The Hopper

MET 494 Senior Design

Alexander Heine, Patrick LaRoy, Kyle Macke, Jedd Minnich

Purpose & Function:

The objective of this project is to improve the method of how ferromanganese is distributed to molten steel at Steel Dynamics Butler, Indiana at their melting facility. When ferromanganese is added it acts as an alloying agent improving the quality of the steel. The current process is neither cost effective nor efficient use of time. SDI purchases ferromanganese in 25-pound bags and empties individual bags into a wheel-barrel then pours into a kiln. The main categories that were focused on for the design include a large industrial hopper, rotating paddle assembly, and a conveyor.

SDI currently owns four large industrial hoppers that can volumetrically hold 4000-6000 lbs. of ferromanganese. Previously the hoppers held lime mineral, as this material is added to molten steel to take out any impurities from scrap steel they receive. The hopper is located on the south end of the melting furnace. SDI found a new method to place lime into the melting furnaces and the hoppers were abandoned. This was a critical aspect of the project as the volumetric capacity of the hopper was calculated with reference to the density of ferromanganese. The bottom section of the hopper will be removed and replaced with the paddle assembly.

The paddle assembly took several weeks to be approved by SDI's engineers. Throughout the design process there were five individual design changes occurred to ensure durability. The housing for this design includes two plates that are welded to a rotary shaft that will be placed in a cylindrical outer casing. The assembly will be ran by a low horsepower and high torque motor that will be attached to the hopper but located outside of the frame in case any maintenance is required. A36 steel was chosen for this particular section as it has durable metallurgic properties such as shear and ultimate tensile strength. The ferromanganese will be dumped into each of the four compartments as the paddles rotate 360 degrees.

As mentioned in the paragraph above the motor used to rotate the paddle assembly will have low horsepower and high torque. The motor is currently attached to the hopper and was cost effective to keep and continue to use it. A gear reducer was required for the paddle assembly, as each rotation needed an immediate stopping mechanism to ensure there was no extra material that will be pouring outside of the 26" wide conveyor. The reducer used will have a 100:1 gear ratio that SDI current has from previous projects. The force of ferromanganese in the hopper will stop spinning the paddle around after the cycle is complete.

A drag chain conveyor was designed and purchased through Enduraveyor. The original hopper has a set of angle iron tracks that it road o with a small motor to bring the hopper up and dispense the material. The current iron tracks are getting cut back, and the conveyor will be attached to the hopper. The conveyor has four caster attached to the bottom that will allow it to be moved easily. Since steel dynamics equipment is susceptible to a harsh environment, the conveyor was designed to be robust and preferably all steel. The weight of the ferromanganese dropping down onto the conveyor was incorporated by changing the plate to hardened steel and making it replaceable. The hardened steel plate will last longer, and have better wear resistance.

Initial Performance & specifications:

The overall aspect for this project was to have an efficient and robust system to withstand the harsh environment of the steel mill. The use of 25-pound bags was eliminated and SDI can now purchase 4000-pound super sacks, which are the main contribution to cost savings. The material will be loaded by forklifts or an overhead crane and will be dumped into the hopper. The conveyor will turn on first then the paddle assembly will start to rotate. A PLC program was written to run the entire process. Once the paddles rotate 360 degrees, the paddles will stop moving while the conveyor keeps running to deliver the load. The conveyor will move 30 ft. /minute. SDI will be installing all equipment and running tests on the system, the lead-time for this project did not leave enough time to run an initial performance.

Design Calculations:

Figure 1:

Volumetric Calculations		
Paddle Volume		
Two Paddle		
(11.5in*11.375in*.5in) + (11in*11.375in*.5in) = **127.969 in³**		
Four Wear Bars		
(1.75in² *11.375in)*4 = **79.625 in³**		
Total Volume		
79.625in³+127.969in³= **207.594 in³**		
Housing Volume		
(((12.5 in)² * pi)/ 4) * 11.375 in = **1395.923 in³**		
Total Volume		
Total Volume = Housing Volume - Paddle Volume		
1395.923 in³ - 207.594 in³ = **1188.329 in³**		
Volumetric Weight Calculation		
Total weight of material through one full rotation		
density of ferromanganese = 249.72 lb/ft³		
1188.329 in³/1728 in³= 0.688 ft³		
.688 ft³ * 249.72 lb/ft³ =	**171.730 lb** **Total Weight**	

Figure 2:

Net Torque = T1 - (T2+Tm)
Tm = 70 # ft. * (5.75 in*(1/12 in)) = 33.54 ft. #
4000 lb Torques
T1 = 4000# *5.75in = 23,000 in # = 1916.67 ft. lb.
T2 = [4000# (sin(135)] * 5.75 in = 16,263.46 in # = 1355.29 ft. #
Tnet(4000 #) : 1916.67 ft. # – (1355.29 ft # + 33.54 ft #) = 527.84 ft # CCW
500 lb Torques
T1 = 500# * 5.75 in = 2875 in # = 239.58 ft. #
T2 = [500# * (sin(135)] *5.75 in = 2032.93 in # = 169.41 ft. #
Tnet(500 #) : 239.58 ft. # – (169.41# + 33.54#) = 36.63 ft. # CCW

<u>Diagrams & Formal Engineering Drawings:</u>

See attached PDF File.

<u>Photographs & Components</u>

Figure 3:

- Bottom half of current hopper will be replaced with paddle assembly as seen in final detail drawings.

Figure 4:

- Ferromanganese will be brought from the hopper, to the conveyor system, the entrance to the kiln is pictured above.

Figure 5:

- Current rail system will be cut down to allow maintenance equipment to flow through area. This is also where our conveyor will be placed to bring it to the kiln.

Fabrication Procedure:

All of the rotary fabrication will be done in house in steel dynamics fabrication shop. The bottom section of the hopper will be completely removed as shown in fig 3 and will be placed in the scrap metal to be melted. A 9 ft. section of the rail system will be removed to make room for the conveyor system and will be utilized elsewhere in the facility. The rotating paddle assembly will be worked on through SDI's fabrication shop as it requires several welds and current materials they already have in inventory. Enduraveyor will be manufacturing the conveyor through their fabrication shop and approximately take 3-6 weeks of lead-time until it is completed. After all fabrications have been implemented testing will begin for efficiency and references from employees.

Test Results:

The conveyor lead-time set back the design from having any tests ran on the system. The lead-time to manufacture the conveyor will take approximately 5 weeks. With the paddle assembly manufactured through SDI's fabrication shop will approximately take 2-3 weeks. The project will be completed and tested during May 1st – 7th as the outage week allows time for implementation. The engineers approved our design and would like us to make additional modifications for the rotary portion of the project to fit on their additional 3 hoppers.

Overall Costs:

The chart below represents the overall cost of the project and the annual cost savings per year after the system has been installed. Ferromanganese is the most cost effective section for this project as buying in bulk has reduced the price savings of $0.20 per pound. This estimation includes one outage week (7 days) and a down day for maintenance every other Wednesday of the month (25 days) throughout the entire working year. The information received from the reduced labor cost was provided by SDI for every down day if maintenance is required the time will be devoted to this.

Figure 6:

Cost Benefit Analysis	
Cost	
Item	**Cost**
Conveyor	$8,936.00
Paddle Wheel Assembly	$500.00
Hopper Modification	$300.00
Labor	$1,500.00
Down time (loss)	$1,000.00
Total Cost	$12,236.00
Benefits (estimated for first year of use)	
Reduced labor cost	$6,200.00
Bulk Price cost savings	$371,280.00
Total Benefits	$377,480.00

Bibliography:

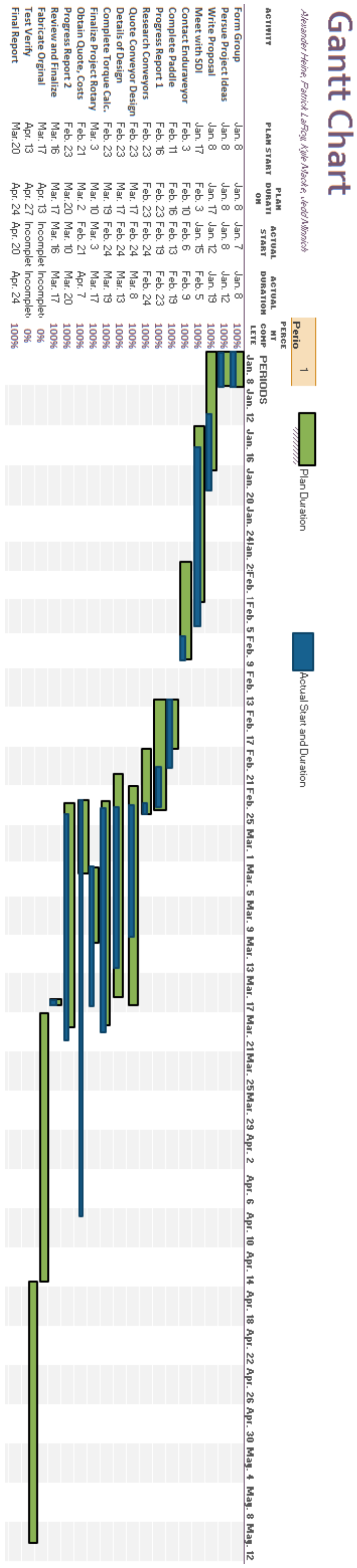
- Eramet. Manganese Alloys, HCFeMN: High carbon ferromanganese, version 1, Eramet Company, 01/01/2017, Paris, France. http://www.eramet.com/en/our-activities/extracting-generating-value/manganese/our-products/hcfemn-high-carbon-ferromanganese
- Enduraveyor. Conveyors, Drag Chain Conveyors, Complete Drives Inc., 01/01/2014, Auburn, Indiana. http://www.endura-veyor.com "Complete Drive Inc."
- Grove Gear. Worm Gear Reducers, Cast Iron (GR Series), 04/01/2017, Grove Gear Inc., Union Grove, Wisconsin. http://www.grovegear.com/products/worm-gear-reducers/gr/
- McMaster-Carr. Products, Measuring & Inspection, 01/01/2017, McMaster-Carr Commercial Company, Elmhurst. https://www.mcmaster.com/

