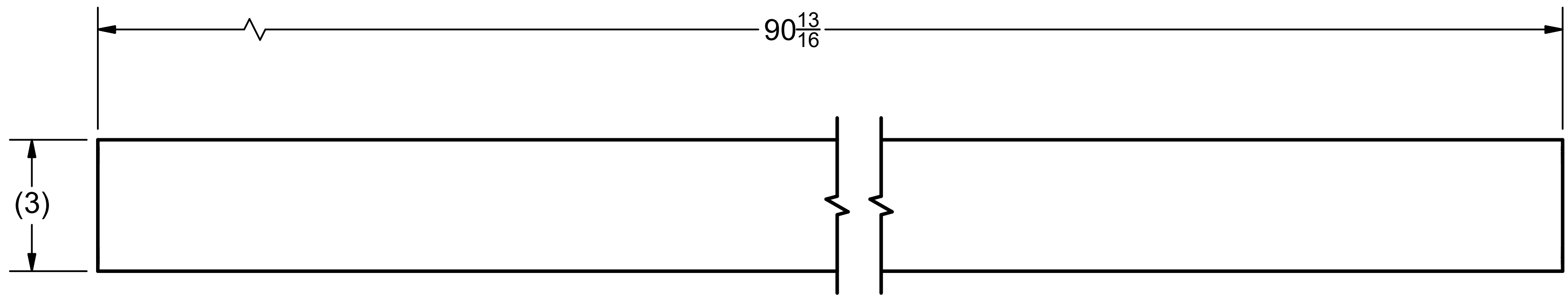
TOLERANCES UNLESS OTHERWISE SPECIFIED
.X ± .015 FRACTIONS ± $\frac{1}{32}$
.XX ± .010 ANGLES ± $\frac{1}{2}$°
.XXX ± .005
ALL DIMENSIONS IN INCHES

DWN BY: M.D.V.
DATE: 27-MAR-2024
CHK BY: E.N.
COURSE: MCEN 2471

NAIT
THIRD ANGLE PROJECTION
DO NOT SCALE DRAWING!

MECHANICAL ENGINEERING TECHNOLOGY
INNER TANK LIP - SHORT BAR
II-1192.0

DWG TYPE: DETAIL
DWG NO: 4013 - 1
SCALE: 1 : 6
SIZE: A
REV: 0
31 OF 42



Stainless Steel, Austenitic	304 SS, C 3 x 4.1 x 90 13/16" LG.
MATERIAL	DESCRIPTION

TOLERANCES UNLESS OTHERWISE SPECIFIED

.X ± .015 FRACTIONS ± $\frac{1}{32}$

.XX ± .010 ANGLES ± $\frac{1}{2}$°

.XXX ± .005

ALL DIMENSIONS IN INCHES

DWN BY:	M.D.V.
DATE:	05-APR-2024
CHK BY:	E.N.
COURSE:	MCEN 2471

NAIT

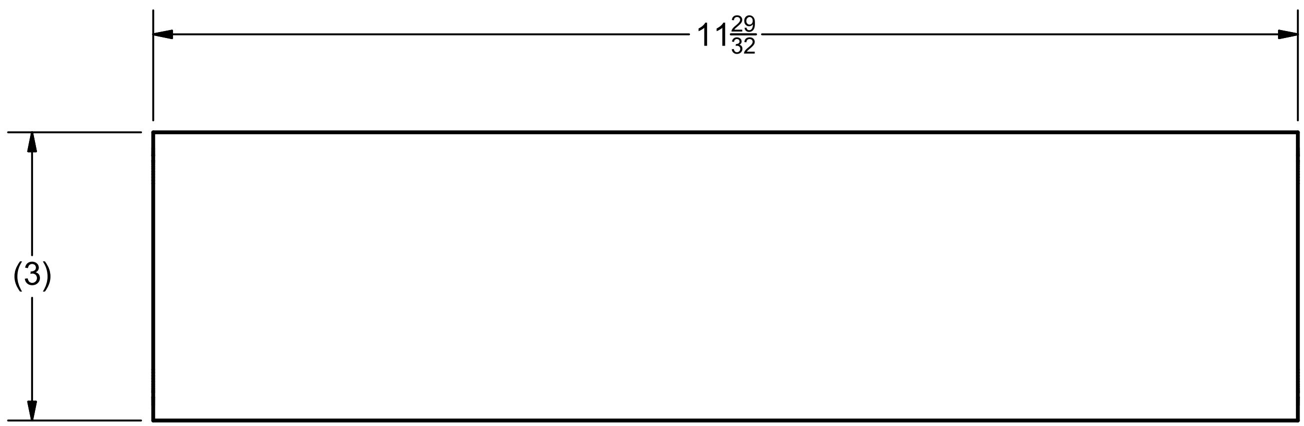
THIRD ANGLE PROJECTION
DO NOT SCALE DRAWING!

