Miami University
Department of Engineering Technology
ENT 498 Senior Design
Pipe Bend Tester

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Contents

1. Statement of Purpose

The purpose of this project is to improve an existing pipe bending testing procedure for HDPE 3”-6” diameter pipe. Instead of a manual, unstandardized process, there will be an automated, standardized one more efficient and easier to operate. This will include a fully guarded fixture, being that safety is a number one priority. Data collection will also be a new option, so that the plant can prevent future defects in the product, thus saving money and time.

1.1 Justification

ADS, specifically the quality control department, has been wanting to find a way to make the Pipe Bend Tester more efficient and more importantly, safe. We saw this as a great opportunity for a senior design project and to help ADS knock this project out. With this type of manufactured pipe, they are having issues with it cracking under cold weather conditions and run into the issue of unsatisfied customers sending it back for replacement. The pipe is called dewatering header pipe, which is 5” diameter single wall high density polyethylene. Many customers use this pipe to remove underground water, usually before starting construction and placing permanent drainage systems in the area.

The existing tester is a manual mechanism and there is no way to standardize the angle or force put on the pipe. Currently, the pipe is being put in a freezer to a specific sub temperature and then placed on the tester and an employee manually turns the handle to bend the pipe at around 180 degrees. One of the biggest issues is that there is no guarding protecting the employee from plastic projectiles if the pipe does crack. If the pipe does fail, they readjust the production line to change the thickness of the pipe. There’s also no data collection to be made other than a pass/fail. This new design will standardize this process, add guarding for safety, and allow for some data analysis in order to prevent future product loss. In completion of this project, it will help the company in various ways of improvement, not only in Sebring, but in other plants as well. We hope to design an automated machine with air controls that could go beyond testing only 5” diameters and to include 3”, 4” and 6” single wall HDPE pipe. The most important aspect of the design is safety for the employees, which should always be implemented within the manufacturing processes in the company.

Current Testing Procedure

1.2 Objective

Currently, in one of the ADS plants in Sebring, FL, there is a manual mechanism that performs a bend test on corrugated pipe to see if it cracks under high angle bend in a cold environment. Our objective is to redesign the existing manual controlled machine so it is automated and can measure force when the pipe is cracking. We plan to automate this machine by using an air logic system and to avoid making it highly sophisticated with electrical components. We also need to have this in a safety enclosure following safety standards since this will be an automated machine and to prevent any injury to employees.

2. Methodology/Scope

In order to successfully complete this project, we will have to include and implement all requirements asked for by the company. While doing this, we also need to make it as cost effective as possible (cheapest options, while still maintaining requirements). The main points are listed below:

Safety

a. Our number one priority in the design
b. Guarding all areas needed while following national and company safety standards
c. Inexpensive and most cost-effective option
d. Working with safety managers in the company to ensure all regulations are met
e. Include an e-stop for emergency situations

Frame Design

a. Must be portable and as compact as possible
b. Limit the amount of materials needed, but still large enough space
c. Must be ergonomic for the employees using it
d. Be able to test various diameters of pipe

Air Controls and Data Collection

a. Implement a rotary air actuator for bending automation
b. Add sensors and gauges where needed for data collection
c. Be sure that the data collected is useful in production and preventing failures in the field
d. Make it as easy and time efficient as possible for employees to use

2.1 Steps

1. Have the existing manual machine sent to ADS New Miami from Sebring, Florida
    a. Examine this machine to see how it’s put together
        i. Gather dimensions and purchased part numbers
        ii. Floor set up
            1. How is it set up when in use?
            2. Is it bolted or stand alone?
        iii. Make decisions on how to use the existing machine to influence new design
2. Begin thought process of new design
    a. Structural build
        i. Determine structural components of the machine
        ii. Design the machine to accommodate 3”-6” corrugated pipe
            1. Will this be a swap out piece, or will each size pipe have its own?
        iii. On floor set up.
            1. Where will it sit in the plant stationary
            2. Fork pockets for easy mobility
            3. Support the weight of machine
            4. Mobility to travel between plants and floor areas
    b. Automation
        i. Determine what components need to move
            1. Direction and angle of these moving parts.
        ii. Amount of force needed to bend the pipe
        iii. Research air logic systems and find what best fits this machine.
            1. Integrate air automation design into this machine
            2. Determine a power supply to the air system
            3. Understand how this works and automates the system
        iv. Design to be a simple push button operation with an E-stop

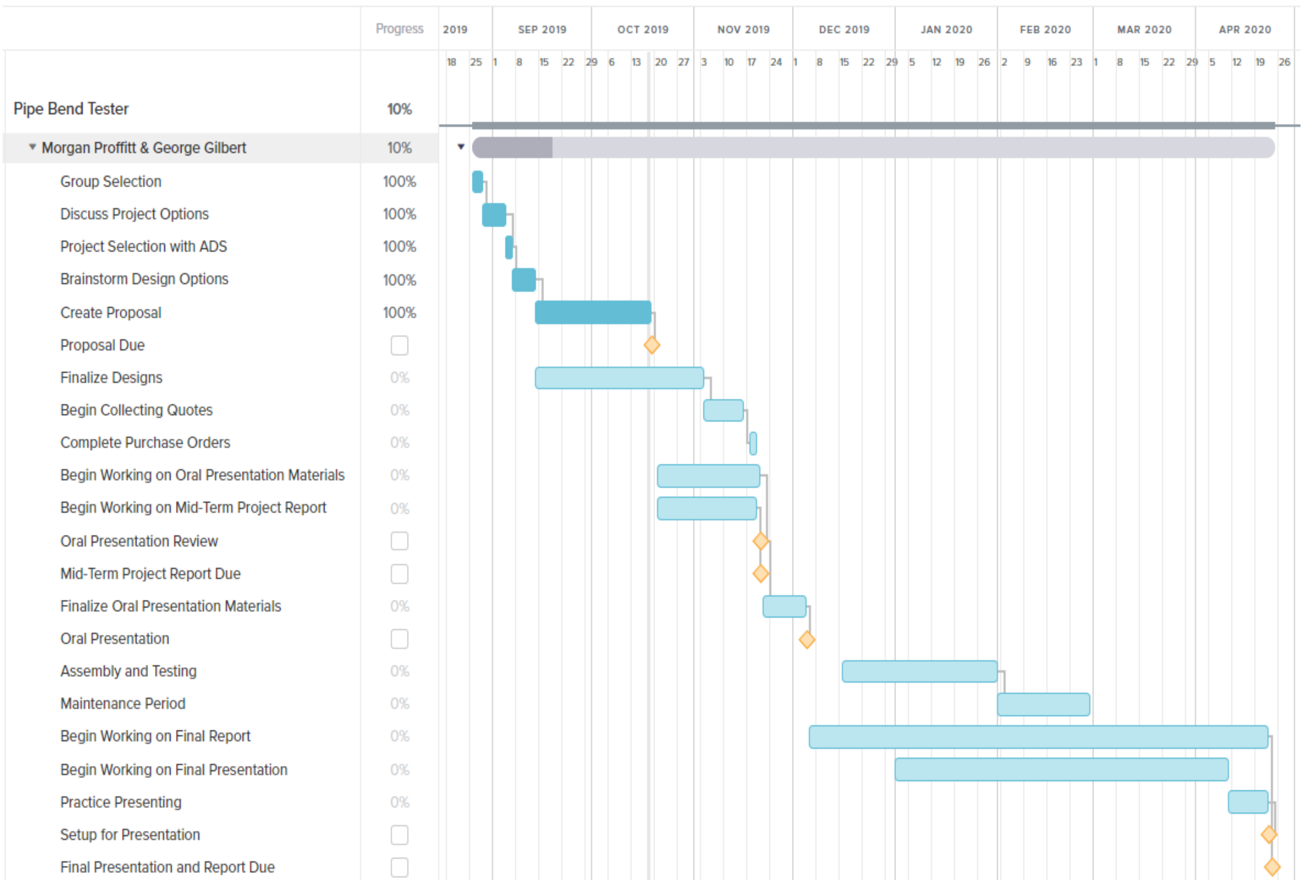
c. Safety
    i. Since this is an automated system, safety precautions should be made with guarding surrounding the machine
        1. Determine what needs guarding and where.
        2. Make sure no guarding will interfere with operation
        3. Any signs or written warnings should be determined and placed for concern of a safety hazard.
d. Data collection
    i. Determine which type of sensors and force gauges are appropriate
        1. Location of sensors and gauges
        2. Output needed for data

3. 3D modeling/drawings
    a. Create working 3D models of components.
        i. Every component should have a 3D model so it will show up in BOM
        ii. Find purchased part models or make close representation of them on own
    b. Assembly
        i. Assemble the components in Inventor so that they are a full representation of what's going to be built.
        ii. Try to work out any issues found in 3D software before building the physical machine.
    c. 2D drawings
        i. Create mechanical drawings of parts as needed
            1. Parts include anything with machining work done etc.
            2. Does not include purchased parts or simple parts i.e. bolts or nuts
            3. Be as detailed as need be.
        ii. Create main assembly drawing with BOM
            1. BOM must be organized and show components as needed for assembly
            2. May reference purchased part numbers and drawing numbers for individual parts as needed.
            3. Include balloons to point out assembly parts corresponding to BOM
            4. Have drawings looked by ADS engineering managers
4. Part ordering
    a. Collect quotes from multiple vendors
        i. Make excel sheet for quote prices and comparison
        ii. Include shipping dates and costs
    b. Order all necessary purchase parts, structural parts, and weldments
        i. Determine if it would be cheaper to assemble purchase parts ourselves or have the vendor do it during manufacturing
    c. Make sure that all parts and assemblies will arrive by scheduled date
5. Assembly
    a. Structure
        i. Build the structure according to the drawing, if not already assembled by vendor
6. Testing
    a. Perform testing for 3”, 4”, 5”, and 6” single wall PE corrugated pipe

b. Record data for force applied to pipe during bending
    i. Are all sensors and gauges working properly and placed correctly within the machine?

7. Data collection
    a. Is this data useful for quality control?
    b. Will this data be helpful in reducing the number of failures?

2.2 Timeline



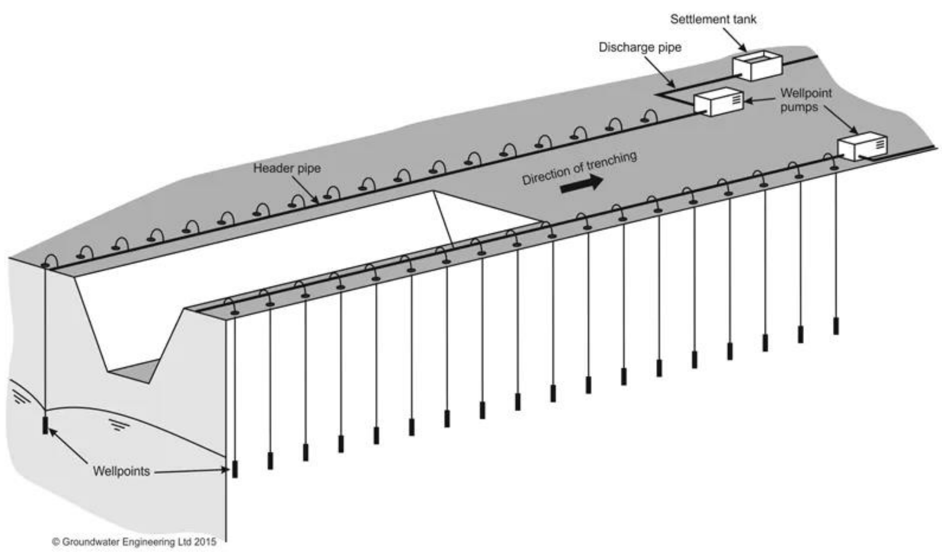
This was our originally planned timeline prior to knowledge of the worldwide pandemic. Because of this we were not able to fully complete our scheduled goals, however our design and preparation for the build are complete. We plan to continue to work with ADS past the semester deadline and eventually assemble and test the full build.

2.3 Research

2.3a Product Application

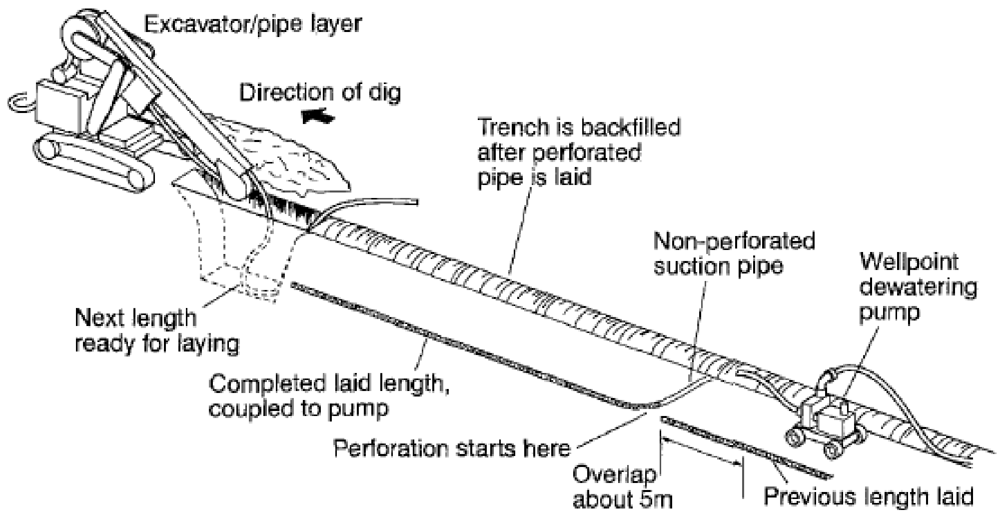
First and foremost, knowing the application and purpose of the product being tested is important in order to understand the issues at hand being presented. After a brief summary of the application by our quality control manager, we decided to research more in depth. The current product being tested is HDPE 5" single wall perforated pipe, which is used in a temporary dewatering process for construction sites. This specific product is only made in two plant locations (Sebring, FL and Owosso, MI).

This product is installed at an excavation site before construction begins during a WellPoint dewatering process. The purpose of this process is to lower the groundwater water table. When doing any sort of construction, vegetation removal happens and can create soil erosion from storm water runoff on the land. Not only this but keeping the land dry is important for the safety of the workers, as well as assuring construction operations will go smoothly [1].



WellPoint Dewatering System [1]

This product is used with a "sock", which is a fabric wrapped around the pipe in order to prevent sand infiltration. These are often called "sock systems" and are connected to a WellPoint dewatering pump. Even though it is used in only a section of the dewatering system, it is still an important aspect of the process and can be left in the ground and capped for future use. Sock applications often give the most cost-efficient method for dewatering [2]. Providing a durable and fracture-resistant product for our customers is important.



Sock System [2]

2.3b Air Pneumatics

Another new addition to the design will be air pneumatics. This will provide a simple and efficient way to turn the fixture into an automated operation that anyone can use. After looking at our options, we decided on a rotary pneumatic actuator that can rotate at least 180 degrees. A couple options that we needed were cushions/and or bumpers installed within the actuator to prevent it from any hard stops. The amount of torque required will be determined to pick an official actuator from doing some force measurements on a 5" sample of the pipe. This information will allow us to exert the correct force desired to bend the pipe accurately each time.

Using air logic was decided to be the simplest way that this machine could be operated by plant workers in the field. The first step in choosing the right one was to calculate the torque and air pressure required to bend the pipe efficiently. We had (4) samples of the 5" SW diameter pipe shipped to us from Sebring, FL to do some testing on them. Having extra sample pieces is important, because this kind of force testing causes permanent deformation or breakage on the pipe samples. It is essential that the tests are done correctly the first time to get accurate readings.

We did this with a force gauge provided by Miami and pulled the pipe with it, bending it at the 180-degree requirement. Some gauges have a limited range of data output, so knowing what the average force applied will allow us to select the correct gauge for our application. In an ideal world we would like to have digital output, but since we are trying to keep things at a low cost and simple as possible, the dial gauge will most likely be used. The model we used for testing was a Desik Instruments DL-100 Manual Push-Pull Force Gauge. This gauge goes up to a maximum force of 100lb, which seemed to be an accurate range for us to use.

Push Pull Force Gauge [3]

The importance of using this specific product for our test was the gram weight per foot of the material. Between the (4) different size diameters of single wall pipe being tested, this one is specifically the highest gram weight. This means that this force output will give us the maximum needed to calculate how much torque the actuator needs to supply.

Advanced Drainage Systems, Inc.
Product Specification Sheet
5" (125mm) I.D. Solid Single Wall Header Pipe, (400g)

Attribute	Specification		Verification Method
	Minimum	Maximum	
Weight (gm/ft)	390	410	VM-01
Pitch (Corr./ft)	17.0	18.0	VM-02
Inside Diameter* (in)	4.85	5.14	VM-03
5% Stiffness* (lb./in²)	50	-	VM-18
10% Stiffness* (lb./in²)	40	-	VM-18
Pipe Flattening/Failure Point*	20%	-	VM-18
Crown Thickness (in)	0.070	-	VM-09
Thickness Variation (in)	-	0.010	VM-09
Circular Perf. Diameter* (in)	-	-	VM-07
Circular Perf./ft.	-	-	VM-07
Slotted Perf. Length* (in)	-	-	VM-07
Slotted Perf. Width* (in)	-	-	VM-07
Slotted Perfs. per foot	-	-	VM-07
Inlet Area* (in²/ft)	-	-	VM-07
Elongation Resistance (%)	-	5%	
Pipe Laying Length* (ft)	99%	102%	VM-13
Impact Resistance*	No Splitting or Cracking		VM-17
Stripe Width (in)	0.265	0.335	VM-15

ADS Quality Control Spec Sheet [4]

For the 5” SW Header Pipe, the gram weight goes up to 410gm/ft. The lowest gram weight would be our H Profile 3” SW Pipe which is 96gm/ft.

Advanced Drainage Systems, Inc.
Product Specification Sheet
3" (75mm) I.D. Single Wall Pipe, (98g)
H - Profile

Attribute	Specification		Verification Method
	Minimum	Maximum	
Weight (gm/ft)	96	100	VM-01
Pitch (Corr./ft)	17.0	18.0	VM-02
Inside Diameter* (in)	2.90	3.08	VM-03
5% Stiffness* (lb./in²)	35	-	VM-18
10% Stiffness* (lb./in²)	25	-	VM-18
Pipe Flattening/Failure Point*	20%	-	VM-18
Crown Thickness (in)	0.020	-	VM-09
Thickness Variation (in)	-	0.005	VM-09
Circular Perf. Diameter* (in)	n/a	n/a	VM-07
Circular Perf./ft.	n/a	n/a	VM-07
Slotted Perf. Length* (in)	0.500	0.875	VM-07
Slotted Perf. Width* (in)	0.050	0.118	VM-07
Slotted Perfs. per foot	46	96	VM-07
Inlet Area* (in²/ft)	1.00	-	VM-07
Elongation Resistance (%)	-	10	
Pipe Laying Length* (ft)	99%	102%	VM-13
Impact Resistance*	No Splitting or Cracking		VM-17
Stripe Width (in)	0.220	0.280	VM-15

ADS Quality Control Spec Sheet [4]

We decided to make use of our Machine Shop Operations and Quality Control locations at our ADS facility in order to perform our test accurately and safely. Since they freeze the pipe first before bending, we decided to do two separate tests – one would be at room temperature and one would be at freezing temperature. In Quality Control, we contacted the manager to see if we could use their walk-in freezer and left the pipe in there overnight for about 24 hours. When performing the bend force test, we made sure to have all safety equipment on (safety glasses and steal toed boots) while in the machine shop. The pipe was locked tightly into a large vice available, so that it would not move while bending as close to 180 degrees as possible.

As we predicted, the force of the frozen pipe was higher than the pipe at room temperature. At room temperature, the force was about 50lb and for the frozen, about 90lb. Using these measurements, we calculated the needed torque in order to bend the pipe at ease with a 10in long arm. The maximum torque needed based on our test was 900 lb-in, which is high for a pneumatic actuator. For leeway and safety factors we decided that the minimum torque needed for what we wanted would be 1200 lb-in or 120 ft-lb. This was only one factor of the actuator that we required.

Testing Photos

There are a couple other requirements needed when selecting the correct actuator that will work best for this fixture. In the plants, there is central drop-down air with a variable maximum of 150 psi. It is important that the actuator can produce 1200 lb-in of torque within the 150 psi range, preferably around 100 psi. We needed a feature that measured the angle vs. time as well. It came down to either a Parker or Numatics actuator from Air & Oil.

The Parker actuator option is a 3-1/4" bore, double rack and pinion style with an electric resolver to measure the angle. This gives us the option to add sensors and air logic accessories. The theoretical torque output at 75 psi is 1711 in-lb. The first Numatics actuator option is a little smaller with 2-1/2" bore, double rack and pinion style with a magnet option to measure angle placement. The theoretical torque output at 150 psi is 1656 in-lb. The second option is the same style, but a 3-1/2" bore and theoretical torque output at 100 psi is 2281 in-lb.