Figure 7:

Updated Contact List			
Andrew Spencer	Steel Dynamics	260-868-8235	andrew.spencer@steeldynamics.com
Brent Walchuk	Steel Dynamics	248-290-6327	brent.walchuk@steeldynamics.com
Joel Grillo	Complete Drives Inc.	260-908-1882	jgrollo@completedrivesinc.com
Tim Bosserman	Steel Dynamics	260-868-8000	tim.bosserman@steeldynamics.com
Tim Burkett	Steel Dynamics	260-868-8000	tim.burkett@steeldynamics.com

Gantt chart:

Figure 8:



Conclusions:

The main goal for this job was to keep the system as robust and cost effective as possible. Once the first system if fully functioning then the three remaining hoppers will have the same system installed as well. If the design lasts over five years then SDI is strongly considering presenting the system to other SDI locations. SDI gave our group full authority to create the project and how to incorporate the opinions of electrical, mechanical and process engineers.

CDI
COMPLETE DRIVES INC.

COMPLETE DRIVES, INC.
1542 AUBURN DRIVE
AUBURN, IN 46706

PHONE: 260-927-0328 FAX: 260-927-0329

QUOTE

Number	130814
Date	03/02/2017
Page	1

Ship To:		Bill To:	
SAME	STEEL DYNAMICS, INC 4500 CR 59 BUTLER, IN 46721	13652	STEEL DYNAMICS, INC 4500 CR 59 BUTLER, IN 46721

Reference #	Expires	Slsp	Terms	Wh	Freight	Ship Via
VERBAL KYLE	04/01/17	JG	2%-10 NET 30	02	PRE/ADD	DEL AUB JG

Quoted By: JG Quoted To: KYLE MACKE

Item	Description	Ordered	UM	Price	UM	Extension
60013-1-2	ENDURA MODEL 2500 2.5" PITCH LEAD TIME 6 WEEKS *********CONVEYOR INFO******** FRAME CON. 10 GAUGE CONVEYOR LENGHT 15' 6" CHAIN STYLE 2.5" PITCH DOUBLE ROLLER CHAIN FLIGHTS 4" TALL @ 10" CENTERS INFEED HEIGHT 30" TOF DISCHARGE HEIGHT 20" SUPPORTS CASTER DISCARGE END SUPPORTS REMOVED ON INFEED END DRIVE 1HP 460V 3PHASE DRIVE MOUNT SIDE MOUNT RIGHT HAND DRIVE LOCATED INFEED CONVEYOR SPEED 30FPM LIVE LOAD 2400 LBS CONTROLS START AND STOP INCLUDED FEATURES CHAIN COVERS AR PLATE BOTTOM PAN ******************************	1	EA	8958.00	EA	8958.00

Merchandise	Misc	Tax	Freight	Total
8958.00	.00	.00	.00	8958.00

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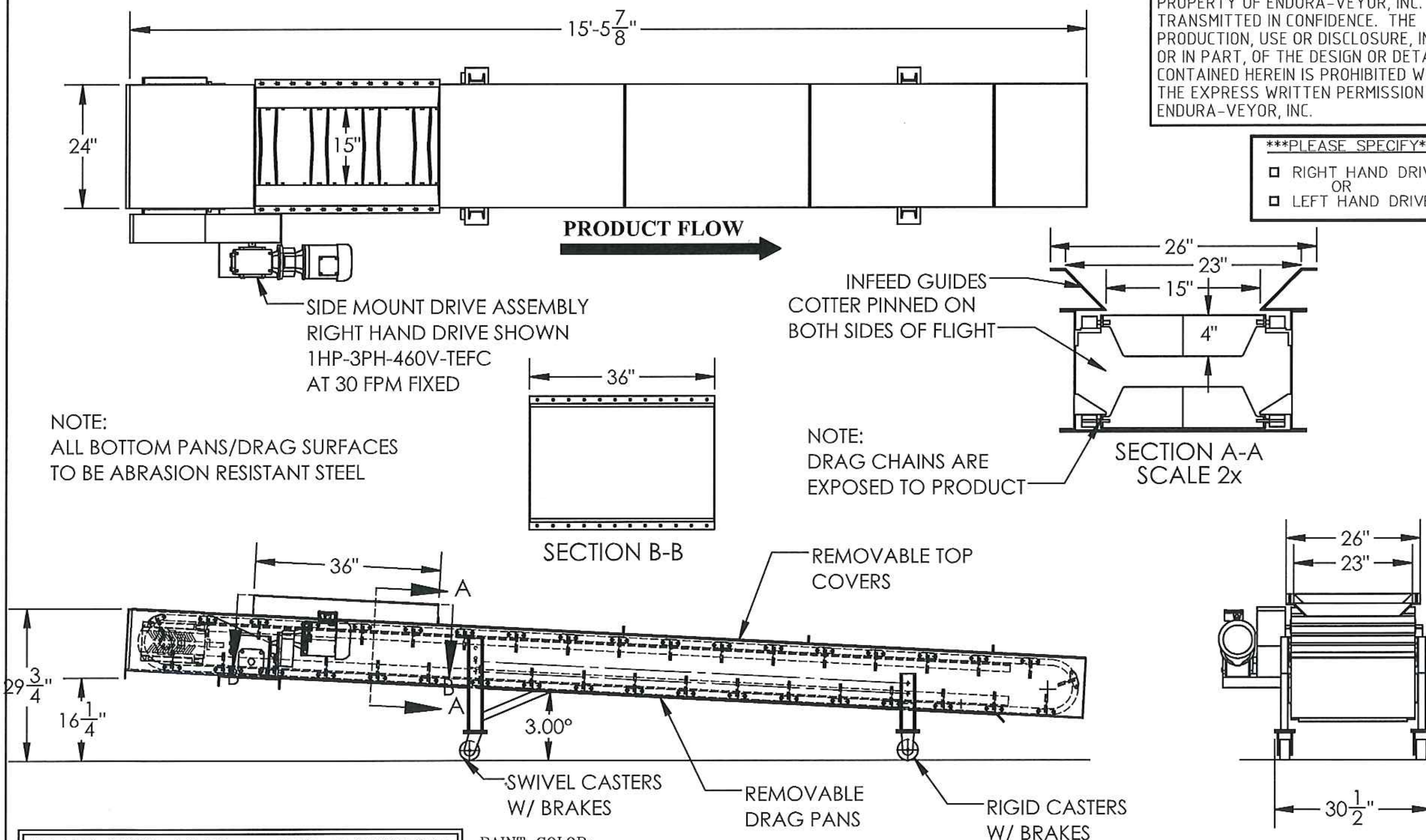
PLEASE SPECIFY

- ☐ RIGHT HAND DRIVE
OR
- ☐ LEFT HAND DRIVE



NOTE:
ALL BOTTOM PANS/DRAG SURFACES TO BE ABRASION RESISTANT STEEL

MAX LIVE LOAD = 950 POUNDS

PAINT COLOR:
RAL-5019 CAPRI BLUE

SAFETY REVIEW

THE NEED FOR SAFETY DEVICES VARIES WITH EACH APPLICATION OF THIS EQUIPMENT. THIS DRAWING MAY NOT INCLUDE ALL APPROPRIATE SAFETY DEVICES FOR YOUR APPLICATION. AS SYSTEMS INTEGRATOR, PLEASE ADVISE YOUR CUSTOMER OF DEVICES THAT ARE APPROPRIATE FOR HIS/HER APPLICATION, BASED ON YOUR SAFETY ASSESSMENT. DEVICES MAY INCLUDE, BUT ARE NOT LIMITED TO THOSE SUCH AS, ADDITIONAL GUARDING, SAFETY CONTROLS, BARRICADES, END STOPS, ETC. COMPLIANCE WITH FEDERAL, STATE, OSHA AND LOCAL LAWS OR CODES ARE THE RESPONSIBILITY OF BOTH OF YOU, AS THE SYSTEMS INTEGRATOR/DISTRIBUTOR, AND THE END USER.