MECHANICAL ENGINEERING TECHNOLOGY

INNER TANK SS - BOTTOM LONG

II-1192.0

DWG TYPE: DETAIL	DWG NO: 4014 - 1		
SCALE: 1 : 4	SIZE: A	REV: 0	32 OF 42



Stainless Steel, Austenitic	304 SS, C 3 x 4.1 x 11 29/32" LG.
MATERIAL	DESCRIPTION

TOLERANCES UNLESS OTHERWISE SPECIFIED

.X ± .015 FRACTIONS ± $\frac{1}{32}$

.XX ± .010 ANGLES ± $\frac{1}{2}$°

.XXX ± .005

ALL DIMENSIONS IN INCHES

DWN BY:	M.D.V.
DATE:	05-APR-2024
CHK BY:	E.N.
COURSE:	MCEN 2471

NAIT

MECHANICAL ENGINEERING TECHNOLOGY

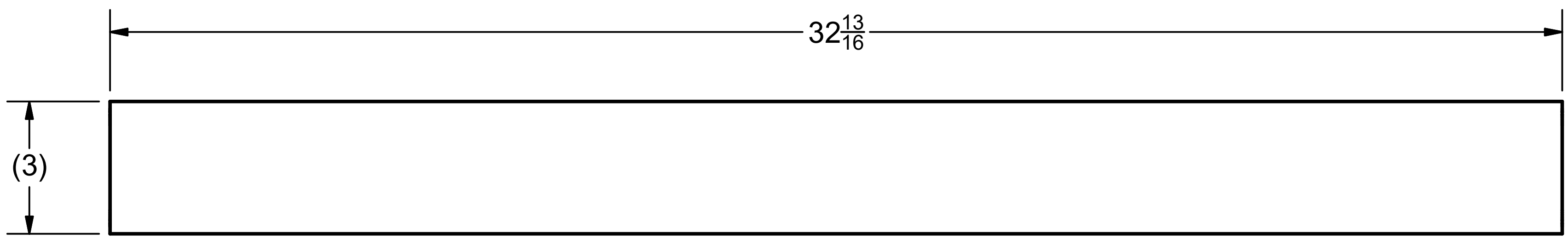
INNER TANK SS - BOTTOM SHORT

II-1192.0

THIRD ANGLE PROJECTION
DO NOT SCALE DRAWING!

DWG TYPE: DETAIL | DWG NO: 4015 - 1

SCALE: 1 : 2 | SIZE: A | REV: 0 | 33 OF 42



Stainless Steel, Austenitic	304 SS, C 3 x 4.1 x 32 13/16" LG.
MATERIAL	DESCRIPTION