Unfortunately, since these actuators need so much power, they are very heavy and large compared to the other air cylinders and actuators we use. The frame design had to be adjusted to accommodate this and be able to properly hold up the weight of the actuator, which is about 20 lbs. This also means that the structure must be sturdy enough to not vibrate too much or react to any backlash and stay securely on the ground of the plant floor. This is for the operator's safety.

PTR	25	1	-	090	3	F	P	-	A	B	2	1	M	V	-	C	

Model[1]	
10	1" Bore
15	1-1/2" Bore
20	2" Bore
25	2-1/2" Bore
32	3-1/4" Bore

Rotation[2]	
090	90°
180	180°
270	270°
360	360°
Or specify any other rotation.	

Configuration	
1	Single Rack
2	Double Rack
3	Three Position Actuator
6	Air/Oil Operation
7	Antibacklash

Cushion / Bumpers	
Omit	None
1	Cushioned CW rotation [3]
2	Cushioned CCW rotation [3]
3	Cushioned both rotations
4	Four cushions [4]
5	Bumper CW rotation [3]
6	Bumper CCW rotation [3]
7	Bumper both rotations
9	Special

Stroke adjusters	
Omit	None
D	0-30° CW rotation [3,5]
E	0-30° CCW rotation [3,5]
F	0-30° both rotations [5]
H	Shock/stroke adj. CW rotation [3,7]
K	Shock/stroke adj. CCW rotation [3,7]
L	Shock/stroke adj. both rotations [7]
X	Special

Mounting	
A	Face/base (standard)
F	Front flange
G	Foot flange
P	Pilot ring
R	Rear flange
X	Special

Port flow controls	
Omit	None
P	Flow control both rotations
R	Flow control CW rotation [3]
S	Flow control CCW rotation [3]

Shaft	
A	Female keyed
B	Single male keyed (standard)
C	Double male keyed
R	Preload keyway
X	Special

Port type	
1	SAE straight thread
2	NPTF
4	BSPP (ISO 1179-1 with ISO 228-1 threads)
9	Special

Design Series	
C	Current

Special Options	
Omit	Standard
(Two-digit code assigned by factory and applies when any "X" or "9" appears in the model number or when special options or features are required.)	

Seals	
Omit	Nitrile
V	Fluorocarbon
X	Special

Port location	
1	Position 1 (standard)
2	Position 2
3	Position 3
4	Position 4 [8]
5	Position 5 [6]
9	Special

Standard options	
Omit	None
M	Magnetic piston ring
S	Shaft seal cover
Q	Prepped for external air/oil tank
L	Air/oil cushion & flow control adj. at location 1 (opposite standard)

Other options

Detail in clear text:
- Proximity Sensors
- Feedback Potentiometer

Notes:

1 Cylinder bore size. See appropriate tables for torque output.

2 For 3-position units, specify middle and total rotation separated by a "/", ie 090/180. To obtain equal rotation both sides of midstroke (theoretical 12:00), order unit with 5° longer rotation than standard with stroke adjusters.

3 Viewed from shaft end.

4 Double rack models only.

5 Reduces to 10° with cushions.

6 Not available with cushions or stroke adjusters.

7 Refer to Catalog 0900-E page H45 for option configuration compatibility.

8 Not available on double rack models

Catalog PDN1000-2US

Parker Pneumatic

Actuator Products – Rotary

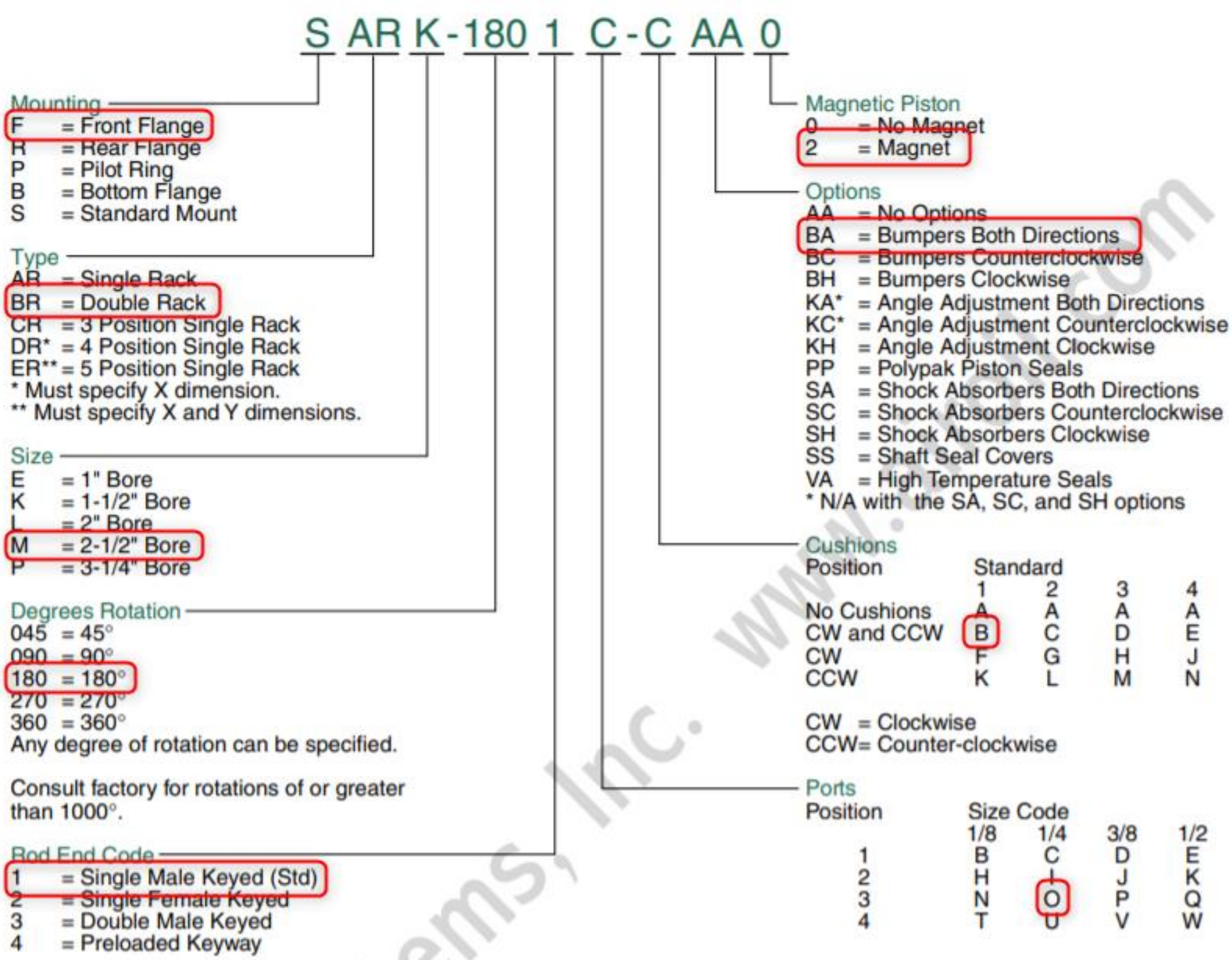
PTR Series

Quick reference data

Model		Typ. actual output torque @ 100 PSI (lb-in)	Theoretical output torque* (lb-in) versus input pressure (PSI)				Displacement per degree rotation (in³/°)	Maximum angular backlash (minutes)	Tolerance (degrees)
Single rack	Double rack		50	75	100	250			
101		35	19	29	39	98	0.007	60	-0, +5
	102	70	39	59	79	197	0.014	60	-0, +5
151		100	59	88	118	294	0.021	45	-0, +4
	152	200	118	177	236	590	0.042	45	-0, +4
201		250	141	212	282	705	0.049	35	-0, +3
251		375	215	322	430	1074	0.075	35	-0, +3
	202	500	282	423	565	1410	0.099	35	-0, +3
	252	750	430	644	859	2148	0.150	35	-0, +3
321		1000	570	856	1141	2852	0.199	25	-0, +2
	322	2000	1141	1711	2281	5703	0.398	25	-0, +2

* Allow 10% for friction loss. Allow 20% on air/oil units. Use the single rack torque values for all air/oil, three position, and anti-backlash actuators.

Appendix 6.6a



BORE	NUMBER OF RACKS	MODEL	THEORETICAL TORQUE OUTPUT (in-lbs) 50 psi	100 psi	150 psi	DISPLACEMENT CU. IN./DEG. OF ROTATION	"MAX. ANGULAR BACKLASH, MINUTES"	MAX. ROTATIONAL TOTAL (DEGREES)
1"	1	SARE	19	39	59	0.007	50	10
1"	2	SBRE	39	79	118	0.014	50	10
1 1/2"	1	SARK	59	118	177	0.021	40	8
1 1/2"	2	SBRK	118	236	353	0.042	40	8
2"	1	SARL	141	282	424	0.049	30	6
2"	2	SBRL	282	565	848	0.099	30	6
2 1/2"	1	SARM	276	552	828	0.096	30	6
2 1/2"	2	SBRM	552	1104	1656	0.193	30	6
3 1/4"	1	SARP	570	1141	1711	0.199	15	4
3 1/4"	2	SBRP	1141	2281	3422	0.398	15	4

Allow 10% for friction loss.

Appendix 6.6b

2.3c Data Collection

Collecting data is essential to this design, so that we can correlate fracture forces with our resin formulas being used in the plants. To do this, we need a simple solution by using strain force gauges that can be mounted onto the fixture and hooked up to electrical software for data output. There are many options on the market, but we need to find the one that is most cost efficient and makes the most sense in our application. We have vendors that work closely with our company that we decided to meet with in order to choose the right products.

Along with this, it is important to choose the correct devices that works directly with the actuator that we choose. For example, if we go with the Parker actuator with the resolver included, we will need to find the correct accessory that works directly with the sensor output electronically. The measurements we obtain need to be transferred into readable data that will be placed in a graph the correlates time, angle position, and maximum forces. The idea is to use record this data during every test in the future and create an official testing procedure that will be implemented within the Quality Control Department.

2.3d Estimated Budget

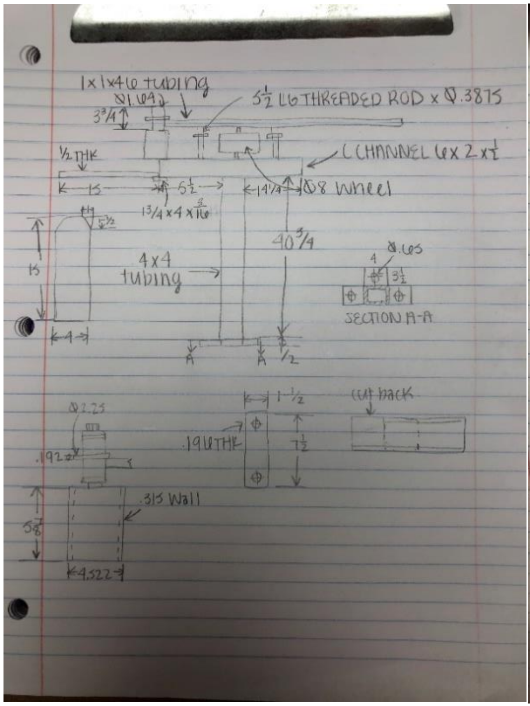
Below is our estimated budget using mostly stock or purchased parts. This will allow the parts to be more easily replaced if needed by the plants, instead of being required to be sent to the machine shop to be repaired. The faster repairs can be made, the better. There are (3) separate totals depending on which pneumatic actuator is chosen. The Parker actuator that includes a sophisticated position resolver is the most expensive, about double the price of the Air & Oil options.

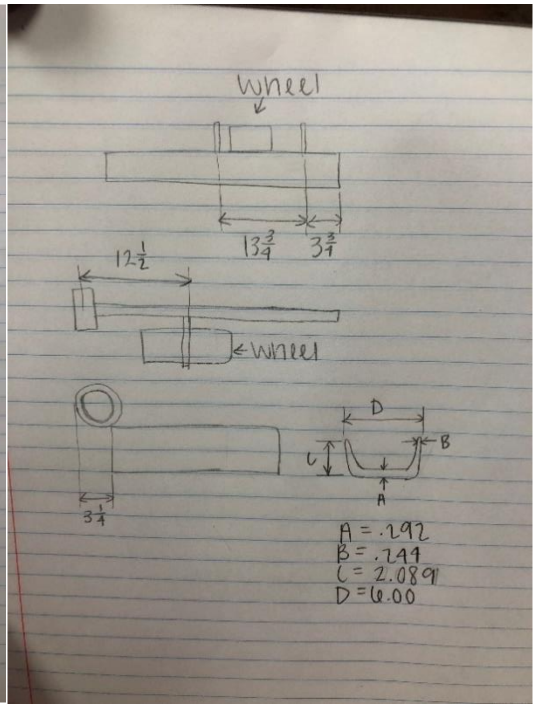
Part	Quantity	Manufacturer	Part Number	Price	Estimated Ship Date
Pnuematic Rotary Actuator	1	Air & Oil - Option 1	FBRM-1801O-BBA2	$2,247.96	5-7 Weeks
Pnuematic Rotary Actuator	1	Air & Oil - Option 2	FBRP-1801P-BBA2	$3,486.12	5-7 Weeks
Pnuematic Rotary Actuator	1	Parker - Option 3	PTR322-1803P-AB21H-C	$7,708.00	7-8 Weeks
Strain Gauges	1	TBD	TBD	$150.00	TBD
Valve Fittings	1	McMaster-Carr	TBD	$50.00	Immediate
Wheel	1	McMaster-Carr	TBD	$25.00	Immediate
Guarding	1	80/20 T-Slotted Framing	TBD	$1,500.00	Immediate
Frame Weldment	1	Vendor	116-00-03-001-0001	$1,000.00	Est 2 Weeks
Shipping	1	Vendor	N/A	$100.00	Immediate
E-Stop	1	McMaster-Carr	6464K18	$33.22	Immediate
Acrylic Sheets	1	McMaster-Carr	8560K435	$150.00	Immediate
Air Tank (if needed)	1	McMaster-Carr	41705K39	$329.09	Immediate
Total - Option 1				**$5,585.27**	
Total - Option 2				**$6,823.43**	
Total - Option 3				**$11,045.31**	

2.4 Frame Design

The existing test fixture is currently being used in Sebring, FL so we had it shipped to us with another machine that was coming to our shop for repair in New Miami. Being able to ship the fixture on shipments that were already scheduled allowed us to save money and time. We had four days to collect all the information we needed on it before it was to be shipped back on a fittings truck that we send weekly. We used this time to take measurements and any part numbers that may be used. The measurements were taken with a standard tape measure and a digital caliper.

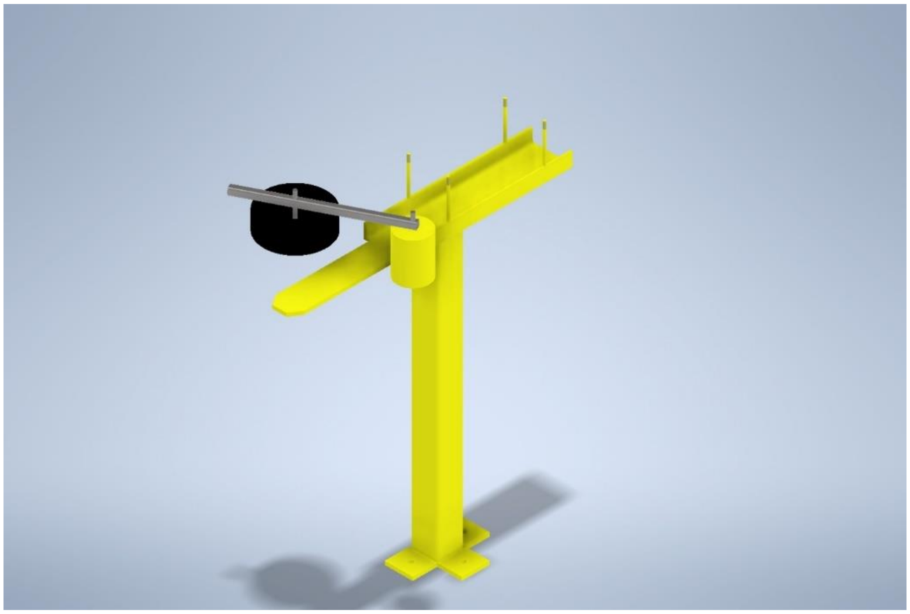
Existing Test Fixture



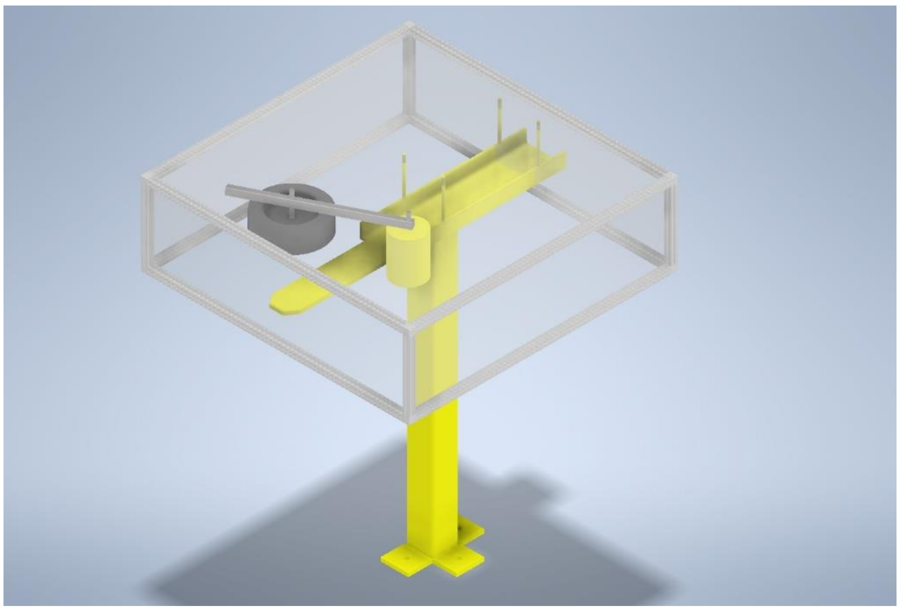


Sketched Measurements

After we had all the information we needed, we created a generic model in Autodesk Inventor Professional 2020. This gave us a reference point to use in creating the new/revised design.

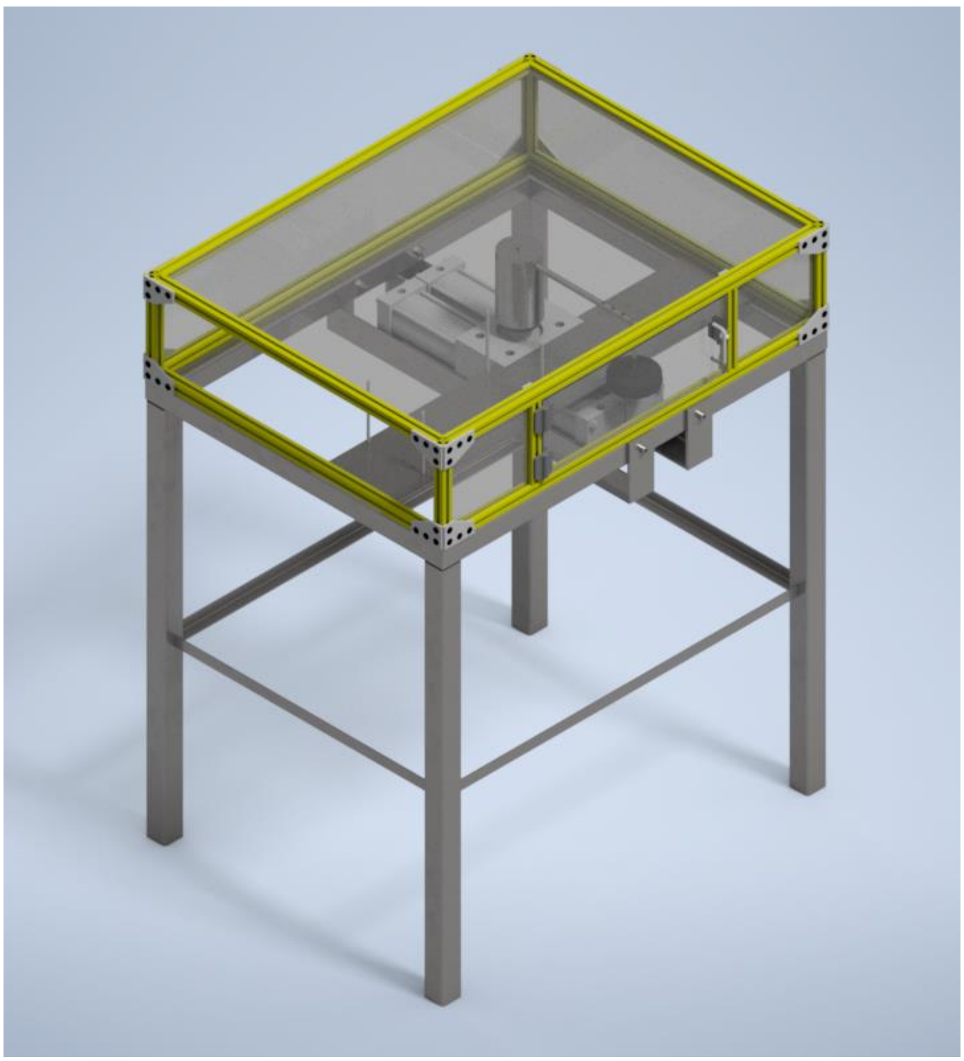


Adding guarding was our #1 priority since safety most important. We decided to use the existing tester reference to get a general idea of how large the guarding may need to be. The initial guarding was fairly large, being about 48” x 48” x 10”. This is not ideal, since smaller would be better. We also decided that if the guarding will be this large, the fixture can no longer be bolt down and will need additional support.