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APPROVED AS SHOWN OR CHANGES REQUIRED

CO. NAME ____________

SIGNATURE ____________

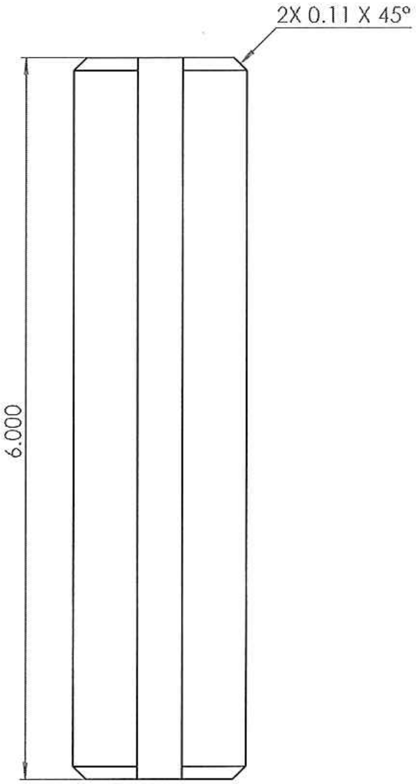
DATE ____________

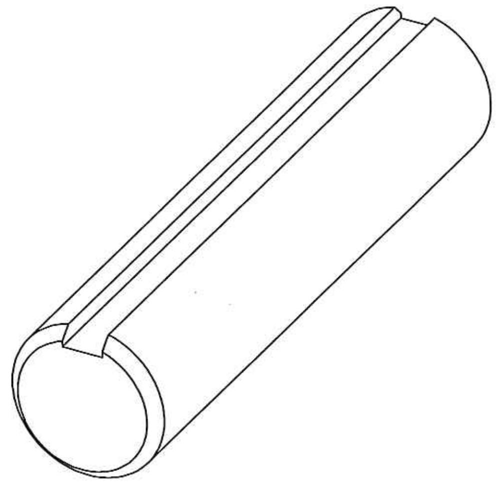
ENDURA-VEYOR INC.
P.O. BOX 205 ALPENA, MI 49707
PHONE: (989) 358-7060

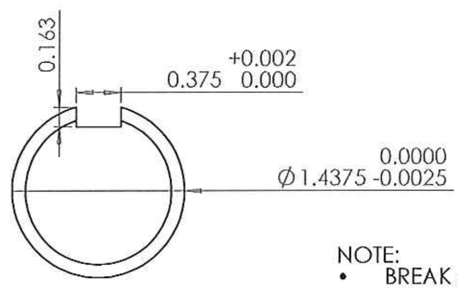
JOB NO: 89625	
DRAWN BY: TEK	
DATE: 4/6/2017	
REVISION: --	
SCALE: N/A	REF JOB#: .

TITLE:
2 1/2" P DRAG CHAIN FLIGHT CONVEYOR
24" BW - 35 DEG. - "D"-STYLE

DRG. NO.: 89625-APPROVAL







NOTE:
- BREAK ALL SHARP EDGES UNLESS OTHERWISE SPECIFIED
- MCMASTERCARR PART#: 1497K166

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DO NOT SCALE DRAWING		

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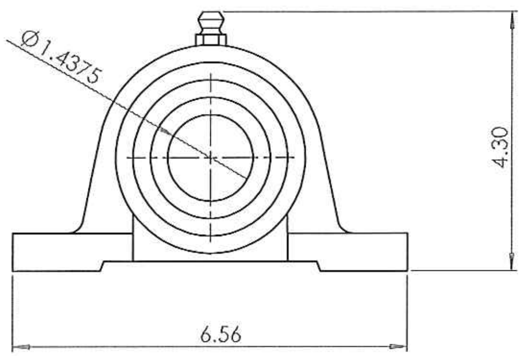

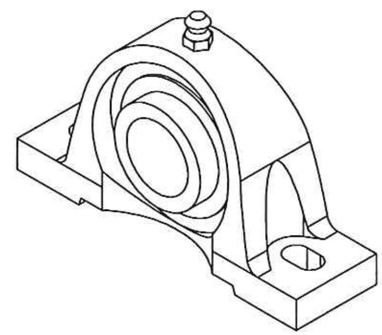

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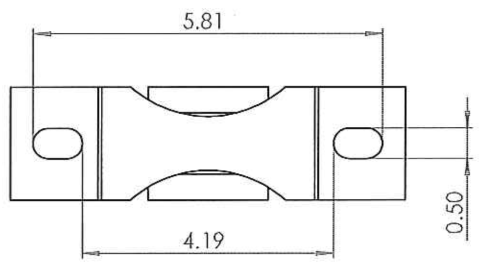

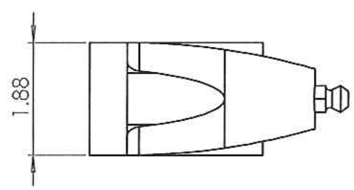

A

A

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- MCMASTERCARR PART #: 7728T610

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DO NOT SCALE DRAWING		

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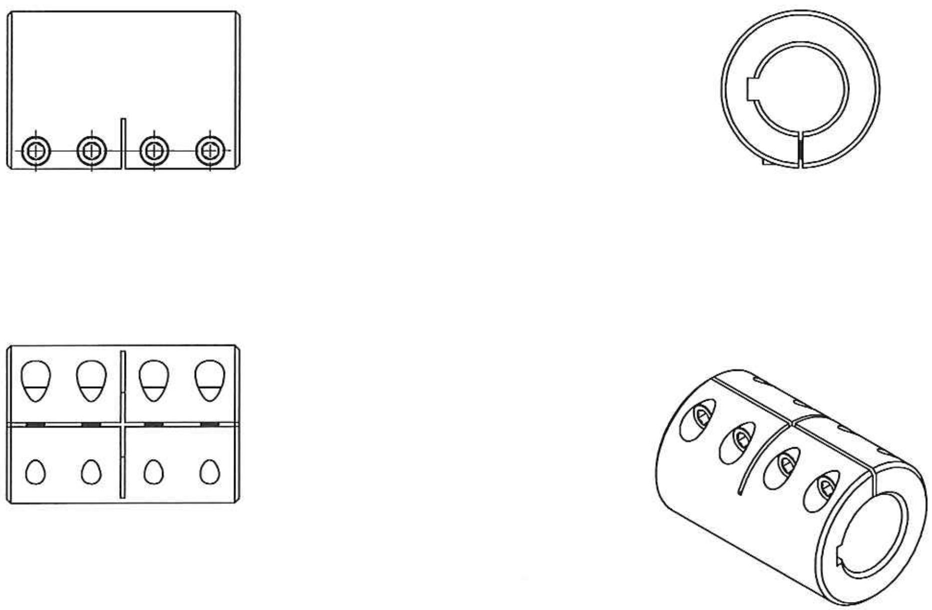

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- McMASTERCARR PART#: 61005K960

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DO NOT SCALE DRAWING	

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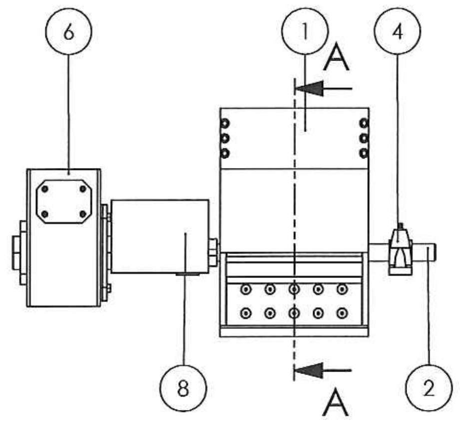
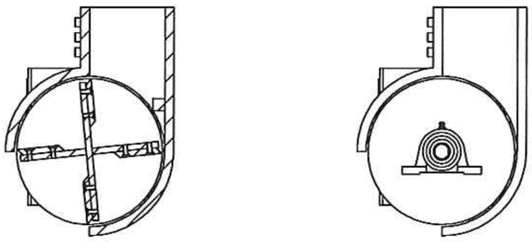
2	PADDLE ASSEMBLY	1
3	61005K96	1
4	7728T61	2
5	1497K166	1
6	GR-HMQ842-XX-H2-56-23	1
7	9414T27	1
8	GUARD	1





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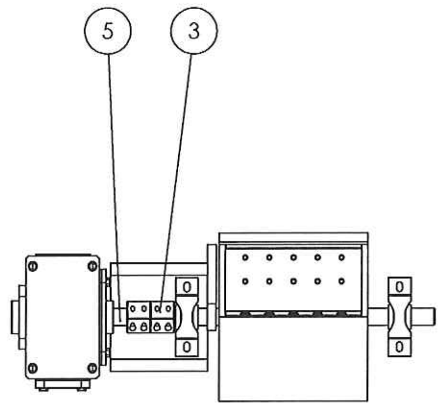