TOLERANCES UNLESS OTHERWISE SPECIFIED

.X ± .015 FRACTIONS ± $\frac{1}{32}$

.XX ± .010 ANGLES ± $\frac{1}{2}^{\circ}$

.XXX ± .005

ALL DIMENSIONS IN INCHES

DWN BY:	M.D.V.
DATE:	05-APR-2024
CHK BY:	E.N.
COURSE:	MCEN 2471

NAIT

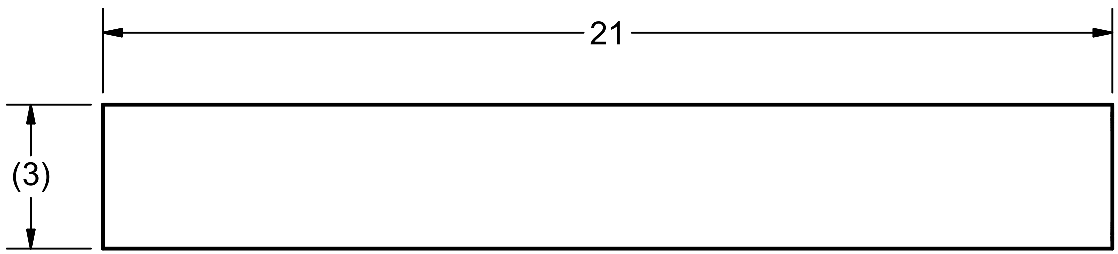
THIRD ANGLE PROJECTION
DO NOT SCALE DRAWING!

MECHANICAL ENGINEERING TECHNOLOGY

INNER TANK SS - FRONT HORIZONTAL

II-1192.0

DWG TYPE: DETAIL	DWG NO: 4016 - 1		
SCALE: 1 : 4	SIZE: A	REV: 0	34 OF 42



Stainless Steel, Austenitic	304 SS, C 3 x 4.1 x 21" LG.
MATERIAL	DESCRIPTION

TOLERANCES UNLESS OTHERWISE SPECIFIED

.X ± .015 FRACTIONS ± $\frac{1}{32}$

.XX ± .010 ANGLES ± $\frac{1}{2}°$

.XXX ± .005

ALL DIMENSIONS IN INCHES

DWN BY:	M.D.V.
DATE:	05-APR-2024
CHK BY:	E.N.
COURSE:	MCEN 2471

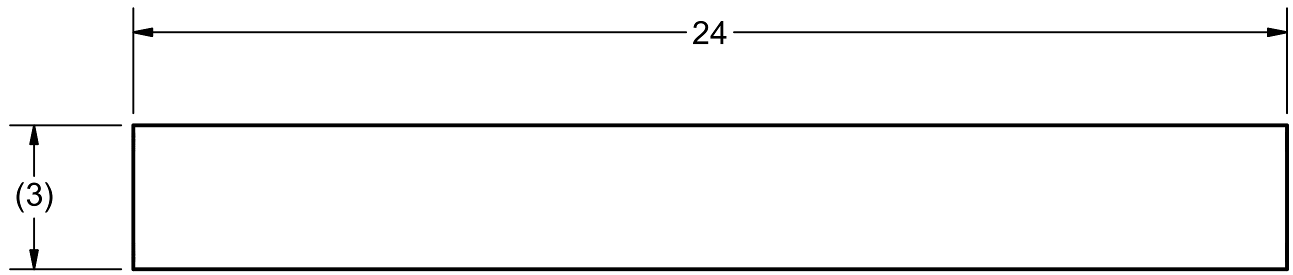
THIRD ANGLE PROJECTION
DO NOT SCALE DRAWING!