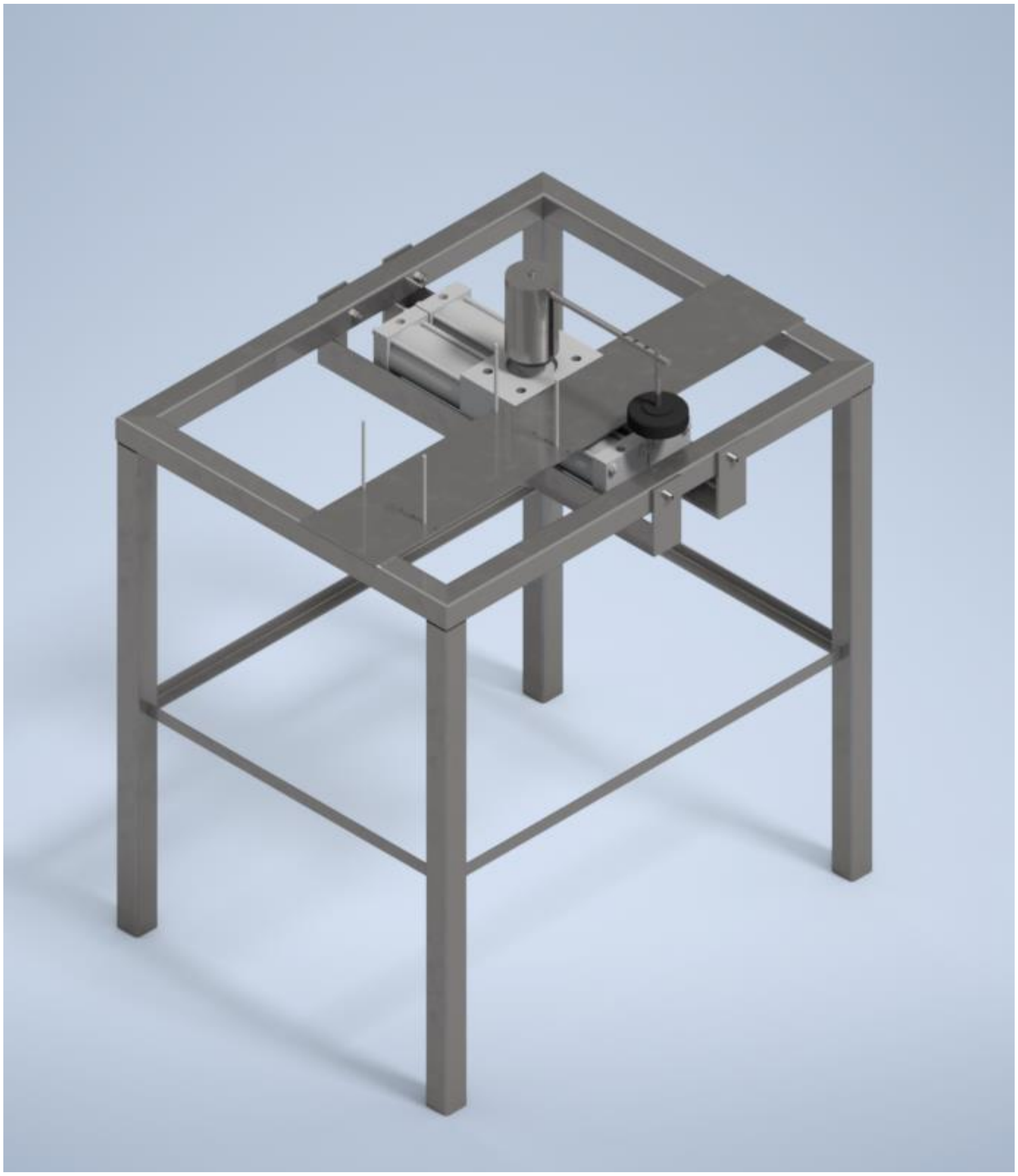


We decided to go with a frame that had four legs, along with a smaller wheel in order to save space. The original fixture was made with some spare parts, so they used an 8” wheel that happened to be lying around. Our goal is to use a wheel 4” or smaller in diameter to make the fixture smaller and more compact. The idea is to make everything as simple as possible, using purchase parts when permitted.

For the guarding, we went with T-Slotted framing from 80/20 that can easily be purchased at anytime and can be put together with ease, even without any tools. In between the frames will be polycarbonate sheets to prevent projectiles from hitting the operators or any bystanders. This is a somewhat flexible and durable material that you can see through to make sure the fixture is operating properly. The framing will be yellow, which is a standard color of safety components within the company.

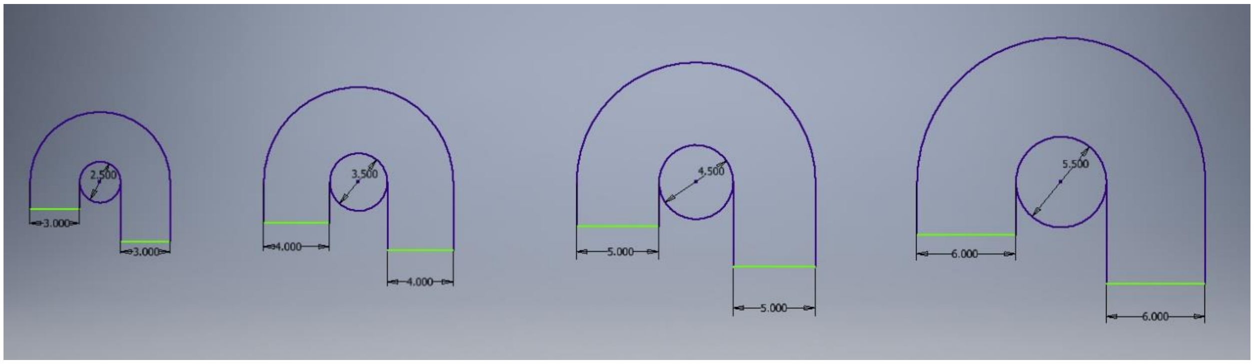


Isometric View of New Design



View of New Design Without Guarding Shown

A 5 ft long sample of pipe is used when being tested, so the length of the guarding would need to stay the same, but the width can be decreased now. At the bottom of the fixture we have the option to attach netting in order to catch any fallen pieces. There are adjustable threaded rods along the flat bar of steel to adjust for different pipe sizes in order to keep it stable when testing. The current bend radius is 2.25” for testing our 5” diameter pipe, so we had to figure out what additional radiuses would need to be used.



According to the photo above, we will need 1.25”, 1.75”, and 2.75” bend radius options for the operators in order to test our full range of 3”-6” pipe. We designed interchangeable pieces that slide along the top of the actuator shaft that can be fastened in place when testing different pipe diameters. There are (4) different radius options available, which match the requirements requested.

Ease of access to the pneumatic actuator is important for maintenance or replacement. The design includes two brackets that the actuator bolts directly into. The brackets can be removed easily with two people on each side after removing the fasteners. They are also able to securely support the weight of the actuator that we decide to use.

The actuator’s shaft was a bit too short for the arm to be above the 6” diameter pipe, so a machinable coupling was added to the top. This is the part that the radius pieces slide over top of. This also allowed a tapped hole to be drilled in the side for the arm to be placed correctly. The arm, being a steel rod, has multiple threaded holes along the middle so the wheel position can be adjusted between pipe diameters.

3. Expected Findings

Once we have our design manufactured, tested, and running we expect that this fixture will be able to save our company time and money, which is our ultimate goal. In the end, we should have a completely automated testing fixture to bend 3”-6” HDPE pipe at any plant necessary that is easily operated. Along with this, force data feedback will be collected and correlated with resin formulas that are currently being used on the line. The “HD” in HDPE is our high-density material, which is more expensive than our standard polyethylene resin that is used. If we can use the least amount of that in our mixture, we will be able to save money in the long run while keeping our customers satisfied and happy.

Hopefully this test fixture will aid in the process of establishing an ASTM or AASHTO testing standard for the products being tested in the future with our quality control department. This would also eliminate any further customer complaints about non-standard testing procedures that people purchasing the product may do in the field. Any product waste and scrap that can be reduced will aid in our production and reputation with the customers we sell to. Being able to standardize any testing process within our company is essential and important.

4. Conclusion

The design group has made great progress so far and are prepared to move forward with quotes and assembly of machine. After implementing guarding into the design, making it automated with air controls, and allowing for data collection through a force gauge, we have met the standards ADS wants for this project.

Keeping our number one priority on safety, we believe we have created an effective design that guards the automated mechanism and prevents any plastic projectiles from flying out at employees upon pipe fractures. A rotary air actuator was chosen in the design to eliminate human variance in testing and maintain a standard applied force and angle during testing. Finally, the force and angle measurements will allow for reference data to be kept and analyzed to help produce pipe that passes this fracture test and keep customers interested in choosing our products.

Our plans now are to have the engineering team fully review the design before the assembly process begins and have their input on any needed design changes. The biggest challenge moving forward will be implementing these air controls properly and effectively. This will be a learning process considering neither of us have experience with pneumatic controls. We plan to start the assembly process as soon as possible when things start to let up with COVID-19 and can transition back into the office setting when permitted.

Overall, we were able to continue the design process under the circumstances we were dealt with during the pandemic and we were able to adapt to a new working environment from home. Even though we did not get the testing fixture built and tested, the project is still ongoing with the company and should be put into production in the future. Engineering is all about ongoing changes and priorities, so we ended up learning more than what we hoped for with the situation at hand.

5. References

[1] Groundwater Engineering, n.d., from https://www.groundwatereng.com/dewatering-techniques/wellpoints

[2] Complete Dewatering Points and Wellpoints Inc., n.d., from https://cdpwinc.com/sock-systems

[3] Bioshishan, n.d., from https://www.amazon.com/BAOSHISHAN-DL-50-Force-Gauge-Pound/dp/B015WK5U8Y?th=1