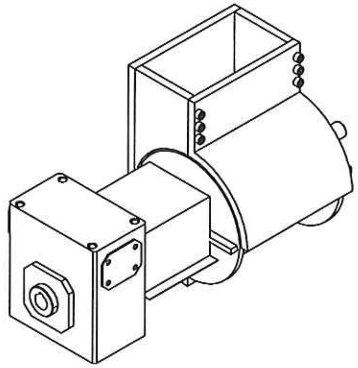

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- BREAK ALL SHARP EDGES UNLESS OTHERWISE SPECIFIED

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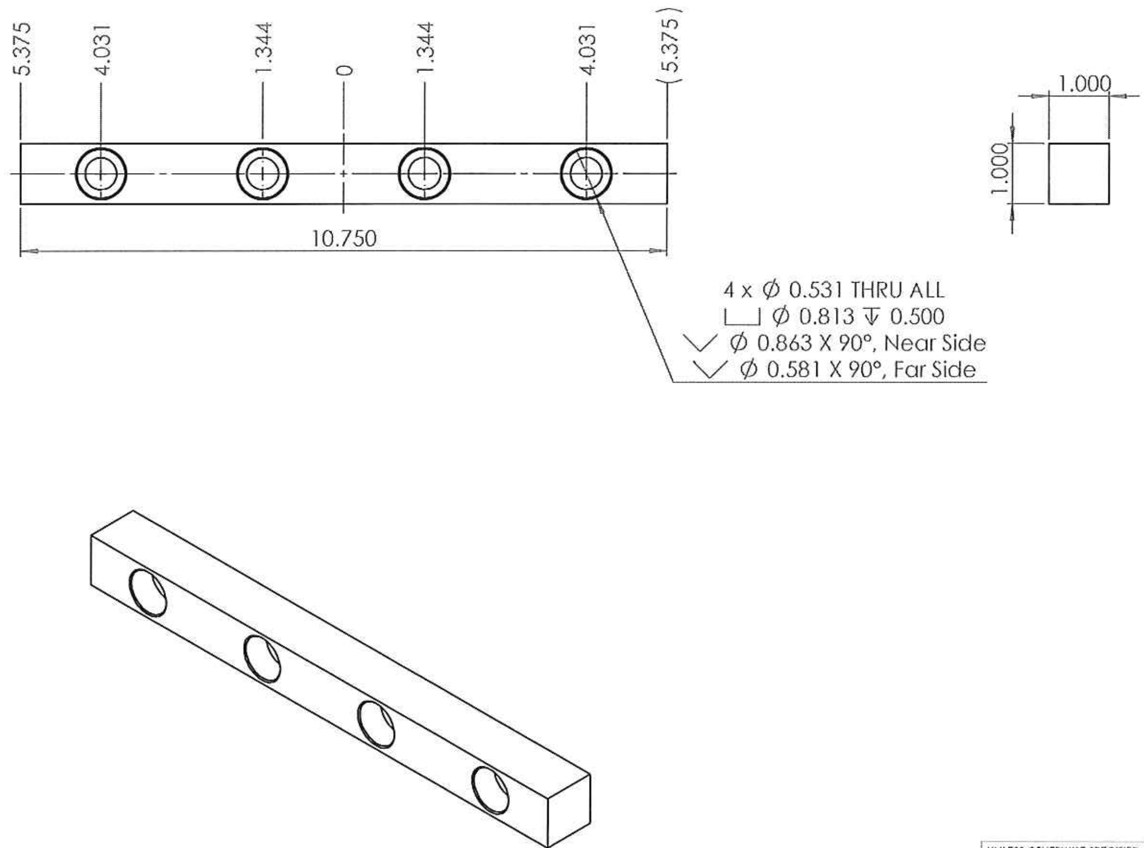
HOUSING_END



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MATERIAL TOOL STEEL	
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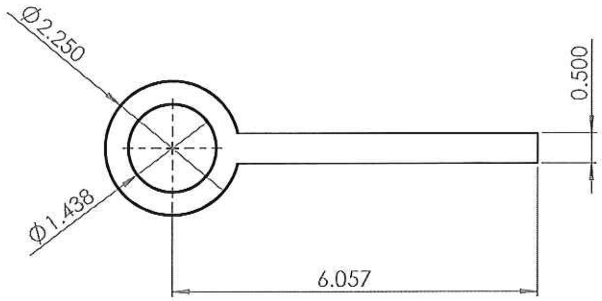

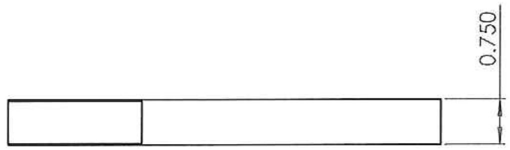

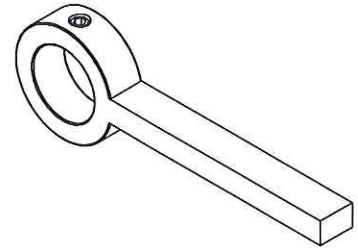

NOTE:
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- PURCHASE SHAFT COLLAR.
- McMASTERCARR PART# : 9414T27

UNLESS OTHERWISE SPECIFIED:	DESIGN: J MINNICH
DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ANGULAR: MACH±1° TWO PLACE DECIMAL ±.01 THREE PLACE DECIMAL ±.005 FOUR PLACE DECIMAL ±.0005	DETAILED: J MINNICH DATE: 3/23/2017 ENG APPR. MFG APPR.
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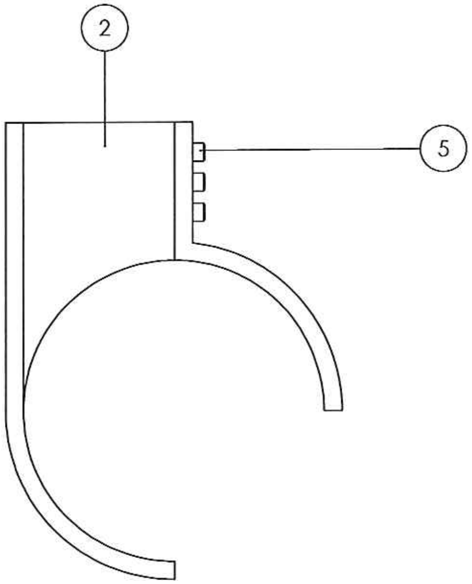

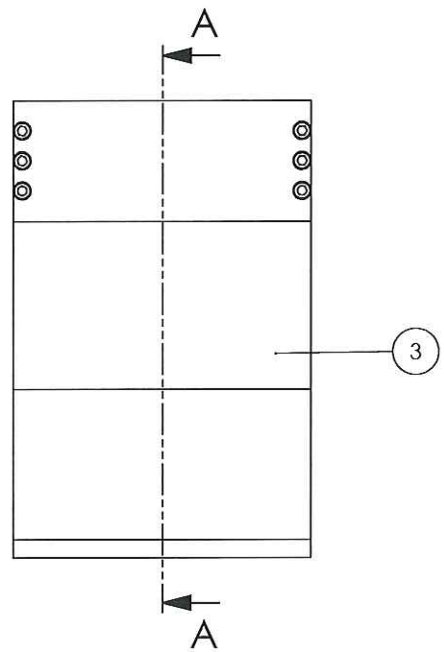

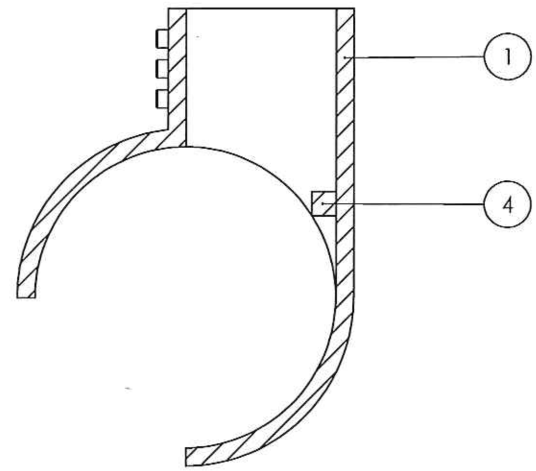

SECTION A-A
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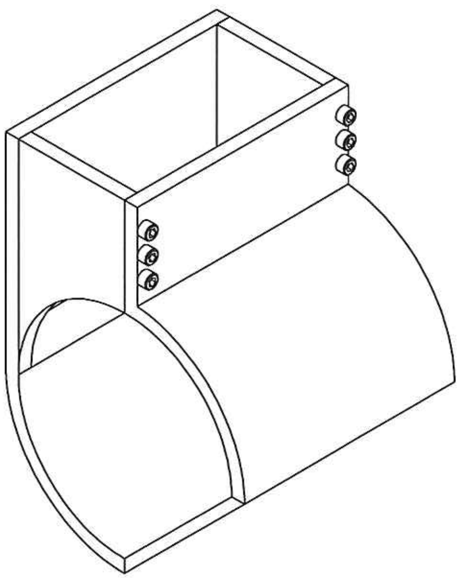

ITEM NO.	PART NUMBER	QTY.
1	HOUSING_ BACK	1
2	HOUSING_END	2
3	HOUSING_FRONT	1
4	CUTTING EDGE	1
5	HX-SHCS 0.5-13x0.75x0.75-C	6
6	HX-SHCS 0.5-13x1.25x1.25-C	4