MECHANICAL ENGINEERING TECHNOLOGY

INNER TANK SS - FRONT/REAR VERTICAL

II-1192.0

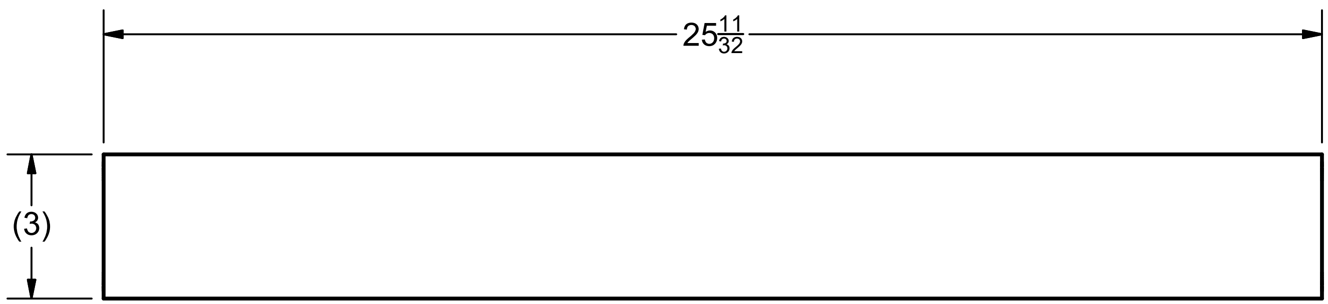
DWG TYPE: DETAIL		DWG NO: 4017 - 1	
SCALE: 1 : 4	SIZE: A	REV: 0	35 OF 42



Stainless Steel, Austenitic	304 SS, C 3 x 4.1 x 24" LG.
MATERIAL	DESCRIPTION

TOLERANCES UNLESS OTHERWISE SPECIFIED	DWN BY: M.D.V.	MECHANICAL ENGINEERING TECHNOLOGY	II-1192.0
.X ± .015 FRACTIONS ± $\frac{1}{32}$	DATE: 05-APR-2024	INNER TANK SS - SIDE VERTICAL	
.XX ± .010 ANGLES ± $\frac{1}{2}$°	CHK BY: E.N.	DWG TYPE: DETAIL	DWG NO: 4018 - 1
.XXX ± .005			
ALL DIMENSIONS IN INCHES	COURSE: MCEN 2471	SCALE: 1 : 4	SIZE: A	REV: 0	36 OF 42

THIRD ANGLE PROJECTION
DO NOT SCALE DRAWING!



Stainless Steel, Austenitic	304 SS, C 3 x 4.1 x 25 11/32 LG.
MATERIAL	DESCRIPTION

TOLERANCES UNLESS OTHERWISE SPECIFIED

.X ± .015 FRACTIONS ± $\frac{1}{32}$

.XX ± .010 ANGLES ± $\frac{1}{2}°$

.XXX ± .005

ALL DIMENSIONS IN INCHES

DWN BY:	M.D.V.
DATE:	05-APR-2024
CHK BY:	E.N.
COURSE:	MCEN 2471

NAIT

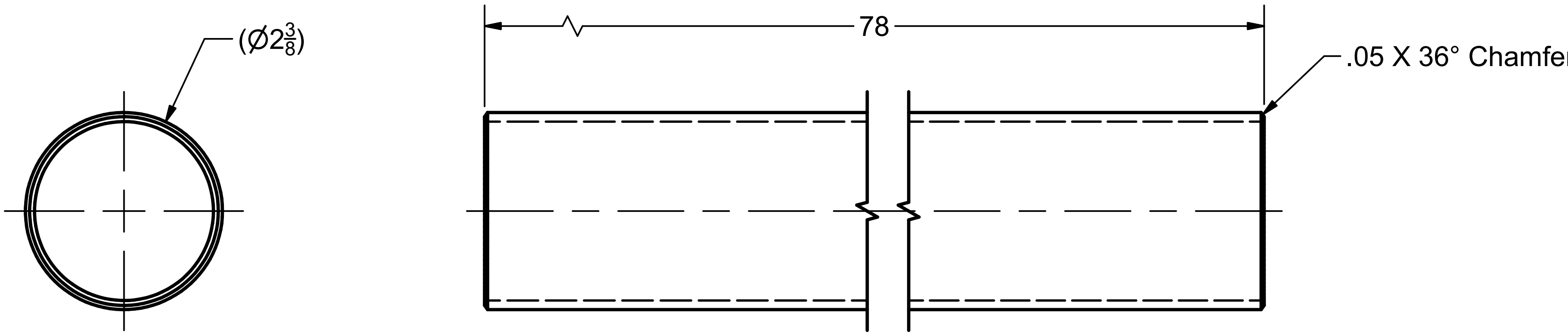
THIRD ANGLE PROJECTION
DO NOT SCALE DRAWING!