[4] Advanced Drainage Systems Quality Control Department

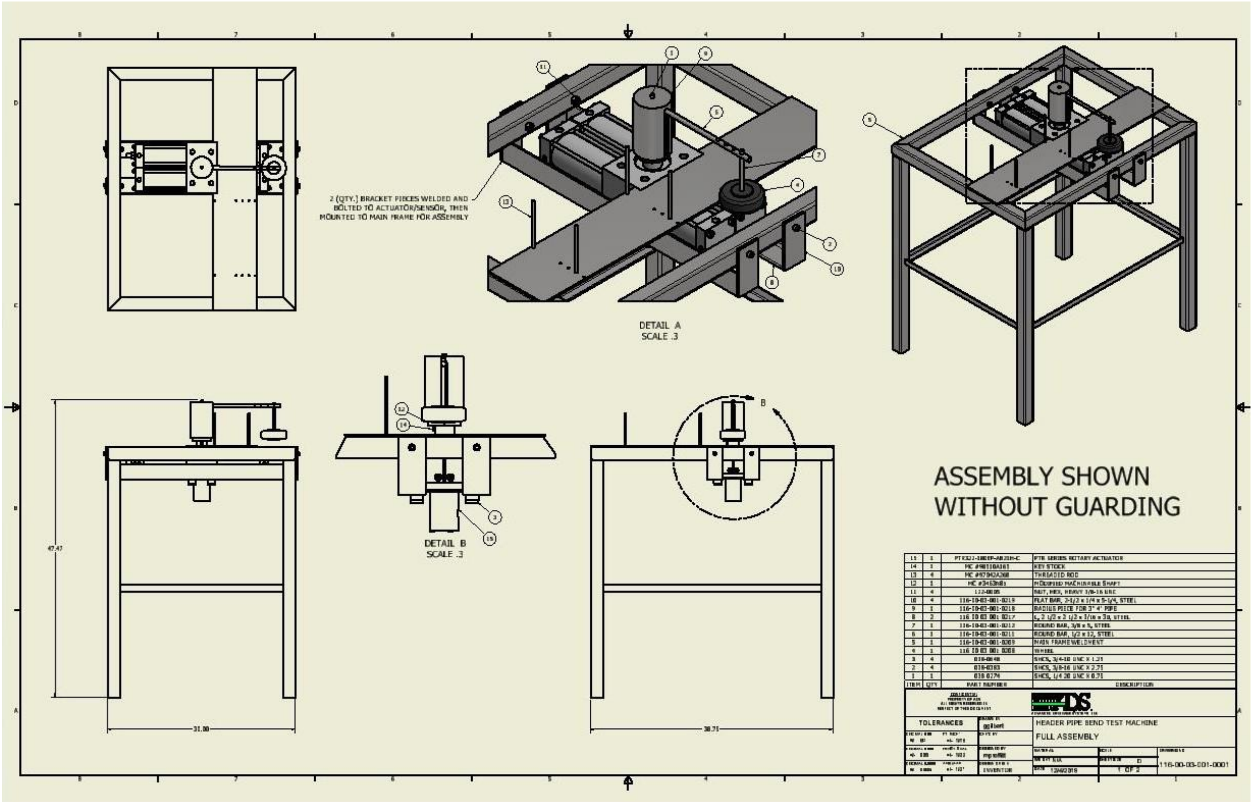
6. Appendices

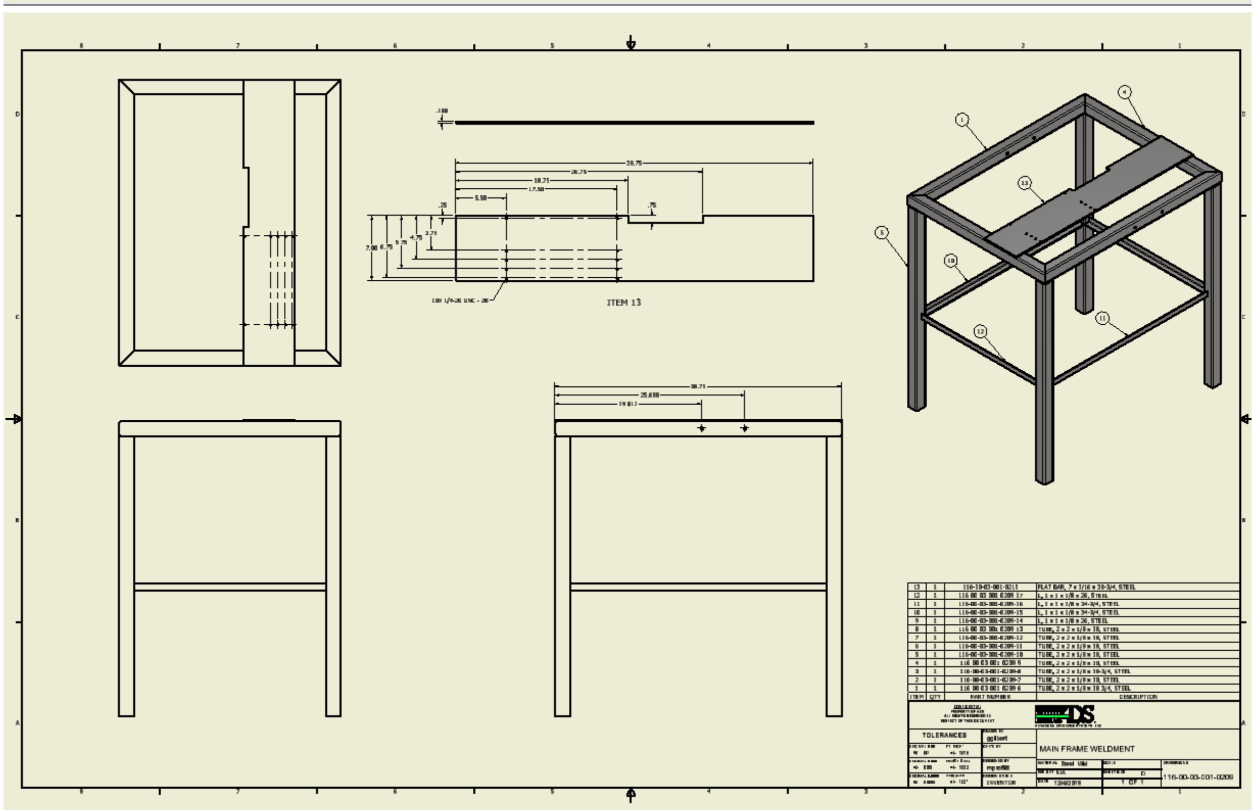
6.1 Additional Photos

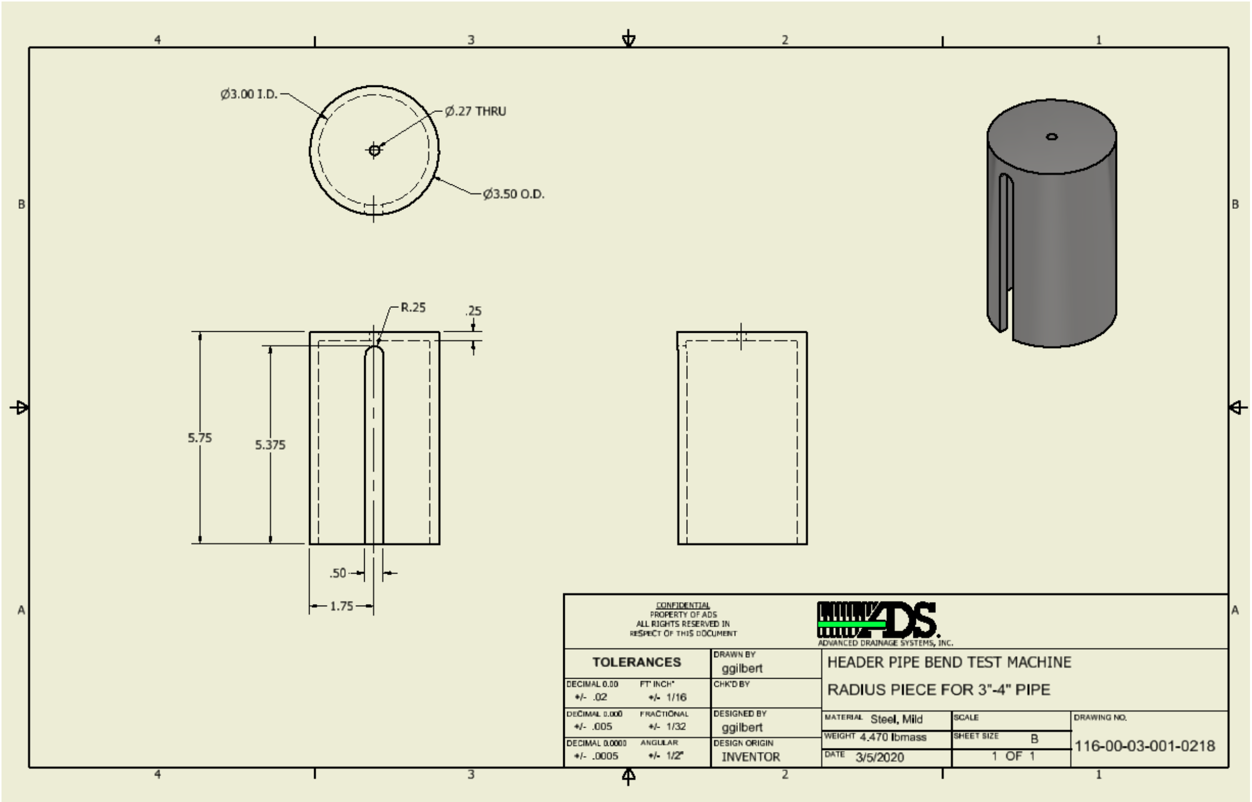
6.1a Testing

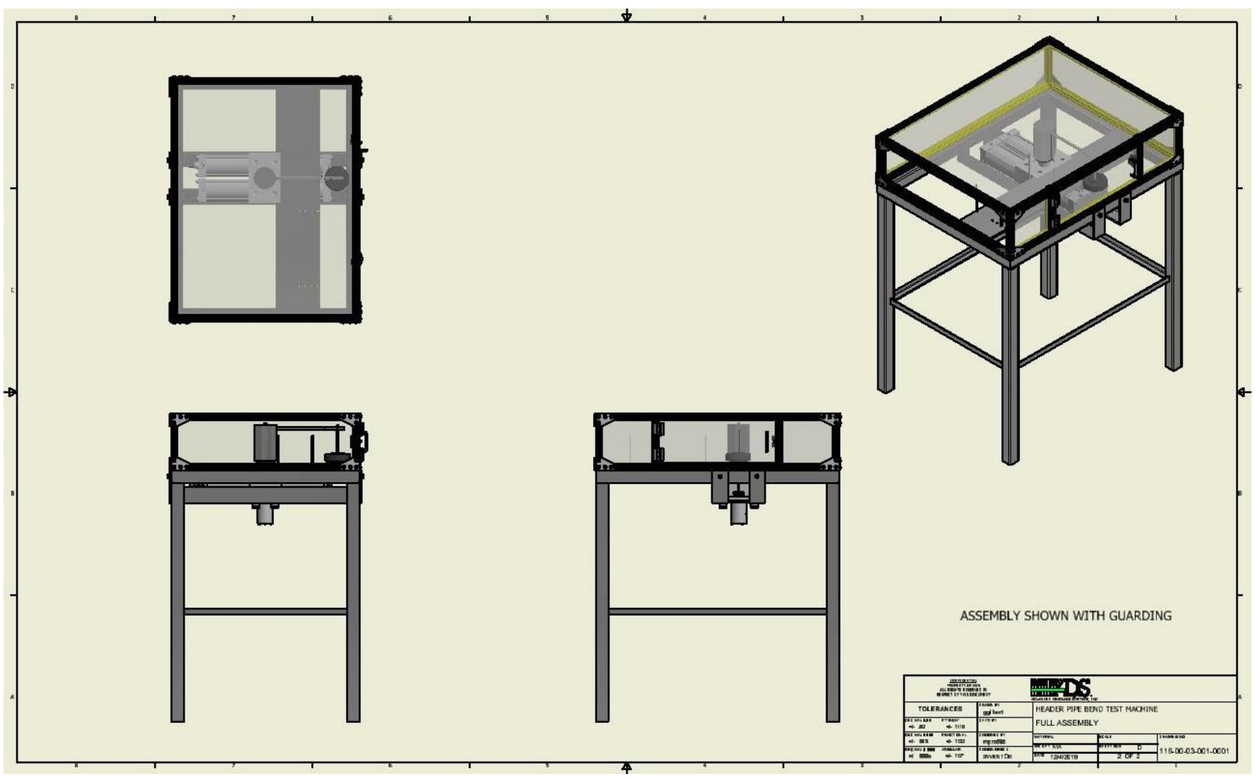
6.1b Existing Fixture

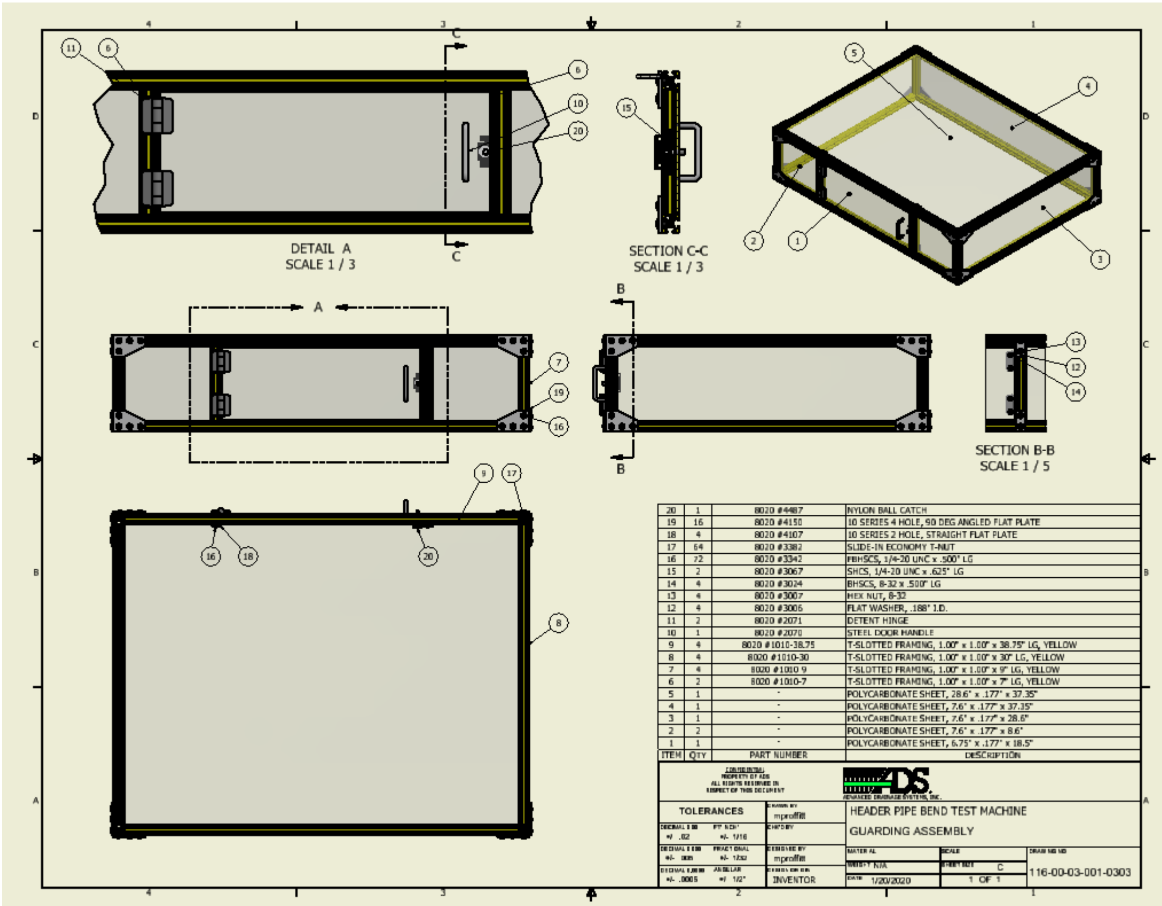
6.2 Manufacturing Drawings


2 (QTY.) BRACKET PIECES WELDED AND BOLTED TO ACTUATOR/SENSOR, THEN MOUNTED TO MAIN FRAME FOR ASSEMBLY
DETAIL A
SCALE .3
DETAIL B
SCALE .3
ASSEMBLY SHOWN WITHOUT GUARDING
TOLERANCES
HEADER PIPE BEND TEST MACHINE
FULL ASSEMBLY


ITEM 13
TOLERANCES
MAIN FRAME WELDMENT


Ø3.00 I.D.
Ø.27 THRU
Ø3.50 O.D.
R.25
.25
5.75
5.375
.50
1.75
CONFIDENTIAL
PROPERTY OF ADS
ALL RIGHTS RESERVED IN
RESPECT OF THIS DOCUMENT
ADS.
ADVANCED DRAINAGE SYSTEMS, INC.
TOLERANCES
DECIMAL 0.00 +/- .02
FT' INCH" +/- 1/16
DECIMAL 0.000 +/- .005
FRACTIONAL +/- 1/32
DECIMAL 0.0000 +/- .0005
ANGULAR +/- 1/2°
DRAWN BY ggilbert
CHK'D BY
DESIGNED BY ggilbert
DESIGN ORIGIN INVENTOR
HEADER PIPE BEND TEST MACHINE
RADIUS PIECE FOR 3"-4" PIPE
MATERIAL Steel, Mild
WEIGHT 4.470 lbmass
DATE 3/5/2020
SCALE
SHEET SIZE B
1 OF 1
DRAWING NO.
116-00-03-001-0218


ASSEMBLY SHOWN WITH GUARDING
HEADER PIPE BEND TEST MACHINE
FULL ASSEMBLY


DETAIL A
SCALE 1 / 3
SECTION C-C
SCALE 1 / 3
SECTION B-B
SCALE 1 / 5
20 | 1 | 8020 #4487 | NYLON BALL CATCH
19 | 16 | 8020 #4150 | 10 SERIES 4 HOLE, 90 DEG ANGLED FLAT PLATE
18 | 4 | 8020 #4107 | 10 SERIES 2 HOLE, STRAIGHT FLAT PLATE
17 | 64 | 8020 #3382 | SLIDE-IN ECONOMY T-NUT
16 | 72 | 8020 #3342 | FBHSCS, 1/4-20 UNC x .500" LG
15 | 2 | 8020 #3067 | SHCS, 1/4-20 UNC x .625" LG
14 | 4 | 8020 #3024 | BHSCS, 8-32 x .500" LG
13 | 4 | 8020 #3007 | HEX NUT, 8-32
12 | 4 | 8020 #3006 | FLAT WASHER, .188" I.D.
11 | 2 | 8020 #2071 | DETENT HINGE
10 | 1 | 8020 #2070 | STEEL DOOR HANDLE
9 | 4 | 8020 #1010-38.75 | T-SLOTTED FRAMING, 1.00" x 1.00" x 38.75" LG, YELLOW
8 | 4 | 8020 #1010-30 | T-SLOTTED FRAMING, 1.00" x 1.00" x 30" LG, YELLOW
7 | 4 | 8020 #1010 9 | T-SLOTTED FRAMING, 1.00" x 1.00" x 9" LG, YELLOW
6 | 2 | 8020 #1010-7 | T-SLOTTED FRAMING, 1.00" x 1.00" x 7" LG, YELLOW
5 | 1 | - | POLYCARBONATE SHEET, 28.6" x .177" x 37.35"
4 | 1 | - | POLYCARBONATE SHEET, 7.6" x .177" x 37.35"
3 | 1 | - | POLYCARBONATE SHEET, 7.6" x .177" x 28.6"
2 | 2 | - | POLYCARBONATE SHEET, 7.6" x .177" x 8.6"
1 | 1 | - | POLYCARBONATE SHEET, 6.75" x .177" x 18.5"
ITEM | QTY | PART NUMBER | DESCRIPTION
TOLERANCES
+/- .02
+/- 1/16
+/- 1/32
+/- .0005
+/- 1/2"
mproffitt
mproffitt
INVENTOR
HEADER PIPE BEND TEST MACHINE
GUARDING ASSEMBLY
N/A
C
1/20/2020
1 OF 1
116-00-03-001-0303

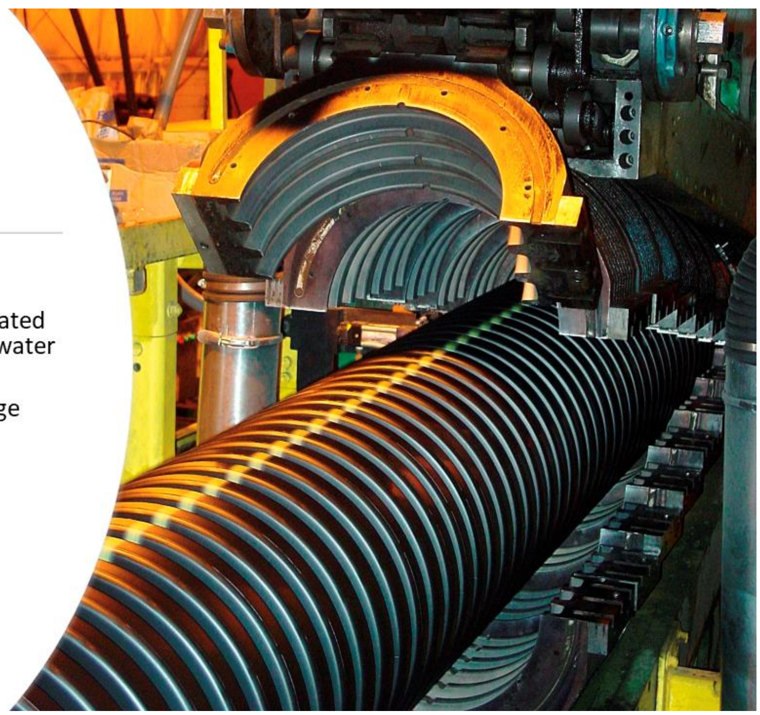
6.3 PowerPoint Presentation

Pipe Bend Tester

Morgan Proffitt, George Gilbert

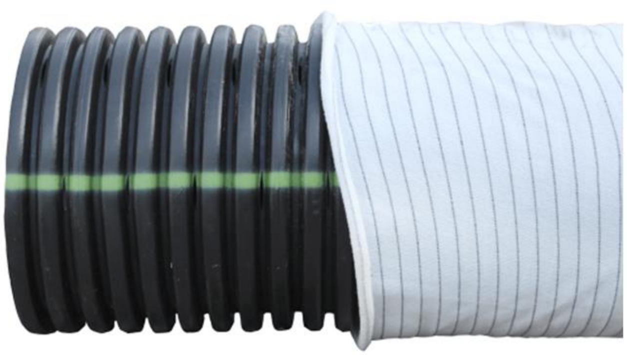
Background- Advanced Drainage Systems

- The company was founded in 1966
- ADS is a leading manufacturer of corrugated drainage pipe focusing on solutions for water management problems
- Two main products are storm and sewage
- These solutions include:
  - Managing storm water runoff
  - Rainwater harvesting systems
  - Construction and infrastructure environment



Our Test Product

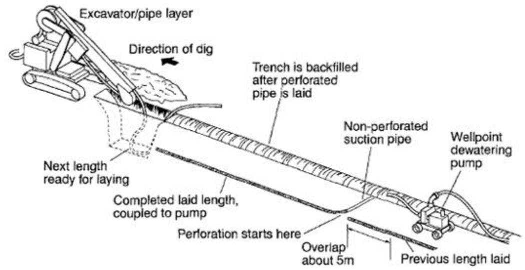
- 5” diameter single wall, perforated pipe
- HDPE (High Density Polyethylene)
- Sock is used on outside of pipe - prevents sand infiltration
- Resistance to chemicals, road salts, motor oil, and gasoline
- Only manufactured in Sebring, FL and Owosso, MI



What is the product used for?

<u>Dewatering Construction Sites</u>

- Temporarily lowers water table groundwater levels
- Keeps excavation sites dry and safe
- Water is moved to a discharge location
- Prevents soil erosion during construction
- Often provide most cost-effective method of dewatering
- Capped for future use or abandoned in place



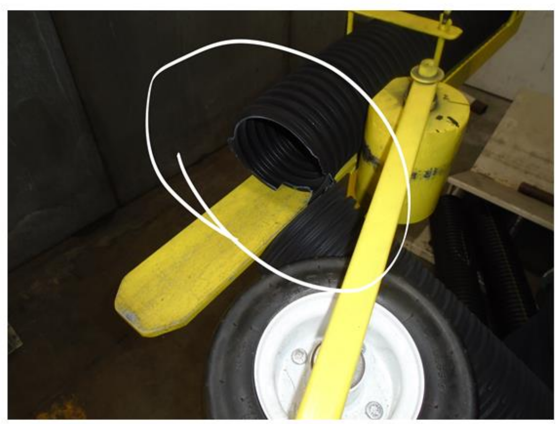
Installation - Trenching

What are the current issues?

- Potential for cracking under cold weather conditions
- Customers send the product back for replacement
- Resin recipe adjustments are made when necessary
- Typically use a 20-80 recipe (20% being our high-density material)
- Customer's have their own "testing" procedures
- Does not currently follow any AASHTO or ASTM standards for the "bend testing" being done – hopefully in future

Existing Test Fixture

Existing Test Fixture



Existing Test Fixture

Test Procedure

- Testing samples every hour of production
- Freeze the pipe to 28°F
- Manually pull the arm back, bending the pipe approximately 180°
- Success/fail
- Looking for fractures and cracking
- Adjust manufacturing operations if needed

Problems

- Safety - no guarding
- No force measurement or data collection
- Manual test - no standard applied force (different every test)
- Not easily mobile - bolted to plant floor
- Only tests one specific diameter

Objective

Improve the existing test fixture design

Automated motion using air control
Fully guarded machine
Measure max force
Ability to test 3”, 4”, 5”, and 6” diameters
Make things more efficient and easier for operators

Keep things simple

Low cost
Exclude expensive data collection
Standard and purchase parts for easy replacement in the plants
Ergonomic for easy access and use for plant workers

Justification

- Safety is #1 priority
- Apply a standard force and angle
  - Manual allows for variation between tests
- Eliminate fractures and cracking

WBS

Begin Process of New Design

- Structural build
- Automation
- Safety

Part Ordering/Fabrication

- Complete drawing packet with BOM
- Quotes for build

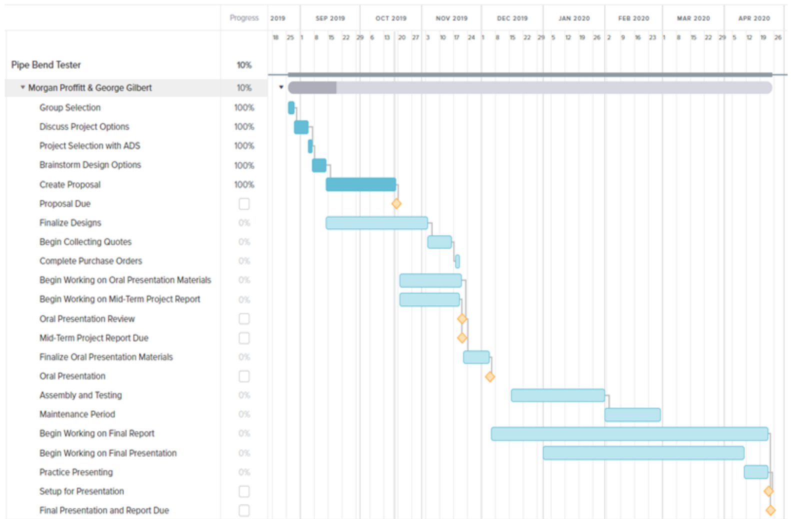
Assembly/Testing

- Assemble anything outside of fabrication process
- Test the machine including tests for 3”,4”, 5”, and 6”

Data Collection

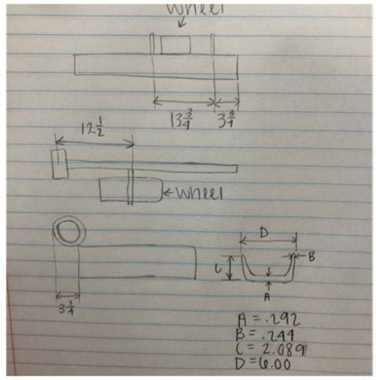
- Collect data with the implemented system designed for the machine

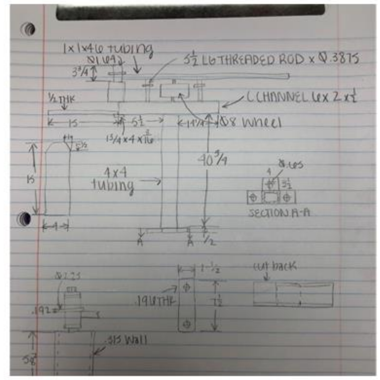
Timeline



Estimated Cost and Budget

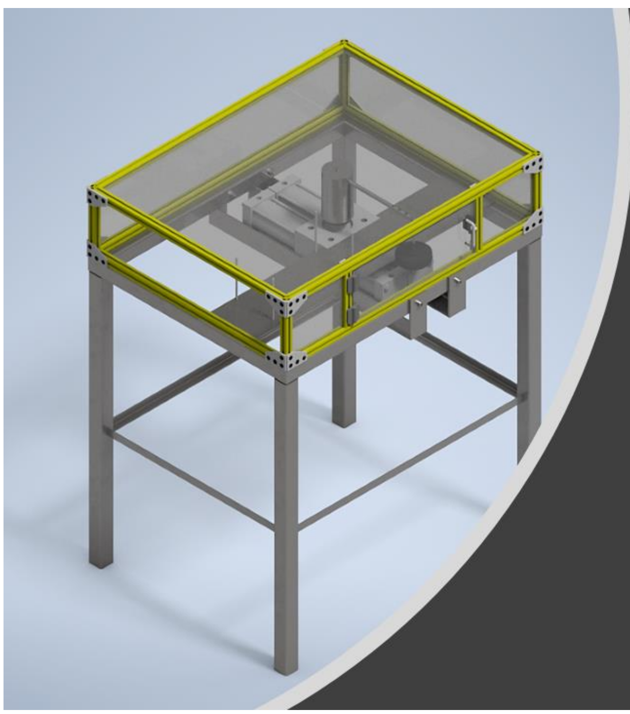
Part	Quantity	Manufacturer	Part Number	Price	Estimated Ship Date
Pnuematic Rotary Actuator	1	Air & Oil - Option 1	FBRM-1801O-BBA2	$2,247.96	5-7 Weeks
Pnuematic Rotary Actuator	1	Air & Oil - Option 2	FBRP-1801P-BBA2	$3,486.12	5-7 Weeks
Pnuematic Rotary Actuator	1	Parker - Option 3	PTR322-1803P-AB21H-C	$7,708.00	7-8 Weeks
Strain Gauges	1	TBD	TBD	$150.00	TBD
Valve Fittings	1	McMaster-Carr	TBD	$50.00	Immediate
Wheel	1	McMaster-Carr	TBD	$25.00	Immediate
Guarding	1	80/20 T-Slotted Framing	TBD	$1,500.00	Immediate
Frame Weldment	1	Vendor	116-00-03-001-0001	$1,000.00	Est 2 Weeks
Shipping	1	Vendor	N/A	$100.00	Immediate
E-Stop	1	McMaster-Carr	6464K18	$33.22	Immediate
Acrylic Sheets	1	McMaster-Carr	8560K435	$150.00	Immediate
Air Tank (if needed)	1	McMaster-Carr	41705K39	$329.09	Immediate
Total - Option 1				**$5,585.27**	
Total - Option 2				**$6,823.43**	
Total - Option 3				**$11,045.31**	