NOTE:
- BREAK ALL SHARP EDGES UNLESS OTHERWISE SPECIFIED

UNLESS OTHERWISE SPECIFIED:	DESIGN: J MINNICH
DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ANGULAR: MACH±1° TWO PLACE DECIMAL ±.01 THREE PLACE DECIMAL ±.005 FOUR PLACE DECIMAL ±.0005	DETAILED: J MINNICH DATE: 3/23/2017 ENG APPR. MFG APPR.
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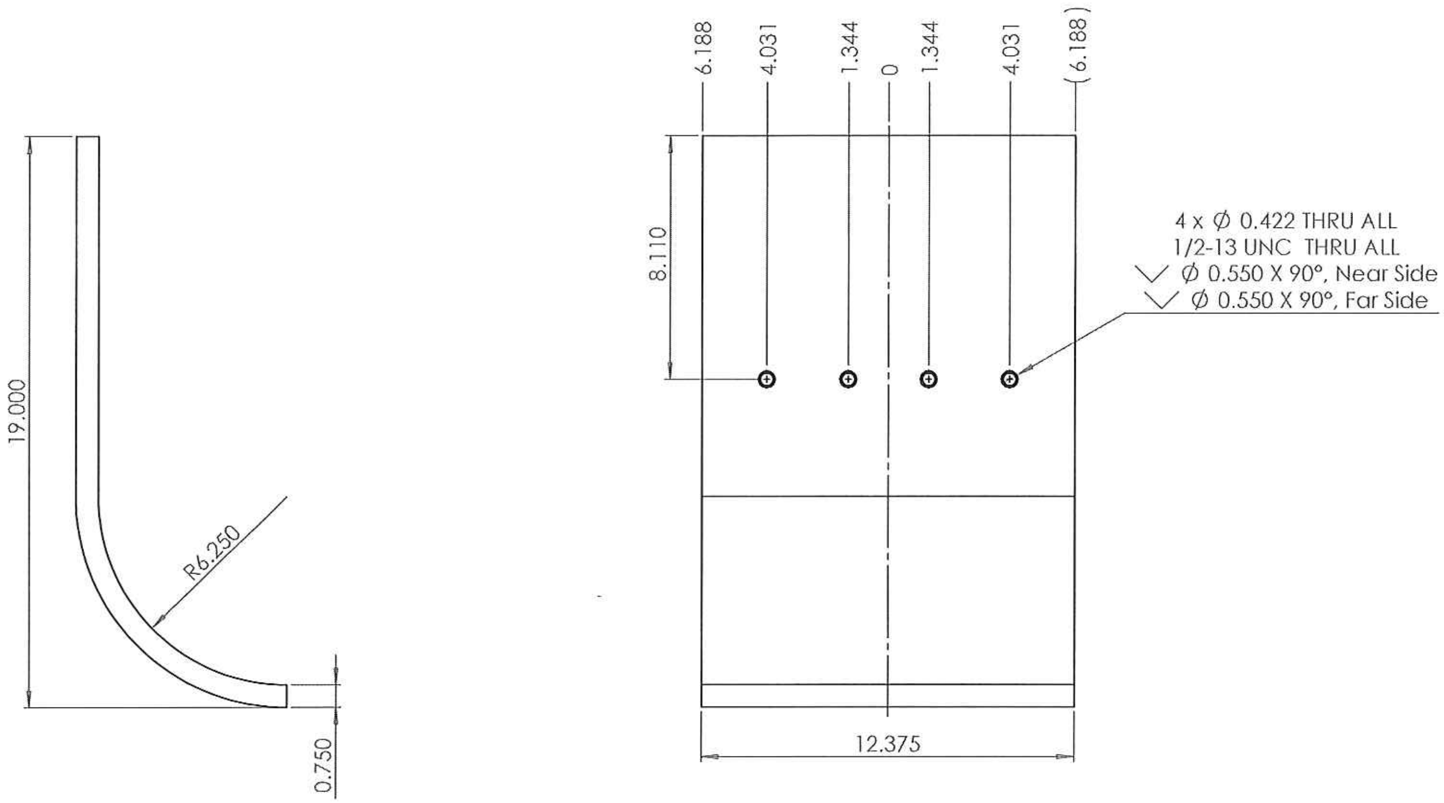
DO NOT SCALE DRAWING	

HOUSING



NOTE:
- USE 14" SCHEDULE 80 STEEL PIPE FOR RADIUS.
- BREAK ALL SHARP EDGES UNLESS OTHERWISE SPECIFIED

UNLESS OTHERWISE SPECIFIED:	DESIGN: J MINNICH	
DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ANGULAR: MACH±1° TWO PLACE DECIMAL ±.01 THREE PLACE DECIMAL ±.005 FOUR PLACE DECIMAL ±.0005	DETAILED: J MINNICH DATE: 3/23/2017 ENG APPR. MFG APPR.	
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MATERIAL HRS	HOUSING_BACK	
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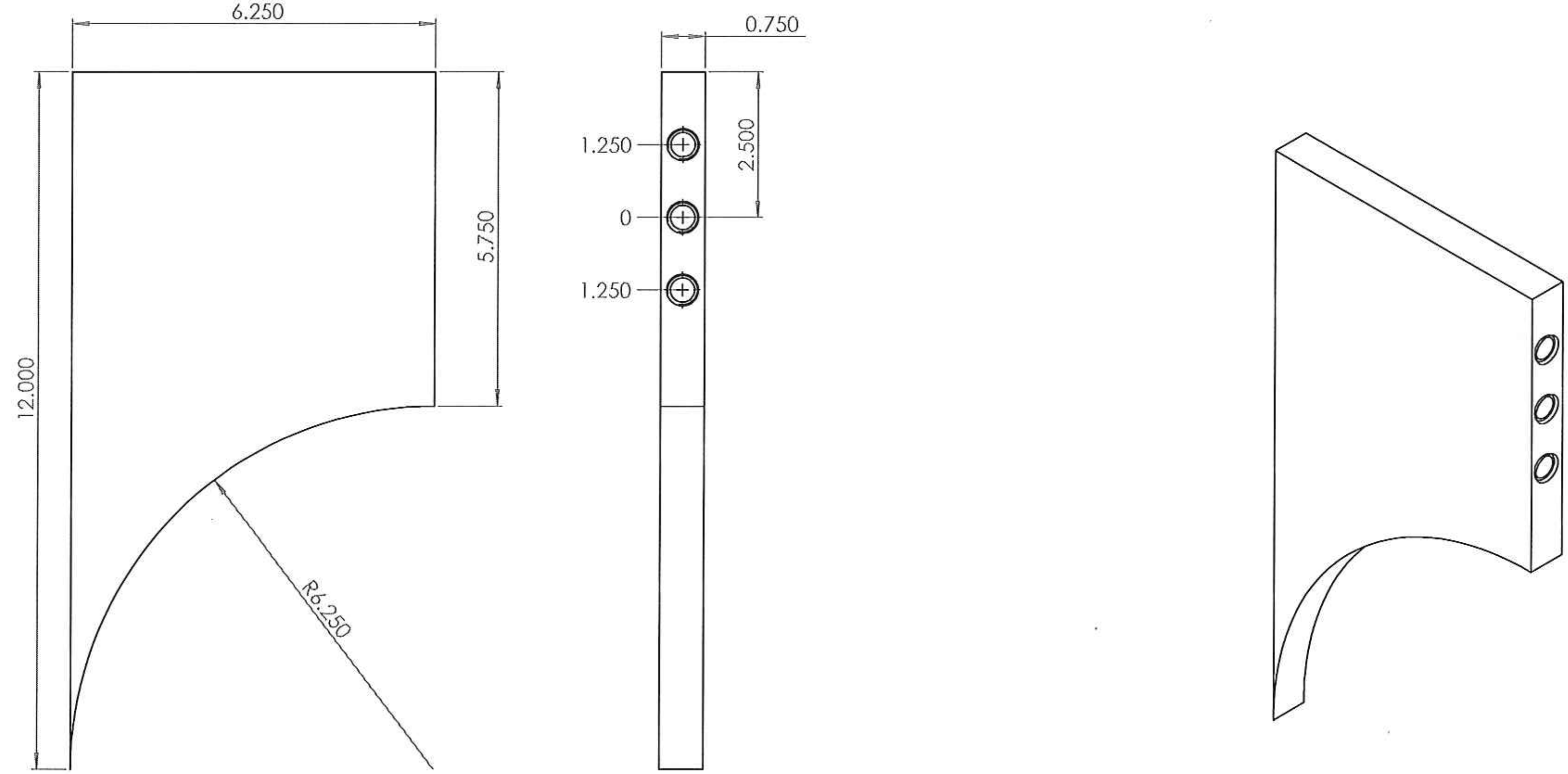
DO NOT SCALE DRAWING		

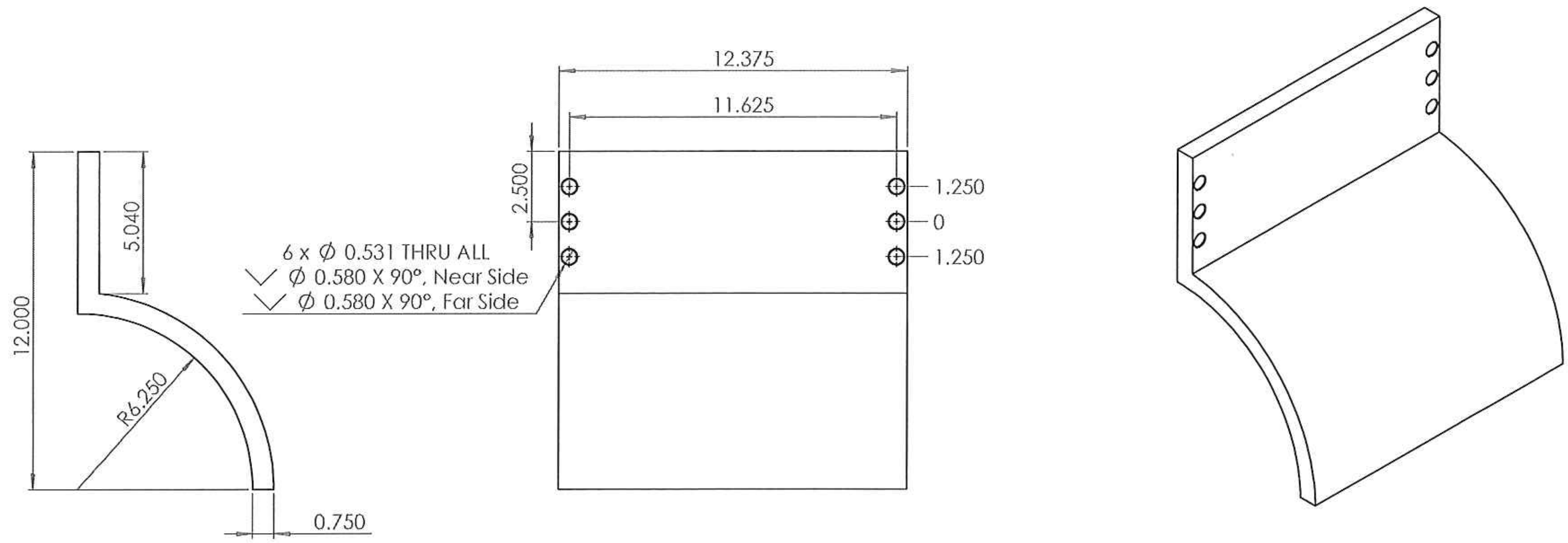


NOTE:
- BREAK ALL SHARP EDGES UNLESS OTHERWISE SPECIFIED

UNLESS OTHERWISE SPECIFIED:	DESIGN: J MINNICH
DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ANGULAR: MACH ±1° TWO PLACE DECIMAL ±.01 THREE PLACE DECIMAL ±.005 FOUR PLACE DECIMAL ±.0005	DETAILED: J MINNICH DATE: 3/23/2017 ENG APPR. MFG APPR.
INTERPRET GEOMETRIC TOLERANCING PER:	Q.A.
MATERIAL HRS	HOUSING_END
FINISH	
DO NOT SCALE DRAWING	