MECHANICAL ENGINEERING TECHNOLOGY

INNER TANK SS - SIDE HORIZONTAL

II-1192.0

DWG TYPE: DETAIL		DWG NO: 4019 - 1	
SCALE: 1 : 4	SIZE: A	REV: 0	37 OF 42



Stainless Steel, Austenitic	304 SS, 2" SCH 10 x 80" LG.
MATERIAL	DESCRIPTION

TOLERANCES UNLESS OTHERWISE SPECIFIED
.X ± .015 FRACTIONS ± $\frac{1}{32}$
.XX ± .010 ANGLES ± $\frac{1}{2}$°
.XXX ± .005
ALL DIMENSIONS IN INCHES

DWN BY:	M.D.V.
DATE:	6-APR-2024
CHK BY:	E.N.
COURSE:	MCEN 2471

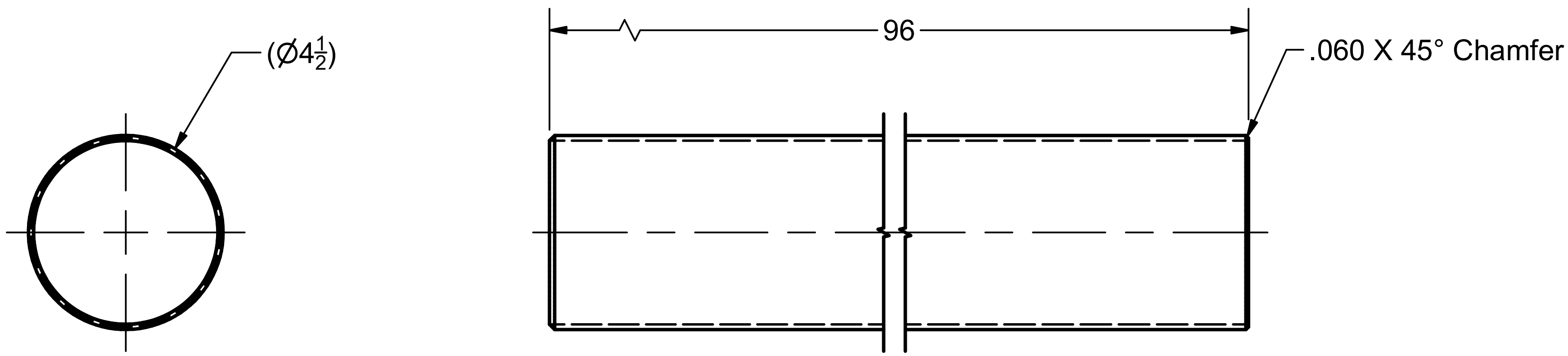
NAIT

MECHANICAL ENGINEERING TECHNOLOGY
2" SCH 10 PIPE, WELDED

II-1192.0

THIRD ANGLE PROJECTION
DO NOT SCALE DRAWING!

DWG TYPE: DETAIL		DWG NO: 4024 - 1	
SCALE: 1 : 2	SIZE: A	REV: 0	38 OF 42



MATERIAL	DESCRIPTION
Stainless Steel, Austenitic	304 SS, 4" SCH 10 PIPE x 96" LG.