Redesigning

- Measuring existing fixture
- Modeling in Inventor for reference



Safety: #1 Priority in Design

Guarding

Guarding

Aluminum guard frame

Polycarbonate sheets

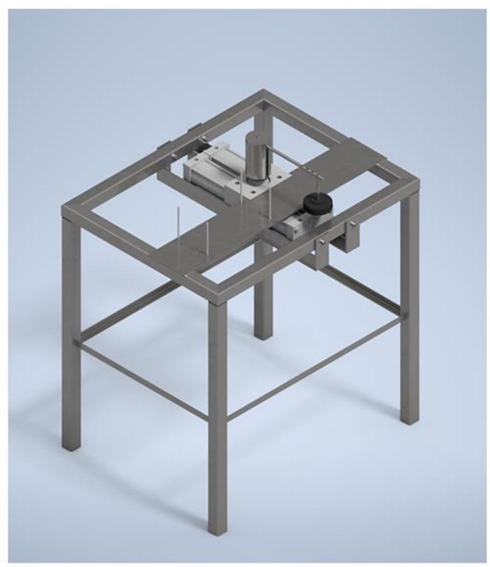
- Allows for visibility of pipe during test
- Provides protection from projectiles if pipe fails test

Allows arm radius to swing completely around inside guarding

Frame Design

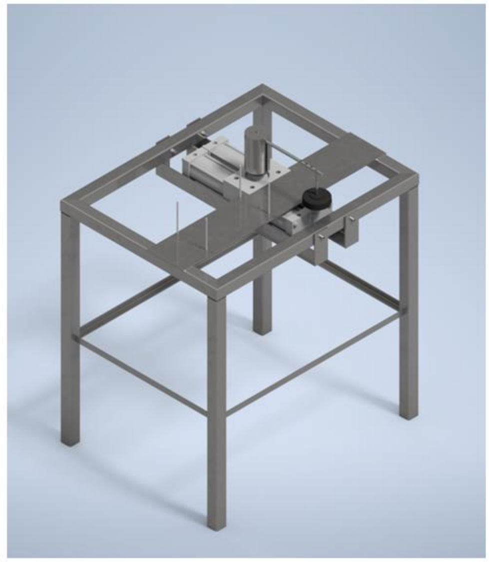
Adjusted frame design to accommodate for guarding and actuator

- Stability
- Sturdy
- Ergonomic

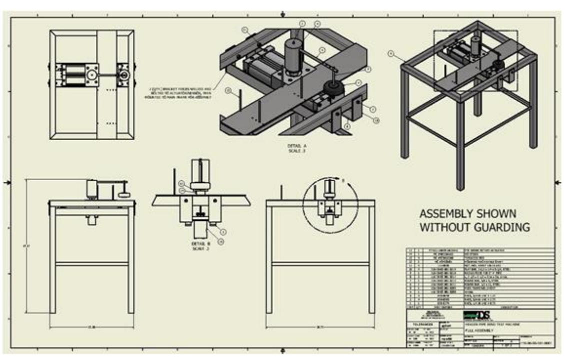


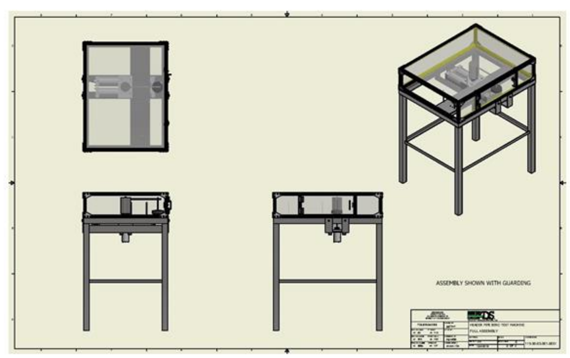
Features

- Added a smaller wheel to make frame more compact
- Wheel position and rods can be adjusted between diameters
- Interchangeable radius
- Removable brackets for actuator maintenance
- Netting can be placed on the bottom supports to catch broken pieces

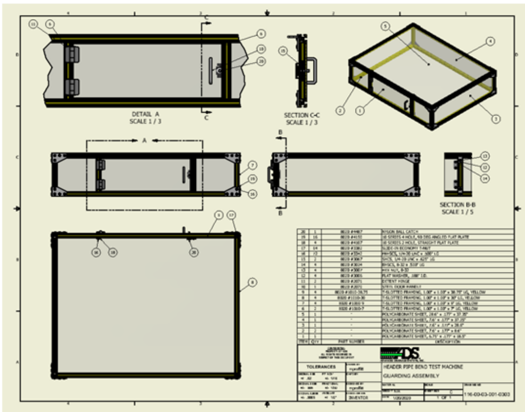


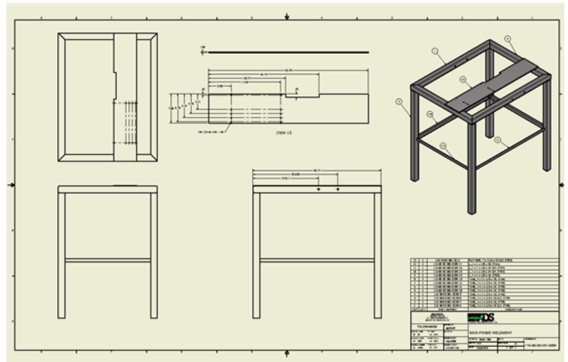
Manufacturing Drawings & Specs



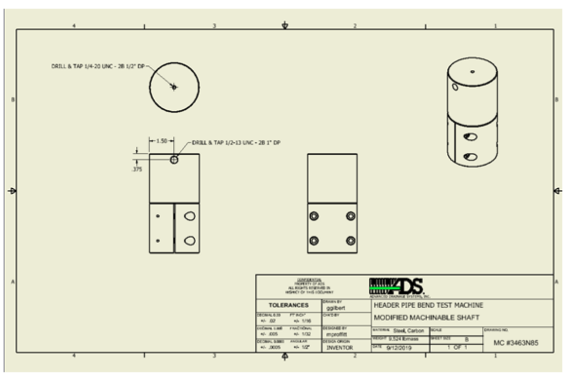


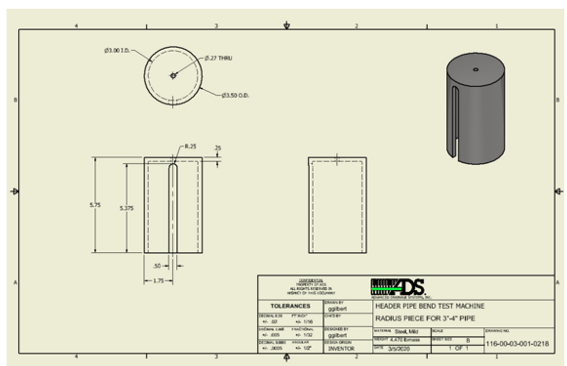
Manufacturing Drawings & Specs





Manufacturing Drawings & Specs





Air Controls - Testing

Air Controls

Catalog PDN1000-2US
Parker Pneumatic

Actuator Products – Rotary
PTR Series

Quick reference data

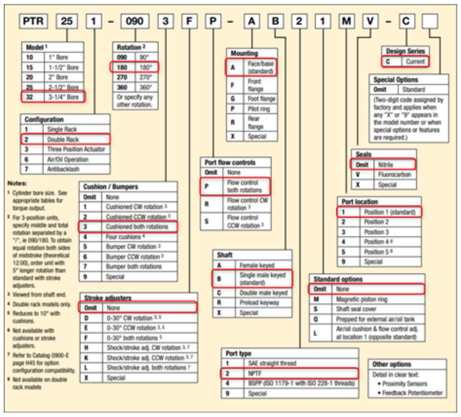
Model		Typ. actual output torque @ 100 PSI (lb-in)	Theoretical output torque* (lb-in) versus input pressure (PSI)				Displacement per degree rotation ($in^3/°$)	Maximum angular backlash (minutes)	Tolerance (degrees)
Single rack	Double rack		50	75	100	250			
101		35	19	29	39	98	0.007	60	-0, +5
	102	70	39	59	79	197	0.014	60	-0, +5
151		100	59	88	118	294	0.021	45	-0, +4
	152	200	118	177	236	590	0.042	45	-0, +4
201		250	141	212	282	705	0.049	35	-0, +3
251		375	215	322	430	1074	0.075	35	-0, +3
	202	500	282	423	565	1410	0.099	35	-0, +3
	252	750	430	644	859	2148	0.150	35	-0, +3
321		1000	570	856	1141	2852	0.199	25	-0, +2
	322	2000	1141	1711	2281	5703	0.398	25	-0, +2

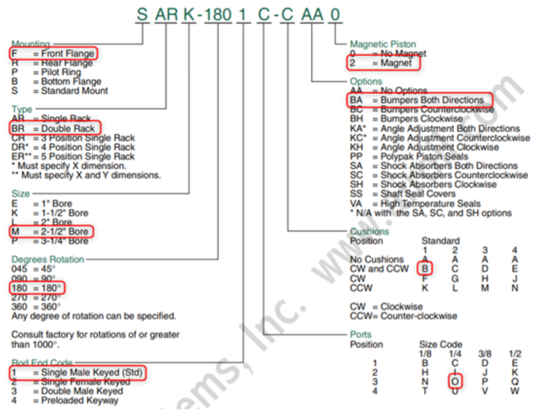
* Allow 10% for friction loss. Allow 20% on air/oil units. Use the single rack torque values for all air/oil, three position, and anti-backlash actuators.

BORE	NUMBER OF RACKS	MODEL	THEORETICAL TORQUE OUTPUT (in-lbs) 50 psi	100 psi	150 psi	DISPLACEMENT CU. IN./DEG. OF ROTATION	*MAX. ANGULAR BACKLASH, MINUTES*	MAX. ROTATIONAL TOTAL (DEGREES)
1"	1	SARE	19	39	59	0.007	50	10
1"	2	SBRE	39	79	118	0.014	50	10
1 1/2"	1	SARK	59	118	177	0.021	40	8
1 1/2"	2	SBRK	118	236	353	0.042	40	8
2"	1	SARL	141	282	424	0.049	30	6
2"	2	SBRL	282	565	848	0.099	30	6
2 1/2"	1	SARM	276	552	828	0.096	30	6
2 1/2"	2	SBRM	552	1104	1656	0.193	30	6
3 1/4"	1	SARP	570	1141	1711	0.199	15	4
3 1/4"	2	SBRP	1141	2281	3422	0.398	15	4

Allow 10% for friction loss.

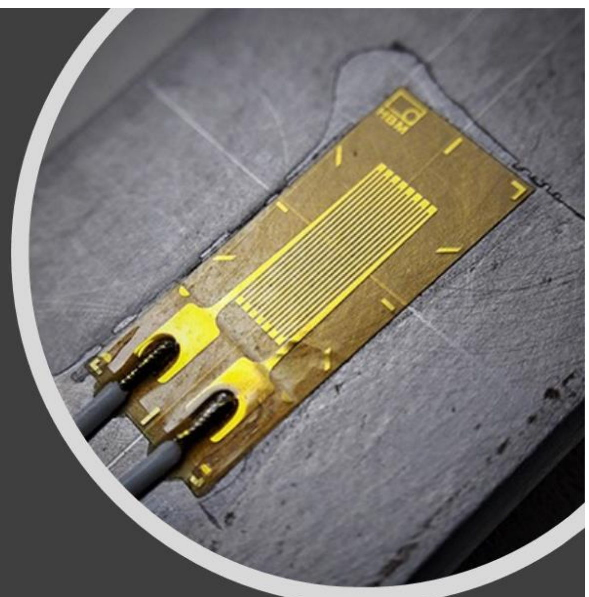
Air Controls





Measurement

- Measure max force of bend
- Relating max force to angle graphically
- Use data to improve manufacturing
- Increase wall thickness when needed to eliminate fractures
- Ability to mount device to frame with easy readability



Any Questions?

6.4 Meeting Journals

6.4a ENT 497

MIAMI UNIVERSITY

Meeting Journal
Department of Engineering Technology
ENT 497 - Senior Design Project
Project Title:

		Present
Advisor:	**Gary Drigel**	[ ]
Student:	**George Gilbert**	[ ]
Student:	**Morgan Proffitt**	[ ]
Student:		[ ]
Student:		[ ]

Meeting Date:	9/5/2019
Meeting Location:	Hamilton Campus

Topics Discussed

Project Options with Advanced Drainage Systems

- 5" Single Wall Durability Testing
- Die Tear Down Pivoting Stand

To Do

- Choose a project that makes most sense time wise and that would provide the company with the most benefit.

Responsibilities/ Actions Taken

8/30/2019

- Met with Randy Kolbet (Manufacturing Engineering Manager) about possible projects.
- Involved Quality Control Manager on scope of the 5" SW durability testing.

9/4/2019

- Met with Seth Harding (Machine Operations Manager) about possible projects.
- Discussed the scope of the tear down die stand that would be used in our machine shop.

Next Meeting Date:	**Location:** Hamilton Campus

Meeting Journal
Department of Engineering Technology
ENT 497 - Senior Design Project
Project Title:

		Present
Advisor:	**Gary Drigel**	[ ]
Student:	**George Gilbert**	[ ]
Student:	**Morgan Proffitt**	[ ]
Student:		[ ]
Student:		[ ]

Meeting Date:	9/12/2019
Meeting Location:	Hamilton Campus

Topics Discussed

Project choice:

- Chose to do the 5" Single Wall Durability Testing project

To Do

- Develop and finalize a project scope in order to write a full and complete project proposal
- Start on the project proposal

Responsibilities/ Actions Taken

9/12/2019

- Met with Randy Kolbet (Manufacturing Engineering Manager) and Terry McElfrish (Quality Control Manager) to discuss scope and and background of the project.

- Deveoped on 3 different project routes to take with design.

- Discussed end goals and project purpose.

Next Meeting Date: **Location:** Hamilton Campus

MIAMI UNIVERSITY

Meeting Journal
Department of Engineering Technology
ENT 497 - Senior Design Project
Project Title: 3"-6" Pipe Bend Tester

		Present
Advisor:	**Gary Drigel**	[ ]
Student:	**George Gilbert**	[ ]
Student:	**Morgan Proffitt**	[ ]
Student:		[ ]
Student:		[ ]

Meeting Date:	9/19/2019
Meeting Location:	Hamilton Campus

Topics Discussed

- Air pnuematics and controls that could be used
- Guarding options as safety will be our #1 priority in all designs
- 3 separate design options will be made (manual, air controled, and air controlled with electronic data output)

Responsibilities/ Actions Taken

- Began researching how air pneumatics work
- Started sketching designs and working in inventor as outlined models
- Filling in sections in the proposal with all the information we gained from the previous week
- Researched types of sensors that could be used

Next Meeting Date: **Location:** Hamilton Campus

MIAMI UNIVERSITY

Meeting Journal
Department of Engineering Technology
ENT 497 - Senior Design Project
Project Title: 3"-6" Pipe Bend Tester

		Present
Advisor:	**Gary Drigel**	[ ]
Student:	**George Gilbert**	[ ]
Student:	**Morgan Proffitt**	[ ]
Student:		[ ]
Student:		[ ]

Meeting Date:	9/26/2019
Meeting Location:	Hamilton Campus

Topics Discussed

- Are we able to get access to the existing machine in Sebring, Florida?
- What options do we have for air controls and where will it be implimented on the machine?
- Should we have interchangable parts between different sizes of pipe, or a mechanism that adjusts height?

Responsibilities/ Actions Taken

- Speak with Randy about possibly shipping the existing machine here to New Miami from Sebring.
- Writing proposal sections between the both of us.

Next Meeting Date: **Location:** Hamilton Campus

MIAMI UNIVERSITY

Meeting Journal
Department of Engineering Technology
ENT 497 - Senior Design Project
Project Title: 3"-6" Pipe Bend Tester

		Present
Advisor:	**Gary Drigel**	[ ]
Student:	**George Gilbert**	[ ]
Student:	**Morgan Proffitt**	[ ]
Student:		[ ]
Student:		[ ]

Meeting Date:	10/3/2019
Meeting Location:	Hamilton Campus

Topics Discussed

- In order to get the original manual machine to New Miami, what is the best and most cost efficient way?
- What are the specific steps we have to take in order to have everything completed on time?
- How long should we have the machine here before we send it back to Sebring?

Responsibilities/ Actions Taken

- Scheduled the machine to be shipped from Sebring with an existing shipment for a die head that needs repaired. Should be here within a week.
- Continued working on the proposal and creating the Gantt Chart.
- Looked at possible rotary air actuators that can be used in our designs.

Next Meeting Date: **Location:** Hamilton Campus

MIAMI UNIVERSITY

Meeting Journal
Department of Engineering Technology
ENT 497 - Senior Design Project
Project Title: 3"-6" Pipe Bend Tester

		Present
Advisor:	**Gary Drigel**	[ ]
Student:	**George Gilbert**	[ ]
Student:	**Morgan Proffitt**	[ ]
Student:		[ ]
Student:		[ ]

Meeting Date:	10/10/2019
Meeting Location:	Hamilton Campus

Topics Discussed

- Best way to automate this system with air control
- Any structual modifications needed to accomplish new automated system
- Best time, and most efficent way of sending the tester back on a truck to Sebring

Responsibilities/ Actions Taken

- Completed 3D model of the bend tester based off dimensions taken from the physical piece
- Continued working on the proposal, still need to finish budget and BOM of machine
- Looked at possible rotary air actuators that can be used in our designs. still need to choose one for final design
- Sent the pipe bend tester back to Sebring this morning 10/10/19

Next Meeting Date: **Location:** Hamilton Campus

MIAMI UNIVERSITY

Meeting Journal
Department of Engineering Technology
ENT 497 - Senior Design Project
Project Title: 3"-6" Pipe Bend Tester

		Present
Advisor:	**Gary Drigel**	[ ]
Student:	**George Gilbert**	[ ]
Student:	**Morgan Proffitt**	[ ]
Student:		[ ]
Student:		[ ]

Meeting Date:	10/17/2019
Meeting Location:	Hamilton Campus

Topics Discussed

- Integrating a 3-way air controlled rotary accuataor in the design
- coming up with a bom of materials and parts
- best options for budget of the project.

Responsibilities/ Actions Taken

- Completed 3D model of the bend tester based off dimensions taken from the physical piece
- BOM and budget are being put together for the proposal finish budget and BOM of machine
- Adding final comments and details to the proposal as well as a list of applicable classes that will benefit us in the project
- Bend tester arrived back at Sebring.

Next Meeting Date: **Location:** Hamilton Campus

MIAMI UNIVERSITY

Meeting Journal
Department of Engineering Technology
ENT 497 - Senior Design Project
Project Title: 3"-6" Pipe Bend Tester

		Present
Advisor:	**Gary Drigel**	[ ]
Student:	**George Gilbert**	[ ]
Student:	**Morgan Proffitt**	[ ]
Student:		[ ]
Student:		[ ]

Meeting Date:	10/24/2019
Meeting Location:	Hamilton Campus

Topics Discussed

- Integrating a 3-way air controlled rotary accuataor in the design
- Design options including guarding. And best option that includes saftey precautions for employees
- Weight of the structure and build depends on mobility and if it needs fork pockets ect.

Responsibilities/ Actions Taken

- Using the 3D cad model for design ideas and concepts that include guarding using this to ensure everything is correct before ordering parts and building
- Basic BOM and budget produced and added to proposal
- Discussed guarding options with Aaron Watkins- design engineer at ADS who specializes in guarding packages.

Next Meeting Date: **Location:** Hamilton Campus

MIAMI UNIVERSITY

Meeting Journal
Department of Engineering Technology
ENT 497 - Senior Design Project
Project Title: 3"-6" Pipe Bend Tester

		Present
Advisor:	**Gary Drigel**	[ ]
Student:	**George Gilbert**	[ ]
Student:	**Morgan Proffitt**	[ ]
Student:		[ ]
Student:		[ ]

Meeting Date:	10/31/2019
Meeting Location:	Hamilton Campus

Topics Discussed

- Continued design options with implementing rotary air unit in machine
- Dertiming overall dimensions of the machine and with guarding included.
- Discussed Weight of the structure and build depends on mobility and if it needs fork pockets.
- Discussed options if pipe breaks off in the machine, how to get it out if the machine is completely surrounded by guarding, thought of options such as doors or gate ways to open the bottom up to get broken pipe out

Responsibilities/ Actions Taken

- Continued design options with 3D models
  Using this to ensure everything is correct before ordering parts and building
- Modeled arm in the 3D sofware and added to design
- Continued discussing guarding options with Aaron Watkins- design engineer who specializes in guarding packages.