4 3 2 1

B B



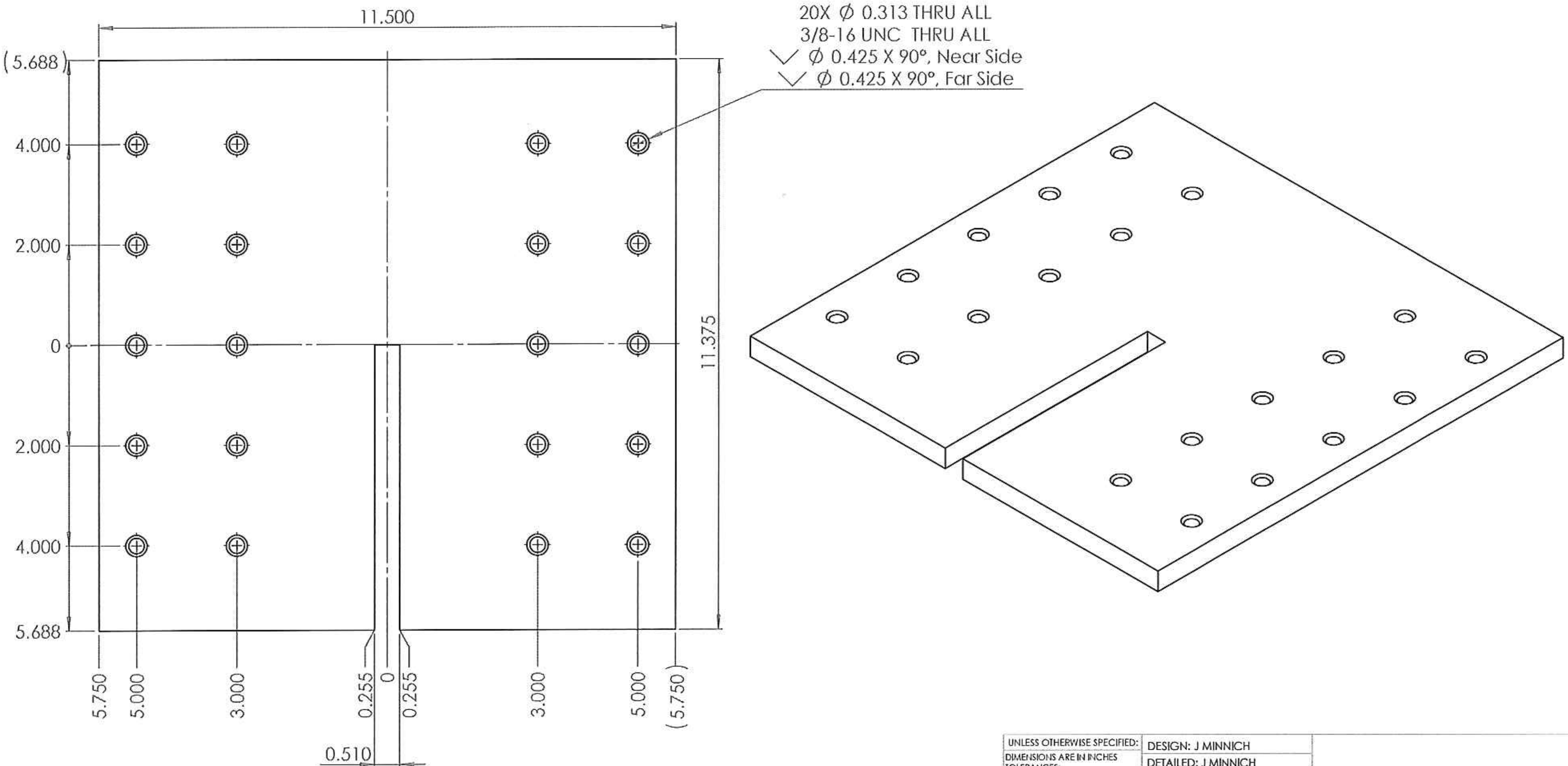
A A

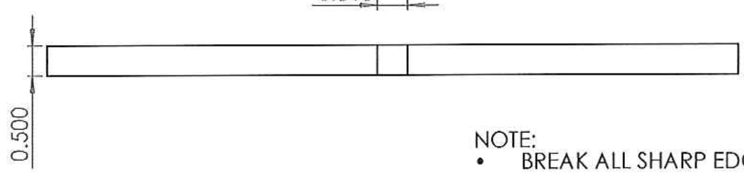
NOTE:
- USE 14" SCHEDULE 80 STEEL PIPE FOR RADIUS.
- BREAK ALL SHARP EDGES UNLESS OTHERWISE SPECIFIED

UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ANGULAR: MACH ±1° TWO PLACE DECIMAL ±.01 THREE PLACE DECIMAL ±.005 FOUR PLACE DECIMAL ±.0005	DESIGN: J MINNICH DETAILED: J MINNICH DATE: 3/23/2017 ENG APPR. MFG APPR.	
INTERPRET GEOMETRIC TOLERANCING PER:	Q.A.	
MATERIAL HRS	HOUSING_FRONT	
FINISH		
DO NOT SCALE DRAWING		

4 3 2 1

B A





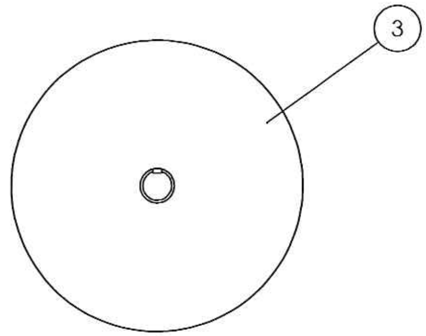
NOTE:
- BREAK ALL SHARP EDGES UNLESS OTHERWISE SPECIFIED

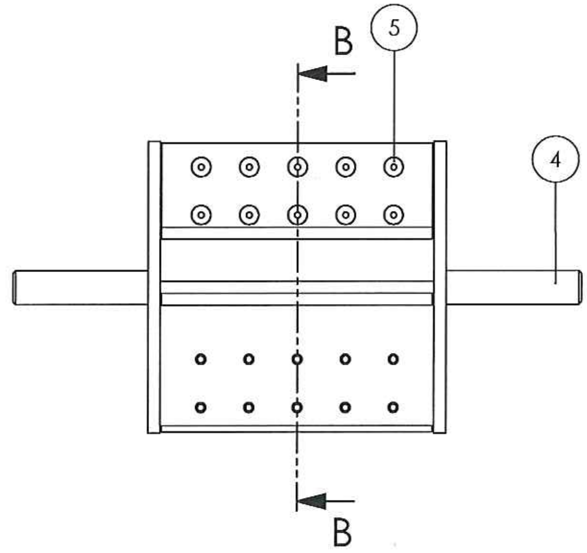
UNLESS OTHERWISE SPECIFIED:	DESIGN: J MINNICH	
DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ANGULAR: MACH±1° TWO PLACE DECIMAL ±.01 THREE PLACE DECIMAL ±.005 FOUR PLACE DECIMAL ±.0005	DETAILED: J MINNICH DATE: 3/23/2017 ENG APPR. MFG APPR.	
INTERPRET GEOMETRIC TOLERANCING PER:	Q.A.	
MATERIAL HRS	PADDLE	
FINISH		
DO NOT SCALE DRAWING		