TOLERANCES UNLESS OTHERWISE SPECIFIED

.X ± .015 FRACTIONS ± $\frac{1}{32}$

.XX ± .010 ANGLES ± $\frac{1}{2}$°

.XXX ± .005

ALL DIMENSIONS IN INCHES

DWN BY:	M.D.V.
DATE:	06-APR-2024
CHK BY:	E.N.
COURSE:	MCEN 2471

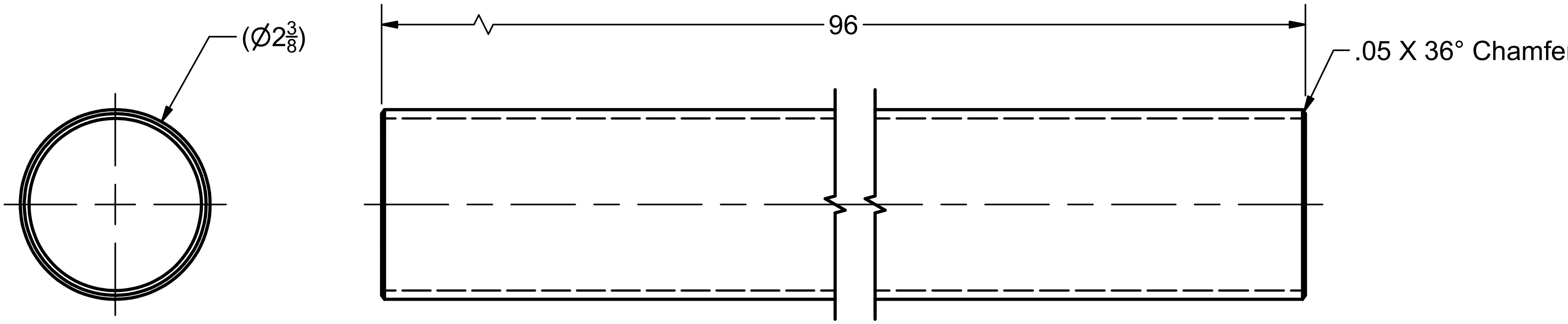
THIRD ANGLE PROJECTION
DO NOT SCALE DRAWING!

MECHANICAL ENGINEERING TECHNOLOGY

4" SCH 10 PIPE, WELDED

II-1192.0

DWG TYPE: DETAIL		DWG NO: 4025 - 1	
SCALE: 1 : 4	SIZE: A	REV: 0	39 OF 42



Stainless Steel, Austenitic	304 SS, 2" SCH 10 PIPE x 96" LG.
MATERIAL	DESCRIPTION

TOLERANCES UNLESS OTHERWISE SPECIFIED

.X ± .015 FRACTIONS ± $\frac{1}{32}$
.XX ± .010 ANGLES ± $\frac{1}{2}$°
.XXX ± .005
ALL DIMENSIONS IN INCHES

DWN BY:	M.D.V.
DATE:	06-APR-2024
CHK BY:	E.N.
COURSE:	MCEN 2471

NAIT

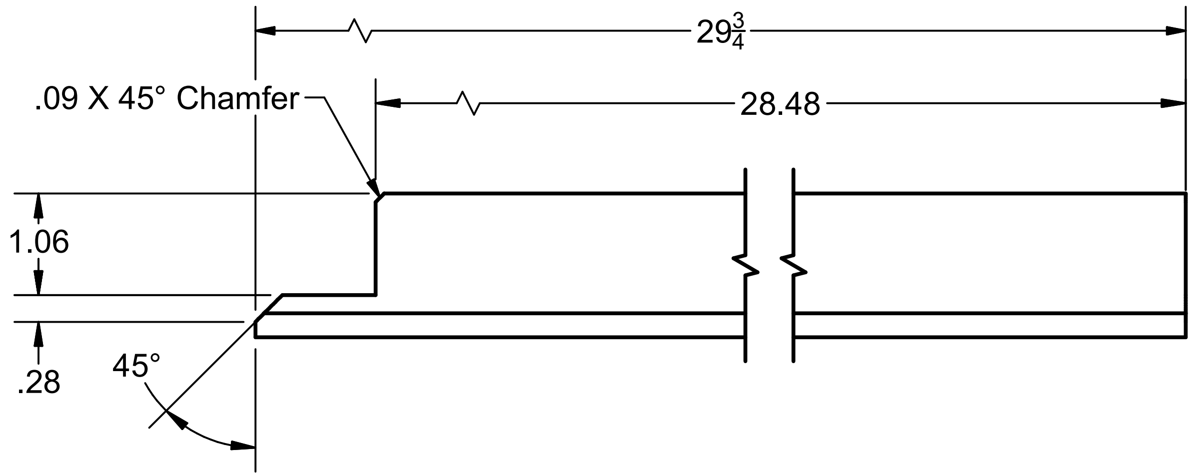
MECHANICAL ENGINEERING TECHNOLOGY

2" SCH 10 PIPE, WELDED (EXHAUST)

II-1192.0

THIRD ANGLE PROJECTION
DO NOT SCALE DRAWING!