Next Meeting Date:	**Location:** Hamilton Campus

MIAMI UNIVERSITY

Meeting Journal
Department of Engineering Technology
ENT 497 - Senior Design Project
Project Title: 3"-6" Pipe Bend Tester

		Present
Advisor:	**Gary Drigel**	[ ]
Student:	**George Gilbert**	[ ]
Student:	**Morgan Proffitt**	[ ]
Student:		[ ]
Student:		[ ]

Meeting Date:	11/7/2019
Meeting Location:	Hamilton Campus

Topics Discussed

- Safety standards on openings within guarding. How much will the guarding weigh? Determined the need for four legs on machine.
- Sensor locations and pricing.
- Vendors that will be used for quoting for guarding and weldments.

Responsibilities/ Actions Taken

- Continued designing in Autodesk Inventor.
- Meeting with Aaron about safety standards within the guarding design.
- Sensor and guage research.

Next Meeting Date:	**Location:** Hamilton Campus

MIAMI UNIVERSITY	Meeting Journal Department of Engineering Technology ENT 497 - Senior Design Project Project Title: 3"-6" Pipe Bend Tester

		Present
Advisor:	Gary Drigel	[ ]
Student:	George Gilbert	[ ]
Student:	Morgan Proffitt	[ ]
Student:		[ ]
Student:		[ ]

Meeting Date:	11/14/2019
Meeting Location:	Hamilton Campus

Topics Discussed

- Different styles of guarding option concepts-using plexi glass instead of expanded metal
- Sensor locations and pricing.
- Vendors that will be used for quoting for guarding and weldments.
- accomodating for different sized pipe diameters.

Responsibilities/ Actions Taken

- Continued designing in Autodesk Inventor.
- Meeting with Aaron about safety standards within the guarding design. also gave thoughts on machine design and the components used.
- started working on oral presentation. Including all information we have about the project and back ground of company and purpose for ADS

Next Meeting Date:	Location: Hamilton Campus

6.4b ENT 498

MIAMI UNIVERSITY	**Meeting Journal** **Department of Engineering Technology** **ENT 498 - Senior Design Project** **Project Title: 3"-6" Pipe Bend Tester**

		Present
Advisor:	**Gary Drigel**	[ ]
Student:	**George Gilbert**	[ ]
Student:	**Morgan Proffitt**	[ ]
Student:		[ ]
Student:		[ ]

Meeting Date:	1/28/2020
Meeting Location:	Hamilton Campus

Topics Discussed

- Over break we discussed sensor design and placement
- plan to call and speak with company on sensors
- Pipe samples

Responsibilities/ Actions Taken

- Received pipe samples
- Updated saftey guarding design
- Sensor and guage research.

Next Meeting Date: 2/6/2020	**Location** Hamilton Campus

MIAMI UNIVERSITY

Meeting Journal
Department of Engineering Technology
ENT 498 - Senior Design Project
Project Title: 3"-6" Pipe Bend Tester

		Present
Advisor:	**Gary Drigel**	[ ]
Student:	**George Gilbert**	[ ]
Student:	**Morgan Proffitt**	[ ]
Student:		[ ]
Student:		[ ]

Meeting Date:	2/6/2020
Meeting Location:	Hamilton Campus

Topics Discussed

- Discussed pipe bend testing procedures with samples
- Met with Gary on force guage
- Met with quality lab manager on freezing pipe to test temp

Responsibilities/ Actions Taken

- Placed pipe in freezer to get it to test temp
- Bend tested one frozen pipe and one room temp pipe
- Determined force needed to apply to pipe

Next Meeting Date: 2/13/2020	**Location:** Hamilton Campus

MIAMI UNIVERSITY

Meeting Journal
Department of Engineering Technology
ENT 498 - Senior Design Project
Project Title: 3"-6" Pipe Bend Tester

		Present
Advisor:	**Gary Drigel**	[ ]
Student:	**George Gilbert**	[ ]
Student:	**Morgan Proffitt**	[ ]
Student:		[ ]
Student:		[ ]

Meeting Date:	2/20/2020
Meeting Location:	Middletown Campus

Topics Discussed

- Redesigning some aspects of the frame to fit the larger actuator.
- Picking out the correct sensors for our application.
- Selecting the right actuator that will perform the force needed.
- Needing to get quotes out ASAP.

Responsibilities/ Actions Taken

- Redesigning frame in Inventor.
- Contact Keyence to meet about sensors (next week).
- Find out what actuators are in stock in Central Parts.

Next Meeting Date: **2/27/2020** **Location:** Middletown Campus

MIAMI UNIVERSITY

Meeting Journal
Department of Engineering Technology
ENT 498 - Senior Design Project
Project Title: 3"-6" Pipe Bend Tester

		Present
Advisor:	**Gary Drigel**	[ ]
Student:	**George Gilbert**	[ ]
Student:	**Morgan Proffitt**	[ ]
Student:		[ ]
Student:		[ ]

Meeting Date:	2/27/2020
Meeting Location:	Middletown Campus

Topics Discussed

- Redesigning some aspects of the frame to fit the larger actuator.
- Picking out the correct sensors for our application.
- Shaft design and adapters for actuator
- Waiting on Quotes

Responsibilities/ Actions Taken

- Added bracket on frame to hold actuator
- Contact Keyence to meet about sensors (tomorrow).
- Get other equipment ordered (actuator ect.)

Next Meeting Date:	**3/5/2020**	**Location:**	Middletown Campus

MIAMI UNIVERSITY

Meeting Journal
Department of Engineering Technology
ENT 498 - Senior Design Project
Project Title: 3"-6" Pipe Bend Tester

		Present
Advisor:	**Gary Drigel**	[ ]
Student:	**George Gilbert**	[ ]
Student:	**Morgan Proffitt**	[ ]
Student:		[ ]
Student:		[ ]

Meeting Date:	3/5/2020
Meeting Location:	Middletown Campus

Topics Discussed

- All specs of actuator needs to be decided before order.
- Picking out the correct sensors for our application.
- Actuator mounting to be finalized to hold up 66lb.
- Need to go over quotes with engineering manager Randy Kolbet.

Responsibilities/ Actions Taken

- All actuator information put into a document for review.
- Meeting scheduled for 3/6/2020 for review and ordering with Randy.
- Lead time for frame is about one week.

Next Meeting Date: **3/12/2020** **Location:** Middletown Campus

MIAMI UNIVERSITY

Meeting Journal
Department of Engineering Technology
ENT 498 - Senior Design Project
Project Title: 3"-6" Pipe Bend Tester

		Present
Advisor:	**Gary Drigel**	[ ]
Student:	**George Gilbert**	[ ]
Student:	**Morgan Proffitt**	[ ]
Student:		[ ]
Student:		[ ]

Meeting Date:	3/12/2020
Meeting Location:	Middletown Campus

Topics Discussed

- Finalization of pneumatic actuator selection.
- Picking out the correct sensors for our application.
- Options for the shaft adapter.

Responsibilities/ Actions Taken

- Waiting on Parker to return a quote an lead time for our actuator.
- Met with Randy about actuator and final frame design.
- Once we know the final lead time of the actuator we can move forward with everything else.
- FEA analysis done on frame.

Next Meeting Date: 3/19/2020 **Location:** Middletown Campus

MIAMI UNIVERSITY

Meeting Journal
Department of Engineering Technology
ENT 498 - Senior Design Project
Project Title: 3"-6" Pipe Bend Tester

		Present
Advisor:	**Gary Drigel**	[ ]
Student:	**George Gilbert**	[ ]
Student:	**Morgan Proffitt**	[ ]
Student:		[ ]
Student:		[ ]

Meeting Date:	3/19/2020
Meeting Location:	Middletown Campus

Topics Discussed

- Replacement actuator options.
- Reducing sensor options on actuator for shorter lead times.
- Last resort - chain drive design instead of pnuematic actuator.

Responsibilities/ Actions Taken

- Parker actuator is 7-8 week lead time.
- Waiting on additional quotes for Numatics actuator.
- Meetings with Randy multiple times a week.
- Trying to work around shutdowns and meeting remotely.

Next Meeting Date: **4/2/2020** **Location:** Middletown Campus

MIAMI UNIVERSITY

Meeting Journal
Department of Engineering Technology
ENT 498 - Senior Design Project
Project Title: 3"-6" Pipe Bend Tester

		Present
Advisor:	**Gary Drigel**	[ ]
Student:	**George Gilbert**	[ ]
Student:	**Morgan Proffitt**	[ ]
Student:		[ ]
Student:		[ ]

Meeting Date:	4/2/2020
Meeting Location:	Webex

Topics Discussed

- Additional design aside from using a rotary actuator.
- Not able to get parts in time due to everything going on with the shut downs and spending cuts within the company.
- Focus on report, presentation, and additional design adjustment.

Responsibilities/ Actions Taken

- New design using a chain drive with sprockets and a linear actuator as an option to rotate the arm in order to bend the pipe.
- Working on writing the paper in full detail.
- Working on powerpoint presentation for video.

Next Meeting Date: 4/9/2020 **Location:** Webex

MIAMI UNIVERSITY

Meeting Journal
Department of Engineering Technology
ENT 498 - Senior Design Project
Project Title: 3"-6" Pipe Bend Tester

		Present
Advisor:	**Gary Drigel**	[ ]
Student:	**George Gilbert**	[ ]
Student:	**Morgan Proffitt**	[ ]
Student:		[ ]
Student:		[ ]

Meeting Date:	4/9/2020
Meeting Location:	Webex

Topics Discussed

- Continued on Report and Presentation
- Further discussion on secondary design
- how to implement this in the report

Responsibilities/ Actions Taken

- Detail drafts of assembly and parts.
- Continued working on writing the paper in full detail.
- Continued working on powerpoint presentation for video.

Next Meeting Date: **4/16/2020** **Location:** Webex

MIAMI UNIVERSITY

Meeting Journal
Department of Engineering Technology
ENT 498 - Senior Design Project
Project Title: 3"-6" Pipe Bend Tester

		Present
Advisor:	**Gary Drigel**	[ ]
Student:	**George Gilbert**	[ ]
Student:	**Morgan Proffitt**	[ ]
Student:		[ ]
Student:		[ ]

Meeting Date:	4/16/2020
Meeting Location:	Webex

Topics Discussed

- Video recording presentation
- Adding more to powerpoint
- Discussed possible practice times

Responsibilities/ Actions Taken

- Continued work on powerpoint and report
- Adding in drafts and detailed part views to powerpoint

Next Meeting Date: **4/23/2020** **Location:** Webex

MIAMI UNIVERSITY

Meeting Journal
Department of Engineering Technology
ENT 498 - Senior Design Project
Project Title: 3"-6" Pipe Bend Tester

		Present
Advisor:	**Gary Drigel**	[ ]
Student:	**George Gilbert**	[ ]
Student:	**Morgan Proffitt**	[ ]
Student:		[ ]
Student:		[ ]

Meeting Date:	4/23/2020
Meeting Location:	Webex

Topics Discussed

- Continue working on paper.
- Finish presentation and create video (due May 1)
- Continuing design after the semester with the company.

Responsibilities/ Actions Taken

- Working from home still and continuing working on presentation and final paper.

Next Meeting Date:	**4/30/2020**	**Location:**	Webex

MIAMI UNIVERSITY

Meeting Journal
Department of Engineering Technology
ENT 498 - Senior Design Project
Project Title: 3"-6" Pipe Bend Tester

		Present
Advisor:	**Gary Drigel**	[ ]
Student:	**George Gilbert**	[ ]
Student:	**Morgan Proffitt**	[ ]
Student:		[ ]
Student:		[ ]

Meeting Date:	4/30/2020
Meeting Location:	Webex

Topics Discussed

- Video recording presentation
- Continuing on powerpoint
- Continuing on paper

Responsibilities/ Actions Taken

- Adding high detail design images in the powerpoint and paper
- Finalizing paper and presentation.

Next Meeting Date: **Location:** Webex

6.5 Individual Reflective Essays

6.5a George Gilbert

George Gilbert

ENT498 Senior Design

Prof. Gary Drigel

Reflective Essay

During spring semester 2020 we were tasked with finishing our set goals for the senior design project and presenting our findings. Overall, I've had a positive experience with our instructor/mentor, Gary Drigel, and the people at Advanced Drainage Systems. We did experience a few setbacks caused by the current pandemic with COVID-19, but this did not completely stop us from pursuing our goals. I am thankful for this opportunity to pursue an engineering project that provided design experience, communication skills, and time/project management experience in a work environment.

The Design aspect was very useful in giving experience on troubleshooting and coming up with a good design for an engineering task. We were given standards and parameters to meet all while keeping it at the lowest cost possible. The project also required the machine to be fully guarded to meet safety standards. Our final design ending up meeting these standards although it has yet to be built with the current circumstances. I really enjoyed the design experience and it provided needed skills for the engineering industry.

Communication was a key factor during the semester. Making sure everything is clear with supervisors and between teammates is very important. We did a great job with this, partially due to us both working at ADS and having preexisting knowledge on ADS product.

The supervisors for this project were kept up to date and provided insight on our machine design. It was a helpful experience working with ADS on this project and it greatly helped my communication skills as an engineer.

Project management also played a huge role in the design. This project really put the skills taught in the project management course to the test. Time management is very important and must be kept steady in order to accomplish everything on time. I believe we put in a good effort in our time management as well as managing the tasks. Implementing these skills in a project for an employer is much needed experience as a newly graduated engineering student.

Overall, we did a great job with what we had to work with in the project. Although we did not complete the build of the design due to the circumstances, we still plan to continue this with ADS after the semester has ended, and eventually build the design to spec. This has provided experience as an engineer in a working environment and has helped develop skills to perform tasks required by industry standards.

6.5b Morgan Proffitt

Morgan Proffitt

ENT489 Senior Design

Prof. Gary Drigel

Reflective Essay

Senior Design has been an experience that has been both fulfilling and educating in many ways. Luckily, I had the opportunity to work with a coworker of mine at Advanced Drainage Systems, George Gilbert, which made this process much easier. Another plus was the project offer from our manager, Randy Kolbet, which will be fully funded and a good asset for the Quality Control department. I could not imagine any better circumstances to have started off with in the beginning of this design process.

Our team made sure to have constant and direct communication between one other, the engineering department, quality control, and our professor in order to all be on the same page. This was important so that we had all the information we needed along with any requirements that needed to be met for the school and the company. We utilized conference calls and in-person meetings at ADS in order to achieve this.

The design process was extensive, and we found ourselves running into certain issues or roadblocks, so the design would have to change multiple times before the final product. This is normal in a design process in the real world, so it was a good learning experience to be able to problem solve and adapt to new situations. For example, once we found out what actuator we needed, we had to redesign the frame and guarding in order to fit it, since we predicted that the actuator would be a bit smaller and more compact. We also took advantage of our safety management team to ensure that the guarding would have the correct specifications and durability needed in the plants.

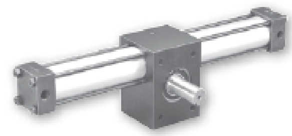
Having a timeline and list of steps to take along our journey helped quite a bit, up until we saw the beginning of the world pandemic, COVID-19, starting to affect multiple aspects of the way the United States was operating, along with the rest of the globe. The beginning of March we were relocated to work from home and were having problems being able to obtain parts needed for our design due to longer arrival times. This was a good lesson of adaptation and being able to work with what you can under different circumstances, which you face in your lifetime more than once.

This semester taught us so many aspects of real-world engineering concepts, such as project management, design, research, communication, and working efficiently as a team. Having such a supportive and knowledgeable professor aided in our educational experience. You can take all the engineering classes you want, but they do not necessarily provide the kind of knowledge or experience needed to work out in the field when you graduate. Therefore, Senior Design has been able to provide this for us and allow us to participate in these sorts of projects that we will be facing in the near future.

Overall, I believe that George and I were able to work well with the resources and circumstances that we had. We were able to learn about air logic, frame design, long distance communication, industry and safety standards, saving cost and time for the company, and adapting to a changing environment. We will be continuing this project after the end of the semester with ADS and look forward to the outcome and seeing the fixture being used during manufacturing operations.

Click here to view bookmarks.

- Rack and pinion rotary actuator
- 5 bore sizes from 1" to 3-1/4"
- Output torque @ 100 PSIG: 39 lb-in to 2281 lb-in
- Standard rotations: 90°, 180°, 270°, 360°
- Available as single or double rack, 3 position, air/oil, anitbacklash
- Optional bumpers, cushions, stroke adjusters, shock absorbers



Operating information

Operating pressure:	250 PSIG
Temperature range:	
Nitrile seals	0°F to 180°F
Fluorocarbon seals	0°F to 250°F
Filtration requirements:	40 micron, dry filtered air
For technical information see CD	

Sensors
For sensors see page B294.

Ordering information

PTR 25 1 – 090 3 F P – A B 2 1 M V – C [ ]

Model [1]	
10	1" Bore
15	1-1/2" Bore
20	2" Bore
25	2-1/2" Bore
32	3-1/4" Bore

Configuration	
1	Single Rack
2	Double Rack
3	Three Position Actuator
6	Air/Oil Operation
7	Antibacklash

Rotation [2]	
090	90°
180	180°
270	270°
360	360°
Or specify any other rotation.	

Cushion / Bumpers	
Omit	None
1	Cushioned CW rotation [3]
2	Cushioned CCW rotation [3]
3	Cushioned both rotations
4	Four cushions [4]
5	Bumper CW rotation [3]
6	Bumper CCW rotation [3]
7	Bumper both rotations
9	Special

Stroke adjusters	
Omit	None
D	0-30° CW rotation [3,5]
E	0-30° CCW rotation [3,5]
F	0-30° both rotations [5]
H	Shock/stroke adj. CW rotation [3,7]
K	Shock/stroke adj. CCW rotation [3,7]
L	Shock/stroke adj. both rotations [7]
X	Special

Mounting	
A	Face/base (standard)
F	Front flange
G	Foot flange
P	Pilot ring
R	Rear flange
X	Special

Port flow controls	
Omit	None
P	Flow control both rotations
R	Flow control CW rotation [3]
S	Flow control CCW rotation [3]

Shaft	
A	Female keyed
B	Single male keyed (standard)
C	Double male keyed
R	Preload keyway
X	Special

Port type	
1	SAE straight thread
2	NPTF
4	BSPP (ISO 1179-1 with ISO 228-1 threads)
9	Special

Design Series	
C	Current

Special Options	
Omit	Standard
(Two-digit code assigned by factory and applies when any "X" or "9" appears in the model number or when special options or features are required.)	

Seals	
Omit	Nitrile
V	Fluorocarbon
X	Special

Port location	
1	Position 1 (standard)
2	Position 2
3	Position 3
4	Position 4 [8]
5	Position 5 [6]
9	Special

Standard options	
Omit	None
M	Magnetic piston ring
S	Shaft seal cover
Q	Prepped for external air/oil tank
L	Air/oil cushion & flow control adj. at location 1 (opposite standard)

Other options
Detail in clear text:
- Proximity Sensors
- Feedback Potentiometer

Notes:
1 Cylinder bore size. See appropriate tables for torque output.
2 For 3-position units, specify middle and total rotation separated by a "/", ie 090/180. To obtain equal rotation both sides of midstroke (theoretical 12:00), order unit with 5° longer rotation than standard with stroke adjusters.
3 Viewed from shaft end.
4 Double rack models only.
5 Reduces to 10° with cushions.
6 Not available with cushions or stroke adjusters.
7 Refer to Catalog 0900-E page H45 for option configuration compatibility.
8 Not available on double rack models

B
Rotary Actuators
Actuator Products
PV Series
PRN(A) Series
PTR Series
HP Series
P1V-S Series

Parker Hannifin Corporation
Pneumatic Division
Richland, Michigan
www.parker.com/pneumatics

B
Rotary Actuators
Actuator Products
PV Series
PRN(A) Series
PTR Series
HP Series
P1V-S Series

Quick reference data

Model		Typ. actual output torque @ 100 PSI (lb-in)	Theoretical output torque* (lb-in) versus input pressure (PSI)				Displacement per degree rotation (in³/°)	Maximum angular backlash (minutes)	Tolerance (degrees)
Single rack	Double rack		50	75	100	250			
101		35	19	29	39	98	0.007	60	-0, +5
	102	70	39	59	79	197	0.014	60	-0, +5
151		100	59	88	118	294	0.021	45	-0, +4
	152	200	118	177	236	590	0.042	45	-0, +4
201		250	141	212	282	705	0.049	35	-0, +3
251		375	215	322	430	1074	0.075	35	-0, +3
	202	500	282	423	565	1410	0.099	35	-0, +3
	252	750	430	644	859	2148	0.150	35	-0, +3
321		1000	570	856	1141	2852	0.199	25	-0, +2
	322	2000	1141	1711	2281	5703	0.398	25	-0, +2

* Allow 10% for friction loss. Allow 20% on air/oil units. Use the single rack torque values for all air/oil, three position, and anti-backlash actuators.