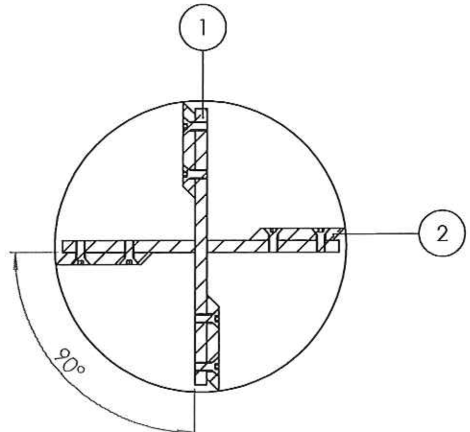
B A

4 3 2 1

B







SECTION B-B

SCALE 1 : 5

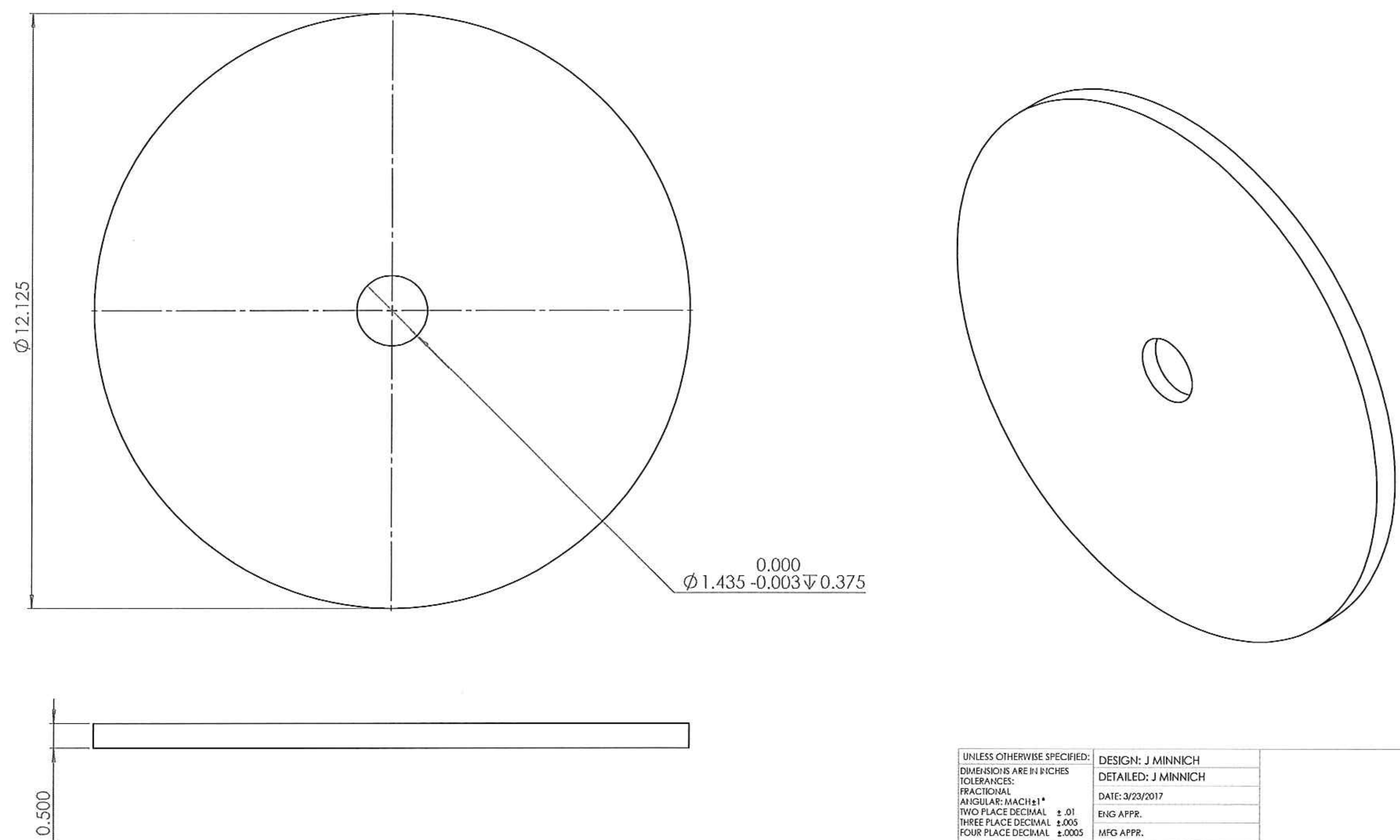
ITEM NO.	PART NUMBER	QTY.
1	PADDLE	2
2	WEAR BAR	4
3	PADDLE_END	2
4	1497K166	2
5	91253A624	40

A

NOTE:
- BREAK ALL SHARP EDGES UNLESS OTHERWISE SPECIFIED

UNLESS OTHERWISE SPECIFIED:	DESIGN: J MINNICH
DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ANGULAR: MACH±1° TWO PLACE DECIMAL ±.01 THREE PLACE DECIMAL ±.005 FOUR PLACE DECIMAL ±.0005	DETAILED: J MINNICH DATE: 3/23/2017 ENG APPR. MFG APPR.
INTERPRET GEOMETRIC TOLERANCING PER:	Q.A.
MATERIAL HRS	
FINISH	PADDLE_ASSEMBLY
DO NOT SCALE DRAWING	

4 3 2 1

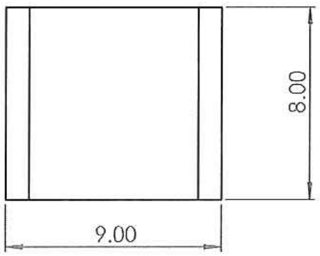


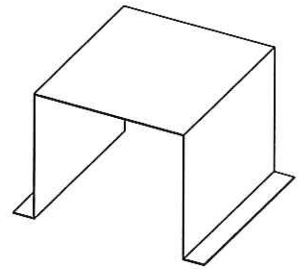
NOTE:
- BREAK ALL SHARP EDGES UNLESS OTHERWISE SPECIFIED

UNLESS OTHERWISE SPECIFIED:	DESIGN: J MINNICH	
DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ANGULAR: MACH±1° TWO PLACE DECIMAL ±.01 THREE PLACE DECIMAL ±.005 FOUR PLACE DECIMAL ±.0005	DETAILED: J MINNICH DATE: 3/23/2017 ENG APPR. MFG APPR.	
INTERPRET GEOMETRIC TOLERANCING PER:	Q.A.	
MATERIAL HRS	PADDLE_END	
FINISH		
DO NOT SCALE DRAWING		

4 3 2 1

B





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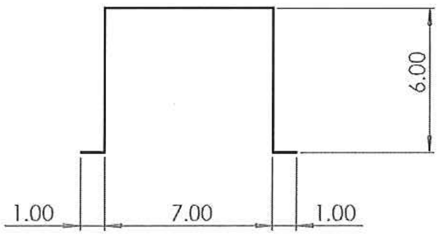


A

NOTE:
- BREAK ALL SHARP EDGES UNLESS OTHERWISE SPECIFIED
- USE 20 GAUGE SHEET METAL FOR GUARD

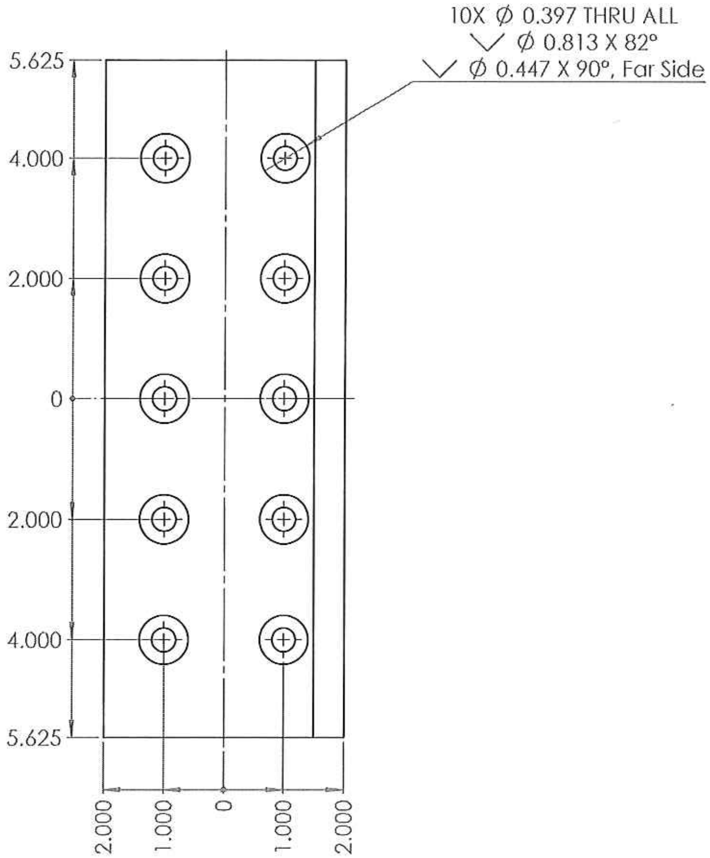
UNLESS OTHERWISE SPECIFIED:	DESIGN: J MINNICH	
DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ANGULAR: MACH ±1° TWO PLACE DECIMAL ±.01 THREE PLACE DECIMAL ±.005 FOUR PLACE DECIMAL ±.0005	DETAILED: JEDD MINNICH DATE: 3/15/2017 ENG APPR. MFG APPR.	
INTERPRET GEOMETRIC TOLERANCING PER:	Q.A.	
MATERIAL HRS	SHAFT GUARD	
FINISH		
DO NOT SCALE DRAWING		

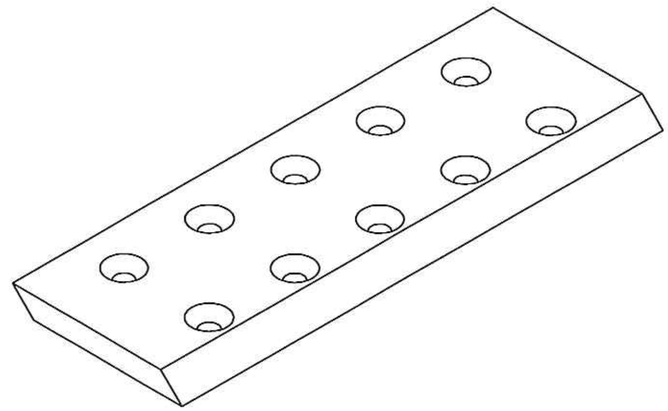
A

4 3 2 1

4 3 2 1

B





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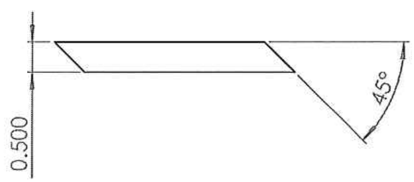