DWG TYPE: DETAIL		DWG NO: 4026 - 1	
SCALE: 1 : 2	SIZE: A	REV: 0	40 OF 42



Stainless Steel, Austenitic	304 SS, 1 1/2" x 1 1/2" x 1/4" x 29 3/4" LG.
MATERIAL	DESCRIPTION

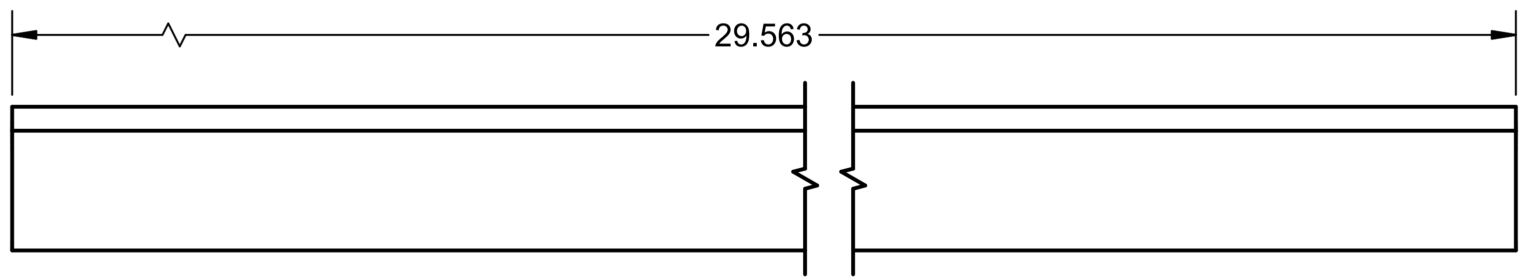
TOLERANCES UNLESS OTHERWISE SPECIFIED
.X ± .015 FRACTIONS ± $\frac{1}{32}$
.XX ± .010 ANGLES ± $\frac{1}{2}$°
.XXX ± .005
ALL DIMENSIONS IN INCHES

DWN BY:	M.D.V.
DATE:	27-MAR-2024
CHK BY:	E.N.
COURSE:	MCEN 2471

NAIT
THIRD ANGLE PROJECTION
DO NOT SCALE DRAWING!

MECHANICAL ENGINEERING TECHNOLOGY
ANGLE BAR SUPPORT - VERTICAL
II-1192.0

DWG TYPE: DETAIL		DWG NO: 4028 - 1	
SCALE: 1 : 2	SIZE: A	REV: 0	41 OF 42



MATERIAL	DESCRIPTION
Stainless Steel, Austenitic	304 SS, 1 1/2" x 1 1/2" x 1/4" x 29 9/16" LG.

TOLERANCES UNLESS OTHERWISE SPECIFIED

.X ± .015 FRACTIONS ± $\frac{1}{32}$

.XX ± .010 ANGLES ± $\frac{1}{2}$°

.XXX ± .005

ALL DIMENSIONS IN INCHES

DWN BY:	M.D.V.
DATE:	27-MAR-2024
CHK BY:	E.N.
COURSE:	MCEN 2471

NAIT

MECHANICAL ENGINEERING TECHNOLOGY

ANGLE BAR SUPPORT - HORIZONTAL

II-1192.0

THIRD ANGLE PROJECTION
DO NOT SCALE DRAWING!

DWG TYPE: DETAIL		DWG NO: 4029 - 1	
SCALE: 1 : 2	SIZE: A	REV: 0	42 OF 42