Bearing load capacities and kinetic energy ratings

Model	Bearing load capacities* (lb)		Distance between bearings	Maximum kinetic energy absorption rating for models based on configuration (lb-in)			
	Radial	Thrust		Standard or stroke adjusters	Bumper	Cushion**	Shock absorbers (per cycle / per hour)
10	100	50	1.40	0.5	0.75	5.00	15/150,000
15	250	125	2.15	1.50	2.25	15.00	35/200,000
20	500	250	2.15	3.00	4.50	35.00	140/350,000
25	750	375	2.50	5.50	8.25	55.00	140/300,000
32	1000	500	3.75	12.00	18.00	155.00	N/A

* Bearing capacities only. Check Kinetic Energy ratings to determine if actuator will stop load.
** Assuming positive back pressure provided by meter-out flow control.

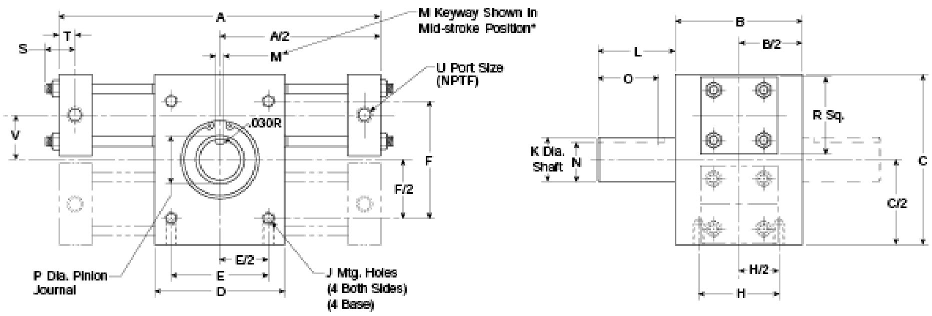
Seal kit ordering information

- Standard units are equipped with Nitrile seals.
- Optional seal compounds are available.
- Seal kit part numbers as shown:

PSK	—	PTR322	V	
Parker seal kit		Base model	Omit	Standard
			V	Fluorocarbon
			Q	Quad ring piston seals
			W	Carboxilated nitrile piston seals

Standard Face Base Mount (A) and Male Keyed Shaft (B)

Double Male Keyed Shaft (C) shown in phantom



Model number	Rotation (Degrees)	A	B	C	D	E	F	H	J	K	L	M	N
10	90°	6-11/16	2	3	2	1.500	2.000	1.500	1/4-20 x 3/8 DP	0.500 0.499	7/8	0.125 0.127	0.430 0.425
	180°	8-1/4											
	360°	11-7/16											
15	90°	9-1/8	3	4-1/4	3	2.000	3.000	2.000	5/16-18 x 1/2 DP	0.675 0.674	1-7/8	0.188 0.190	0.771 0.761
	180°	11-3/16											
	360°	15-3/8											
20	90°	11-3/16	3	5	4	2.500	3.500	2.000	3/8-16 x 1/2 DP	1.125 1.124	1-7/8	0.250 0.252	0.986
	180°	14-1/16											
	360°	19-11/16											
25	90°	12-9/16	3-1/2	6	4	2.500	4.500	2.000	1/2-13 x 3/4 DP	1.375 1.374	2-1/4	0.313 0.315	1.201 1.191
	180°	15-1/2											
	360°	20-5/8											
32	90°	16-5/8	5	8	5	3.000	5.000	2. 500	3/4-10 x 1 DP	1.750 1.749	3-1/2	0.375 0.377	1.542 1.532
	180°	21-1/8											
	360°	29-3/8											

Model number	O	P	R	S	T	U	V
10	5/8	0.59	1-1/2	1/4	0.31	1/8	3/4
15	1-1/2	0.98	2	5/16	0.41	1/4	1-1/16
20	1-1/2	1.18	2-1/2	3/8	0.41	1/4	1-1/4
25	1-3/4	1.38	3	3/8	0.41	1/4	1-1/2
32	3	1.77	3-3/4	7/16	0.56	3/8	1-15/16

* To obtain equal rotation both sides of midstroke (theoretical 12:00), order 5° longer rotation than standard with stroke adjusters.

Parker Hannifin Corporation
Pneumatic Division
Richland, Michigan
www.parker.com/pneumatics

6.6b Numatics

Table of Contents

NUMATICS

R Series

Rev. 1/06

numatics

R Series
Rotary Actuator

The **R Series** is a heavy-duty rack and pinion style rotary actuator that is designed to excel in the most rigid applications. The R Series includes a high torque-to-size ratio as well as accurate positioning.

Rack and Pinion
The **rack** and **pinion** is made from high strength alloy steel. It is induction hardened for long life. The geometry factors of the rack and pinion have been balanced to ensure equal wear, which provides maximum gear life. The pinion shaft includes a male key as standard offering.

Ball Bearings
The **ball bearings** are sealed and pre-lubed in an effort to prevent contamination from negatively affecting the operation. They are sized to except high loads and still retain smooth maintenance free operation.

Rack Bushing
The **rack bushing** is made from bearing bronze. The durability of the bushing enables it to support nearly the full length of the rack. Furthermore, we have included a small gap to allow grease/lubrication to be added.

Tube
The profile **tube** is hard coat anodized. The hard coating is an electro-chemical process, which produces a very dense surface of aluminum oxide. This surface has extreme hardness (60 RC.), excellent wear and corrosion resistance, and low coefficient of friction.

End Caps
The **end caps** are accurately machined from (6061-T6) solid aluminum bar stock. They are anodized for corrosion resistance. Additionally, port positioning is extremely flexible.

Piston
The solid aluminum alloy **piston** is strong and durable. A magnet groove is standard allowing for easy field conversation.

Piston Seal
The **piston seal** is a carboxilated nitrile with Teflon® compound for self-lubricating. The U-cup type seal construction is proven and durable.

Wear Band
The **wear band** is a stable, lubricating strip located on the piston.

Grease Opening
A 1/4-28 tapped hole (which is plugged) is provided for future installation of an optional grease fitting. Note that the unit is pre-lubed.

Teflon® is a registered trademark of DuPont™. For detailed information regarding the properties of Teflon®.

Standard Specifications:
- Bore sizes from 1" through 3-1/4"
- Nominal pressure rating is 150 psi air
- Standard rotations are: 45°, 90°, 180°, 270°, and 360°
- Minimum breakaway pressure: 5 psi non-cushioned, 10 psi cushioned
- Standard temperature -10°F to 165°F (-23°C to 74°C)
- NPTF ports
- Flexible port locating

The keyway at position 12:00, is always the mid-rotation of the actuator unless otherwise specified.

How to Order

S AR K-180 1 C-C AA 0

Mounting
- F = Front Flange
- R = Rear Flange
- P = Pilot Ring
- B = Bottom Flange
- S = Standard Mount

Type
- AR = Single Rack
- BR = Double Rack
- CR = 3 Position Single Rack
- DR* = 4 Position Single Rack
- ER** = 5 Position Single Rack

* Must specify X dimension.
** Must specify X and Y dimensions.

Size
- E = 1" Bore
- K = 1-1/2" Bore
- L = 2" Bore
- M = 2-1/2" Bore
- P = 3-1/4" Bore

Degrees Rotation
- 045 = 45°
- 090 = 90°
- 180 = 180°
- 270 = 270°
- 360 = 360°

Any degree of rotation can be specified.

Consult factory for rotations of or greater than 1000°.

Rod End Code
- 1 = Single Male Keyed (Std)
- 2 = Single Female Keyed
- 3 = Double Male Keyed
- 4 = Preloaded Keyway

Magnetic Piston
- 0 = No Magnet
- 2 = Magnet

Options
- AA = No Options
- BA = Bumpers Both Directions
- BC = Bumpers Counterclockwise
- BH = Bumpers Clockwise
- KA* = Angle Adjustment Both Directions
- KC* = Angle Adjustment Counterclockwise
- KH = Angle Adjustment Clockwise
- PP = Polypak Piston Seals
- SA = Shock Absorbers Both Directions
- SC = Shock Absorbers Counterclockwise
- SH = Shock Absorbers Clockwise
- SS = Shaft Seal Covers
- VA = High Temperature Seals

* N/A with the SA, SC, and SH options

Cushions

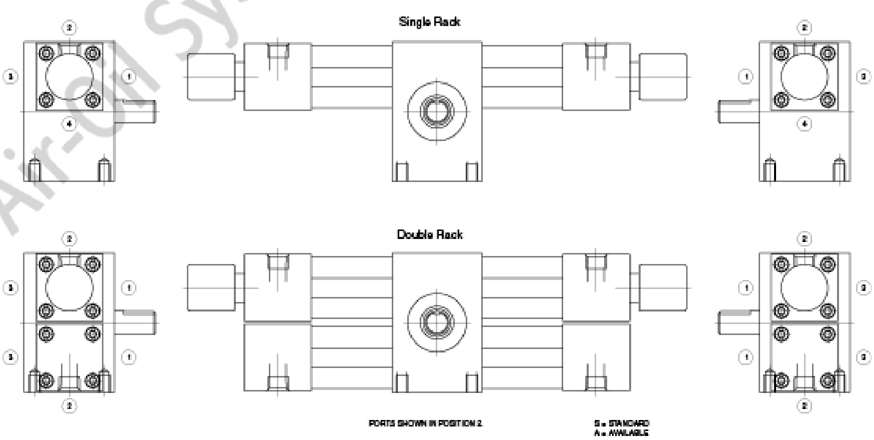
Position	Standard 1	2	3	4
No Cushions	A	A	A	A
CW and CCW	B	C	D	E
CW	F	G	H	J
CCW	K	L	M	N

CW = Clockwise
CCW= Counter-clockwise

Ports

Position	Size Code 1/8	1/4	3/8	1/2
1	B	C	D	E
2	H	I	J	K
3	N	O	P	Q
4	T	U	V	W

Cushion and Port Positions



NOTE: Consult factory for repair kit information.

NUMATICS

R Series
Rotary Actuator

Standard Specifications

Maximum operating pressure: 150 psi pneumatic

Standard rotations: 45˚, 90˚, 180˚, 270˚, 360˚ and other rotations optional

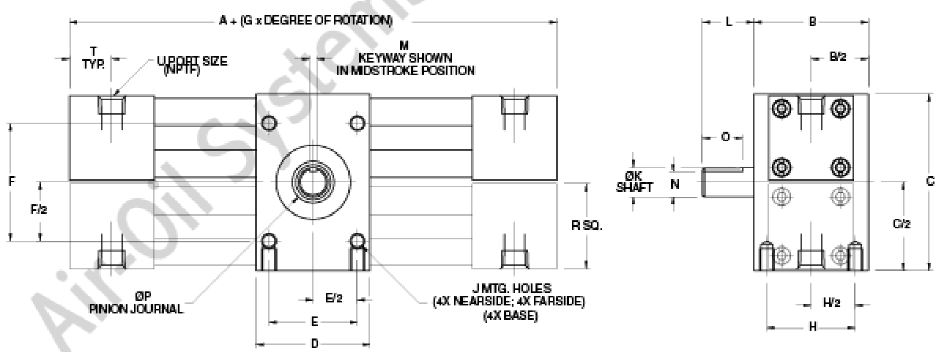
Maximum breakaway pressure: 5 psi non-cushion, 10 psi cushioned

Operating temperature: 0˚ F to 180˚ F (standard seals)
-20˚ F to 400˚ F (viton seals)

BORE	NUMBER OF RACKS	MODEL	THEORETICAL TORQUE OUTPUT (in-lbs)			DISPLACEMENT CU. IN./DEG. OF ROTATION	"MAX. ANGULAR BACKLASH, MINUTES"	MAX. ROTATIONAL TOTAL (DEGREES)
			50 psi	100 psi	150 psi			
1"	1	SARE	19	39	59	0.007	50	10
1"	2	SBRE	39	79	118	0.014	50	10
1 1/2"	1	SARK	59	118	177	0.021	40	8
1 1/2"	2	SBRK	118	236	353	0.042	40	8
2"	1	SARL	141	282	424	0.049	30	6
2"	2	SBRL	282	565	848	0.099	30	6
2 1/2"	1	SARM	276	552	828	0.096	30	6
2 1/2"	2	SBRM	552	1104	1656	0.193	30	6
3 1/4"	1	SARP	570	1141	1711	0.199	15	4
3 1/4"	2	SBRP	1141	2281	3422	0.398	15	4

Allow 10% for friction loss.

Standard Mount



Dimensions

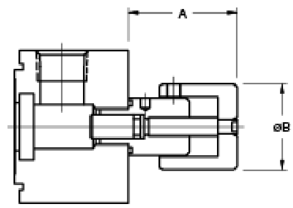
BORE	A	B	C	D	E	F	G	H	J	K	L	M	N	O	P	R	T	U	V
1"	7.50	2.00	3.00	2.00	1.50	2.00	0.01746	1.50	1/4-20 X 3/8 DEEP	.500/.499	0.88	.125/.127	.430/.425	.625	0.59	1.44	0.75	1/8	0.75
1-1/2"	8.50	3.00	4.25	3.00	2.00	3.00	0.02328	2.00	5/16-18 X 1/2 DEEP	.875/.874	1.88	.188/.190	.771/.761	1.50	0.98	2.00	0.75	1/4	1.13
2"	9.50	3.00	5.00	4.00	2.50	3.50	0.03124	2.00	3/8-16 X 1/2 DEEP	1.125/1.124	1.88	.250/.252	.986/.976	1.50	1.18	2.44	0.75	1/4	1.25
2-1/2"	9.75	3.50	6.00	4.00	2.50	4.50	0.03926	2.00	1/2-13 X 3/4 DEEP	1.375/1.374	2.25	.313/.315	1.201/1.191	1.75	1.57	2.94	0.75	1/4	1.50
3-1/4"	11.25	5.00	8.00	5.00	3.00	5.00	0.04800	2.50	3/4-10 X 1 DEEP	1.750/1.749	3.50	.375/.377	1.542/1.532	3.00	1.77	3.75	0.88	3/8	1.94

numatics

Options

Rotation Adjust

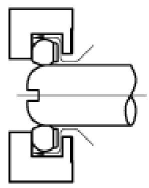
Rotation adjusting knobs can be added to control rotation more precisely. They can be used on both ends or on either end individually. Rotation adjusters can be used in conjunction with cushions. Their "high tech" style makes rotation adjustment easy to do without tools. The metric set screw in the side of knob securely locks the rotation setting. Thus, the rotation is very easy to adjust, but cannot be changed without a metric allen wrench. When used with cushions, maximum rotation adjustment will still allow at least 20˚ of rotation to be in cushion.



BORE	A	B	DEGREE OF ROTATION PER END
1"	1.43	1.13	43
1 1/2"	1.43	1.13	32
2"	2.22	1.75	40
2 1/2"	2.22	1.75	32
3 1/4"	2.67	2.35	32

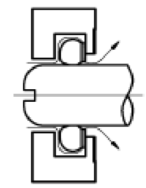
Cushions

Seals



Into Cushion

Our cushion seal has a built-in function. It seals in one direction and permits full flow in the opposite direction.



Flows

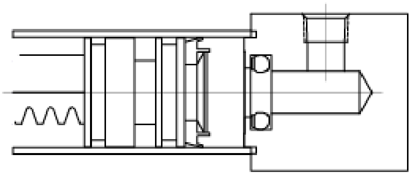
Out of Cushion

Cushions can be added to meter deceleration. Cushion adjustment needles can be put in any quadrant. Normally, cushions will be added to only one half of the double rack unit. The cushion and its operation is very similar to our current A series design. Rotation adjust can be used in conjunction with cushions. Cushions and Shock absorbers together are not available.

Bumpers

Bumper seals can be added to reduce impact. The bumper and seal are one piece. Bumpers can be used in conjunction with cushions if necessary.

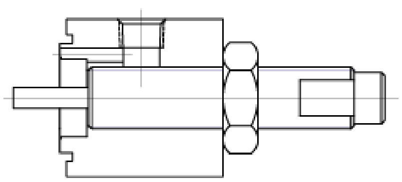
NOTE: Cannot be used with rotation adjustment.



Shock Absorbers

Hydraulic shock absorbers can be added to reduce noise and large impacts. Shocks are fixed orifice self-compensating type. The 3 1/4" bore rotary actuator will not have this option. Cushions and shock absorbers together are not available.

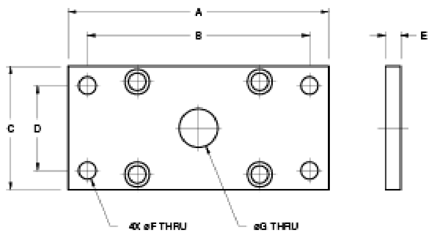
NOTE: Shock cannot be adjusted.



Mounting Options

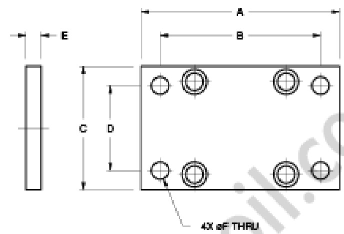
Flanges

Front and Rear Flange



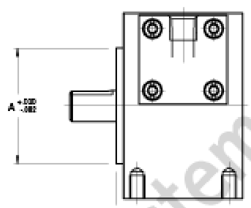
BORE	A	B	C	D	E	F	G
1"	4.25	3.63	2	1.38	0.25	9/32	5/8
1 1/2"	5.75	5.13	3	2.13	0.44	13/32	1
2"	6.50	5.88	4	3.38	0.44	13/32	1 1/4
2 1/2"	8.25	7.25	4	3.00	0.44	17/32	1 5/8
3 1/4"	12.00	10.00	5	3.00	0.75	25/32	2

Bottom Flange



BORE	A	B	C	D	E	F
1"	3.25	2.63	2	1.38	0.25	9/32
1 1/2"	4.50	3.88	3	2.13	0.44	13/32
2"	4.50	3.88	4	3.38	0.44	13/32
2 1/2"	5.50	4.50	4	3.00	0.44	17/32
3 1/4"	8.00	6.50	5	3.50	0.75	25/32

Shaft Seal Cover and Pilot Ring



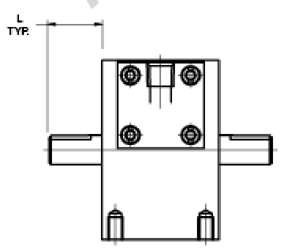
BORE	A	B
1"	1.875	0.125
1 1/2"	3.000	0.250
2"	3.250	0.250
2 1/2"	3.625	0.250
3 1/4"	4.480	0.250

The pilot ring and the shaft seal cover are dimensionally the same. Pilot rings are used to help center the shaft to the work piece. Shaft seal covers are used to prevent contamination to the ball bearings. They can only be used on single and double male shafts.