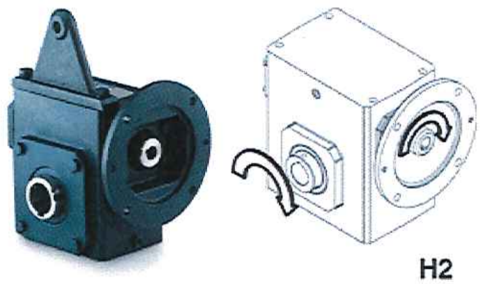
NOTE:
- BREAK ALL SHARP EDGES UNLESS OTHERWISE SPECIFIED

UNLESS OTHERWISE SPECIFIED:	DESIGN: J MINNICH
DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ANGULAR: MACH±1° TWO PLACE DECIMAL ±.01 THREE PLACE DECIMAL ±.005 FOUR PLACE DECIMAL ±.0005	DETAILED: J MINNICH DATE: 3/23/2017 ENG APPR. MFG APPR.
INTERPRET GEOMETRIC TOLERANCING PER:	Q.A.
MATERIAL HRS	WEAR BAR
FINISH	
DO NOT SCALE DRAWING	

4 3 2 1

IRONMAN GR Series

ADD TO CART BACK TO SELECTOR



H2

General Information	
Model Number	GR-HMQ842-100-H2-56-23
Unique Part Number	GR8420684.23
Product Family	GR
Weight (lbs.)	149

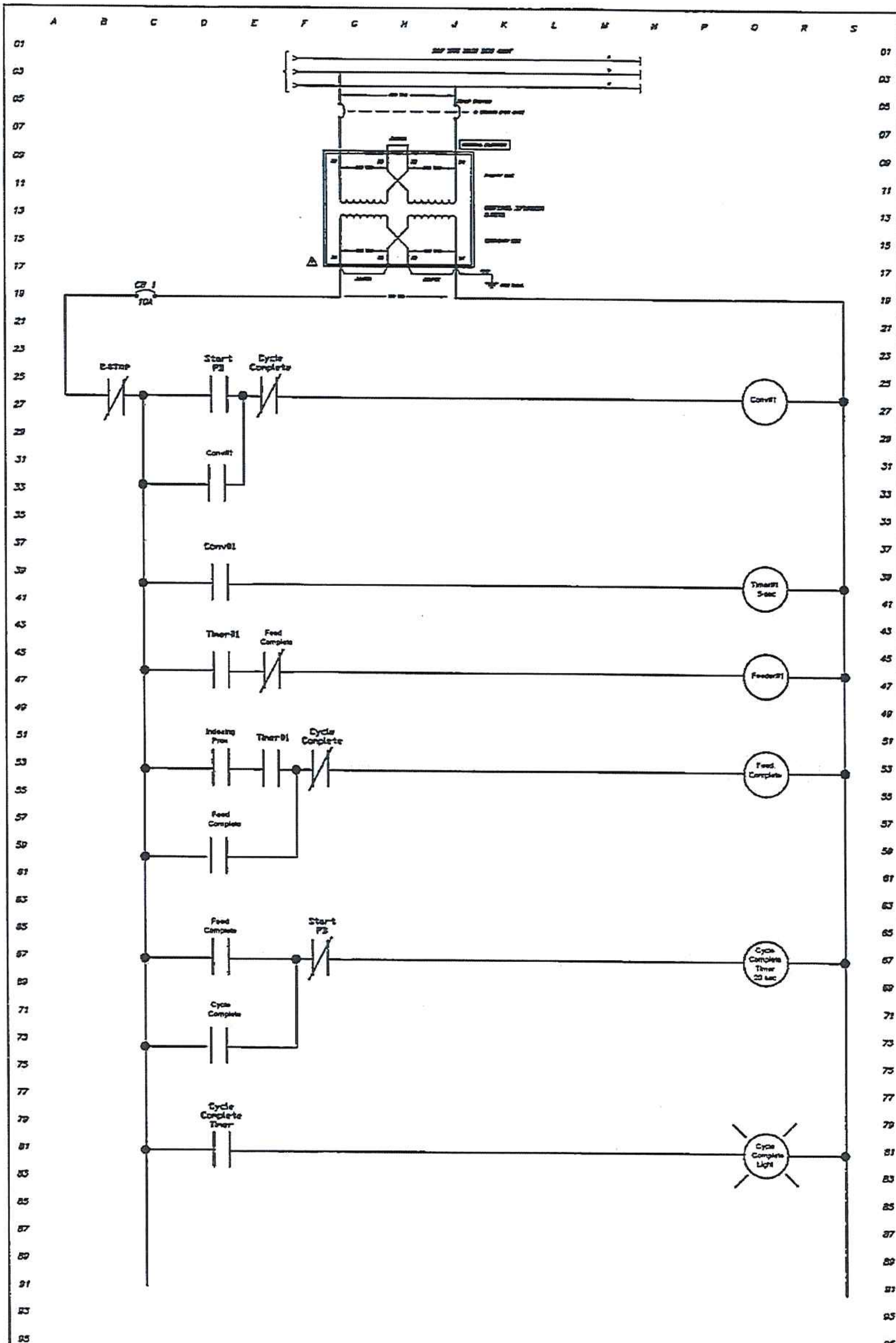
*Please contact your local sales representative for net pricing.

Product Specifications	
Ratio:1	100
Input RPM	1750
Output RPM	17.5
Input HP	1.201
Output HP	0.792
Output Torque (lb.-in.)	2852
Housing Construction	Cast Iron 800 Worm Gear Reducers
Overhung Load (lbs.)	3750
Reducer Type	Worm - Right Angle
Center Distance (in)	4.25
Input Style	Motorized, Quill Input
Frame Size	56
Output Orientation	H2
Output Shaft Assembly	Hollow Shaft
Bore Size (in)	1.438

* Service Factor of 1.0, dependent upon application

Confirm motor power ratings do not exceed gearbox power ratings

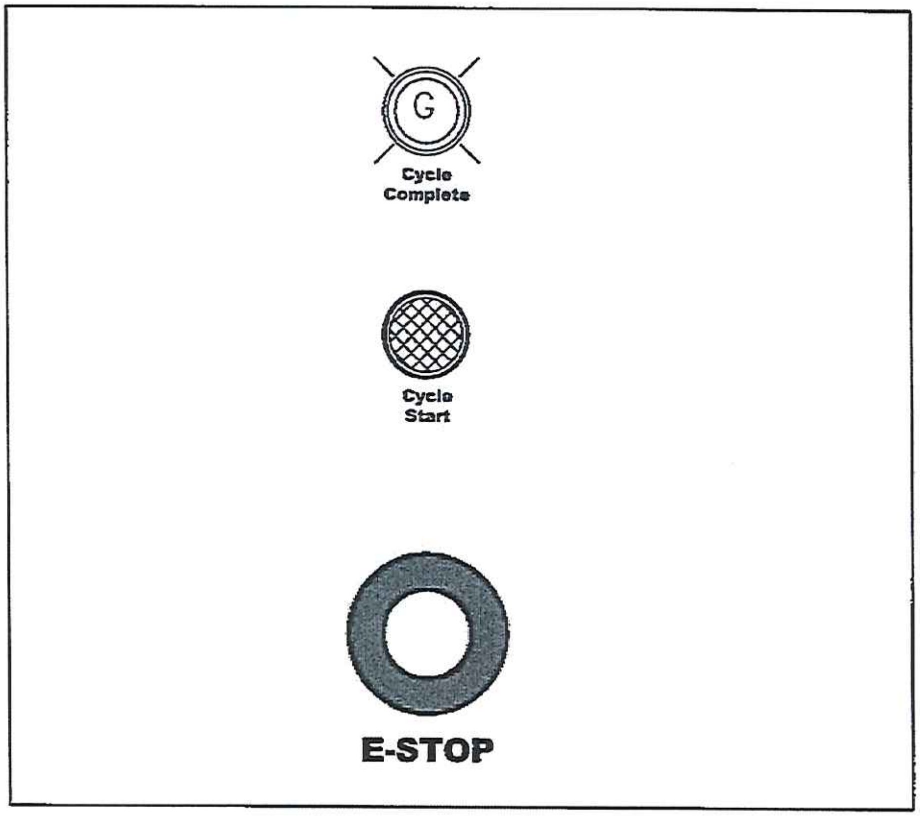
Others Chose . . .



CUSTOMER:		DES.			REV.	.	.	
PROJECT:	STEEL DYNAMICS TWIN-SHELL EAF/LMF	REV.			REV.	.	.	
SECTION:		CUSTOMER DWG No.				SHEET		
TITLE:	EAF CONTROL POWER DISTRIBUTION	-				CONT.		FILE NAME

SH. No.

CONT. ON SH.



14X14
Hoffman
Enclosure

CUSTOMER:		DES.		REV.	.
PROJECT:	STEEL DYNAMICS TWIN-SHELL EAF/LMF	REV.		REV.	.
SECTION:		CUSTOMER DWG No.		SHEET	
TITLE:	EAF CONTROL POWER DISTRIBUTION	.		CONT.	

CONT. ON SH.

SH. No.

FILE NAME