Shaft Options

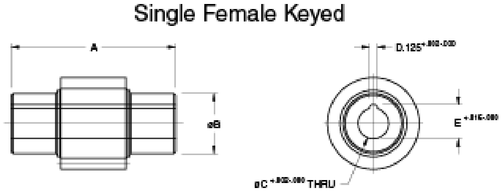
BORE	A	B	C	D	E
1"	1.81	0.59	0.250	N/A	N/A
1 1/2"	2.69	0.98	0.500	0.125	0.560
2"	2.72	1.18	0.688	0.187	0.780
2 1/2"	3.13	1.57	0.813	0.250	0.901
3 1/4"	4.56	1.77	1.125	0.250	1.247

Double Male Keyed



BORE	L
1"	0.875
1 1/2"	1.875
2"	1.875
2 1/2"	2.250
3 1/4"	3.500

Single Female Keyed



Kinetic Energy Basic Formula

$KE = 1/2\ J\omega^2$

$$\omega = 0.035 \times \frac{\text{Angle traveled (degrees)}}{\text{Rotation time (seconds)}}$$

Where:

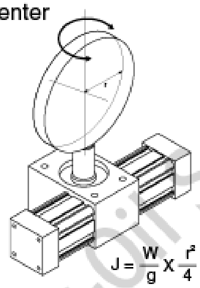
KE	=	Kinetic Energy (in-lb)
J	=	Rotational mass moment of inertia (in-lb-sec^2) (Dependent on physical size of object and weight)
ω	=	Peak Velocity (rad/sec) (Assuming twice average velocity)
W	=	Weight of load (lb)
g	=	Gravitational constant = 386.4 in/sec^2
r	=	Radius of gyration (in)

Moments of Inertia

Maximum Kinetic Energy Rating for Models Based on Configuration (in-lb)

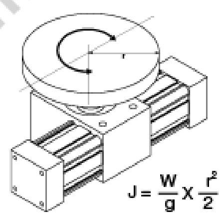
BORE	STANDARD	ROTATION ADJUSTERS	CUSHIONS	SHOCK ABSORBERS (PER CYCLE/PER HOUR)
1"	0.50	0.50	5	150/300,000
1 1/2"	2.00	2.00	20	225/400,000
2"	4.00	4.00	40	600/600,000
2 1/2"	7.00	7.00	70	600/600,000
3 1/4"	15.00	15.00	150	N/A

Thin Disk-End mounted on center



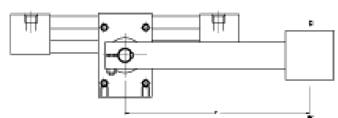
$$J = \frac{W}{g} \times \frac{r^2}{4}$$

Thin Disk-Mounted on center



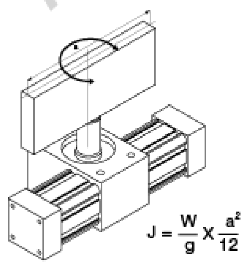
$$J = \frac{W}{g} \times \frac{r^2}{2}$$

Point Load



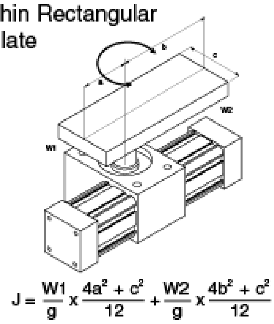
$$J = \frac{W}{g} \times r^2$$

Thin Rectangular Plate-Mounted on center



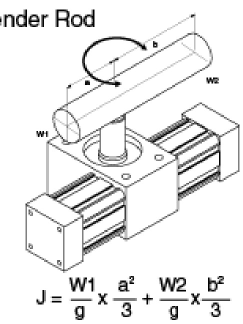
$$J = \frac{W}{g} \times \frac{a^2}{12}$$

Thin Rectangular Plate



$$J = \frac{W1}{g} \times \frac{4a^2 + c^2}{12} + \frac{W2}{g} \times \frac{4b^2 + c^2}{12}$$

Slender Rod

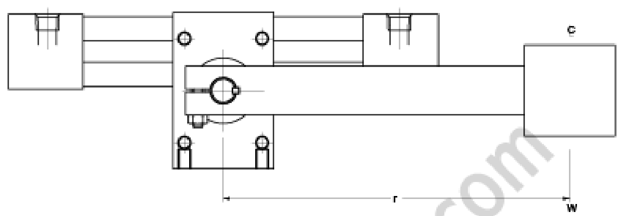


$$J = \frac{W1}{g} \times \frac{a^2}{3} + \frac{W2}{g} \times \frac{b^2}{3}$$

Size and Selection Example

Point load application
W=5 lb. load
r=12 inch arm length
Want to use 1 1/2 bore rotary actuator
Need to rotate 180 degrees in 2 seconds
Should I use bumpers, cushions, shocks, or none of these?

Point Load



$$J = \frac{W}{g} \times r^2$$

From Catalog:

$$\omega = 0.035 \times \frac{\text{Angle traveled (DEG)}}{\text{Rotation time (SEC)}}$$

$$\omega = 0.035 \times \frac{180\ \text{DEG}}{2\ \text{SEC}}$$

$$\omega = \frac{3.15}{\text{SEC}}$$

$$J = \frac{W}{g} \times r^2$$

$$J = 5\ \text{LB}\ \frac{\text{SEC}^2}{386.4\ \text{IN}} \times \text{IN}^2$$

$$J = 1.86\ \text{IN-LB-SEC}^2$$

$$KE = 1/2\ J\omega^2$$

$$KE = \frac{1}{2} \times 1.86\ \text{IN-LB-SEC}^2 \times \left(\frac{3.15}{\text{SEC}}\right)^2$$

$$KE = 9.23\ \text{IN-LB}$$

Maximum Kinetic Energy Rating
for Models Based on Configuration (in-lb)

BORE	STANDARD	STROKE ADJUSTERS	CUSHIONS	SHOCK ABSORBERS (PER CYCLE/PER HR.)
1"	0.50	0.50	5	150/300,000
1 1/2"	2.00	2.00	20	225/400,000
2"	4.00	4.00	40	600/600,000
2 1/2"	7.00	7.00	70	600/600,000
3 1/4"	15.00	15.00	150	N/A

Looking at Kinetic Energy Rating Chart:

Maximum KE=20 IN-LBS for a 1 1/2" bore rotary with cushions

Therefore, application requires cushions.

Specifications

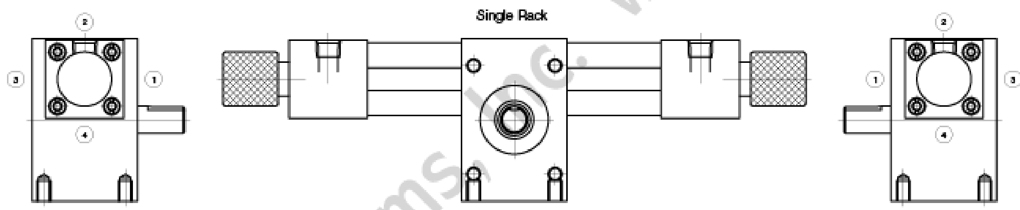
Unit Weights (lbs)

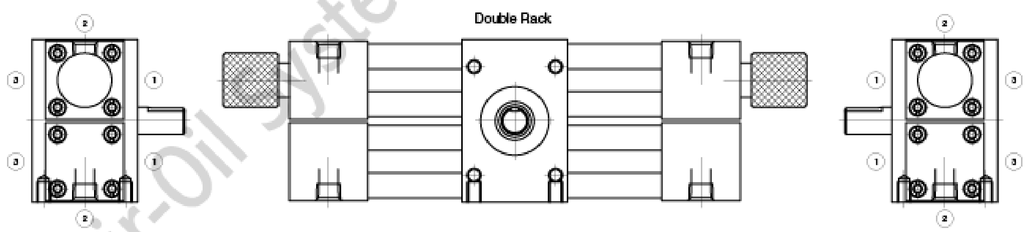
MODEL	ROTATION (DEGREES) 90	180	270	360
SARE	3	3	3	3
SBRE	4	4	4	5
SARK	9	9	10	10
SBRK	12	13	14	15
SARL	14	15	16	17
SBRL	20	22	24	27
SARM	22	23	25	27
SBRM	31	34	38	41
SARP	45	47	49	52
SBRP	62	67	72	77

Bearing Load Capacities

BORE	RADIAL LOAD (lb)	THRUST LOAD (lb)	DISTANCE BETWEEN BEARINGS (in)
1"	100	75	1.40
1 1/2"	300	200	2.15
2"	500	350	2.15
2 1/2"	900	600	2.50
3 1/4"	1300	900	3.75

Port and Cushion Locations





PORTS SHOWN IN POSITION 2.

Standard port location is position 1. Standard cushion location is position 2. Ports and/or cushions in position 4 are only available on single rack rotary actuators.

BORE SIZE	PORT SIZE 1/8	1/4	3/8	1/2
1"	S	A	-	-
1 1/2"	A	S	A	-
2"	A	S	A	-
2 1/2"	A	S	A	-
3 1/4"	A	A	S	A

S=Standard
A=Available

Information subject to change without notice. For ordering information or regarding your local sales office visit www.numatics.com.

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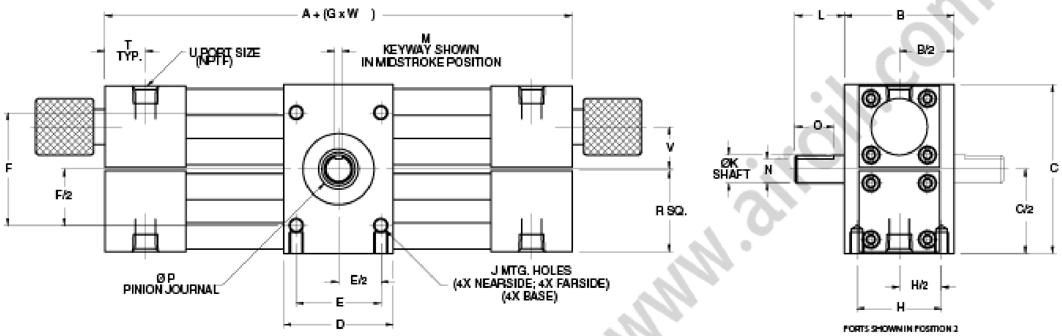
R Series
Rotary Actuator

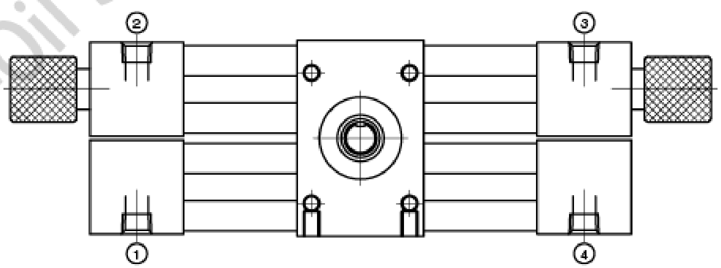
Multi-position Rotary Actuator
3 Position

Our rotary actuators are available in various multi-position configurations. The following shows 3, 4 and 5 position types. Consult factory.



Dimensions

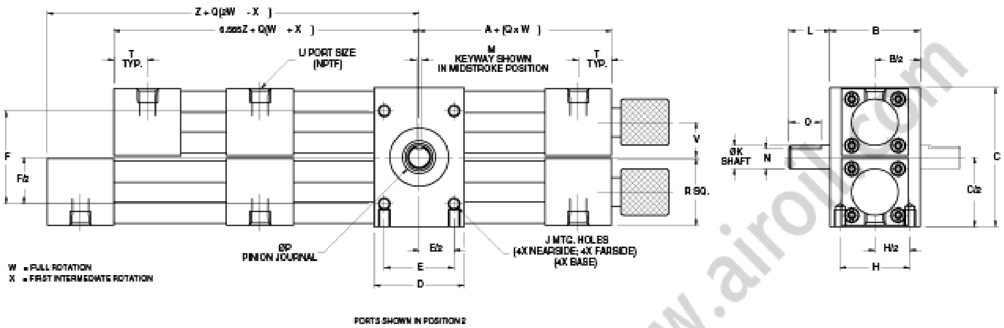
BORE	A	B	C	D	E	F	G	H	J	K	L	M	N	O	P	R	T	U	V
1"	7.50	2.00	3.00	2.00	1.50	2.00	0.01746	1.50	1/4-20 X 3/8 DEEP	.500/.499	0.88	.125/.127	.430/.425	0.63	0.59	1.44	0.75	1/8	0.75
1 1/2"	8.50	3.00	4.25	3.00	2.00	3.00	0.02328	2.00	5/16-18 X 1/2 DEEP	.875/.874	1.88	.188/.190	.771/.761	1.50	0.98	2.00	0.75	1/4	1.13
2"	9.50	3.00	5.00	4.00	2.50	3.50	0.03144	2.00	3/8-16 X 1/2 DEEP	1.125/1.124	1.88	.250/.252	.986/.976	1.50	1.18	2.44	0.75	1/4	1.25
2 1/2"	9.75	3.50	6.00	4.00	2.50	4.50	0.03926	2.00	1/2-13 X 3/4 DEEP	1.375/1.374	2.25	.313/.315	1.201/1.191	1.75	1.57	2.94	0.75	1/4	1.5
3 1/4"	11.25	5.00	8.00	5.00	3.00	5.00	0.04800	2.50	3/4-10 X 1 DEEP	1.750/1.749	3.50	.375/.377	1.542/1.532	3.00	1.77	3.75	0.88	3/8	1.94



A three position rotary actuator provides one intermediate stopping position between the full counterclockwise and full clockwise position. The full counterclockwise position is achieved by pressurizing port 1. The intermediate position is achieved by pressurizing both ports 2 and 3. The final clockwise position is achieved by pressurizing port 4. Rotation adjustment for the full counterclockwise and full clockwise positions only are standard.

4 Position

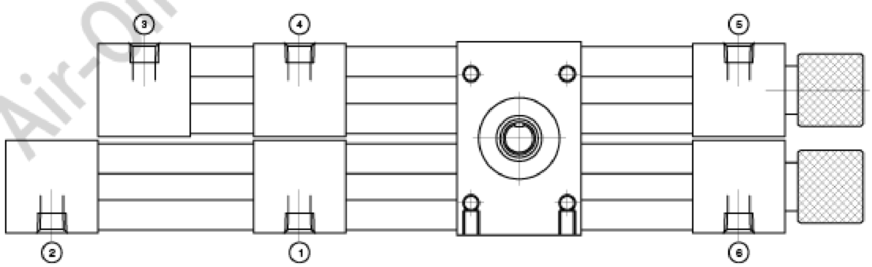
W° = Full Rotation
X° = First Intermediate Rotation



Dimensions

BORE	A	B	C	D	E	F	H	J	K	L
1"	3.75	2.00	3.00	2.00	1.50	2.00	1.50	1/4-20 X 3/8 DEEP	.500/.499	0.88
1 1/2"	4.25	3.00	4.25	3.00	2.00	3.00	2.00	5/16-18 X 1/2 DEEP	.875/.874	1.88
2"	4.75	3.00	5.00	4.00	2.50	3.50	2.00	3/8-16 X 1/2 DEEP	1.125/1.124	1.88
2 1/2"	4.88	3.50	6.00	4.00	2.50	4.50	2.00	1/2-13 X 3/4 DEEP	1.375/1.374	2.25
3 1/4"	5.63	5.00	8.00	5.00	3.00	5.00	2.50	3/4-10 X 1 DEEP	1.750/1.749	3.50

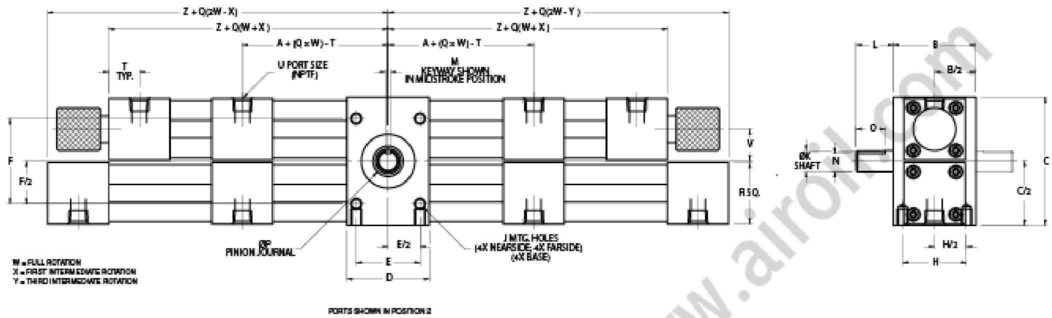
M	N	O	P	Q	R	T	U	V	Z
.125/.127	.430/.425	0.63	0.59	0.00872	1.44	0.75	1/8	0.75	6.405
.188/.190	.771/.761	1.50	0.98	0.01164	2.00	0.75	1/4	1.13	6.904
.250/.252	.986/.976	1.50	1.18	0.01571	2.44	0.75	1/4	1.25	7.407
.313/.315	1.201/1.191	1.75	1.57	0.01963	2.94	0.75	1/4	1.50	7.655
.375/.377	1.542/1.532	3.00	1.77	0.02400	3.75	0.88	3/8	1.94	8.660



A four position rotary actuator provides two intermediate stopping positions between the full counterclockwise and full clockwise positions. The full counterclockwise position is achieved by pressurizing port 1. The first intermediate position is achieved by pressurizing both ports 2 and 3. The second intermediate position is achieved by pressurizing both ports 4 and 5. The final position is achieved by pressurizing port 6. Rotation adjustment for the full counterclockwise and full clockwise positions only are standard.

5 Position

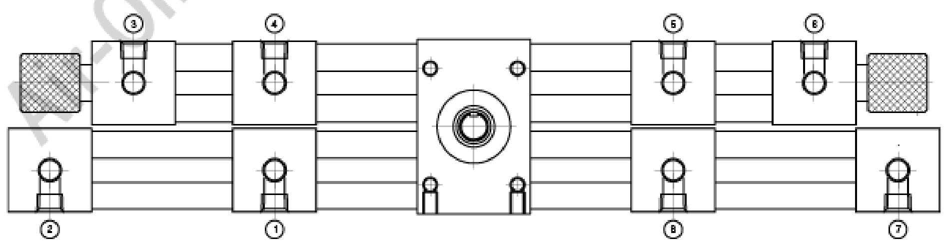
W° = Full Rotation
X° = First Intermediate Rotation
Y° = Third Intermediate Rotation



Dimensions

Bore	A	B	C	D	E	F	H	J	K	L
1"	3.75	2.00	3.00	2.00	1.50	2.00	1.50	1/4-20 X 3/8 DEEP	.500/.499	0.88
1 1/2"	4.25	3.00	4.25	3.00	2.00	3.00	2.00	5/16-18 X 1/2 DEEP	.875/.874	1.88
2"	4.75	3.00	5.00	4.00	2.50	3.50	2.00	3/8-16 X 1/2 DEEP	1.125/1.124	1.88
2 1/2"	4.88	3.50	6.00	4.00	2.50	4.50	2.00	1/2-13 X 3/4 DEEP	1.375/1.374	2.25
3 1/4"	5.63	5.00	8.00	5.00	3.00	5.00	2.50	3/4-10 X 1 DEEP	1.750/1.749	3.50

M	N	O	P	Q	R	T	U	V	Z
.125/.127	.430/.425	0.63	0.59	0.00872	1.44	0.75	1/8	0.75	6.405
.188/.190	.771/.761	1.50	0.98	0.01164	2.00	0.75	1/4	1.13	6.904
.250/.252	.986/.976	1.50	1.18	0.01571	2.44	0.75	1/4	1.25	7.407
.313/.315	1.201/1.191	1.75	1.57	0.01963	2.94	0.75	1/4	1.50	7.655
.375/.377	1.542/1.532	3.00	1.77	0.02400	3.75	0.88	3/8	1.94	8.660



A five position rotary actuator provides three intermediate stopping positions between the full counterclockwise and full clockwise positions. The full counterclockwise position is achieved by pressurizing port 1. The first intermediate position is achieved by pressurizing both ports 2 and 3. The second intermediate position is achieved by pressurizing both ports 4 and 5. The third intermediate position is achieved by pressurizing both ports 6 and 7. The final clockwise position is achieved by pressurizing port 8. Rotation adjustment for the full counterclockwise and full clockwise positions only are standard.

R series Switches

R series Global Switch

Cylinders	Bore		Switches					
			RSS02	RSQ02	HPNPS31	HPNPQ31	HNPNS32	HNPNQ32
R series	All	Bracket	Direct Fit w/included adapter	Direct Fit w/included adapter	Direct Fit w/included adapter	Direct Fit w/included adapter	Direct Fit w/included adapter	Direct Fit w/included adapter

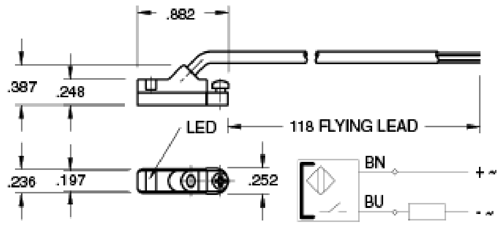
R series World Switch

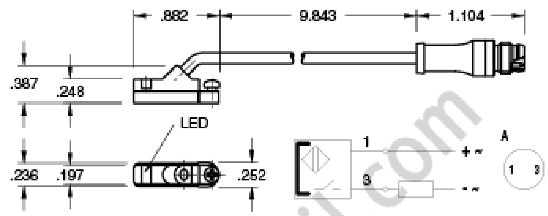
Cylinders	Bore		Switches					
			SR6-002	SR6-022	SH6-021	SH6-031	SH6-022	SH6-032
R series	All	Bracket	Direct Fit	Direct Fit	Direct Fit	Direct Fit	Direct Fit	Direct Fit

NOTE: See page 17 for dimensional and technical data

R series Global Switches

Reed Switch (AC/DC NO), flying lead - RSS02, 8mm connector - RSQ02





Sensing Data

Ambient temperature range T_a	(°F/°C)	-4 to 176 (-20 to 80)
Frequency of operating cycles f at U_e	(kHz)	0.5
Turn on time t	(ms)	<= 0.25
turn off time t	(ms)	0.03
LED function indication		yes

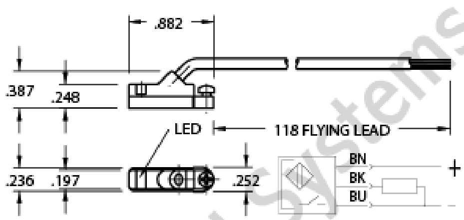
Electrical Data

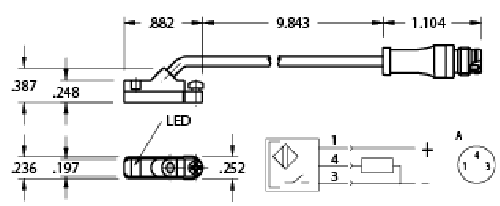
Rated operational voltage U_e	(V)	3...130 AC/DC
Supply voltage U_B	(V)	3...130 AC/DC
Voltage drop U_d at I_e Stat./dyn.	(V)	3.5
Rated insulation volatage U_i	(V)	2750 DC (EN 60335-1)
Rated supply frequency	(Hz)	AC/DC
Rated operational current I_e	(mA)	50 (10W max.)
No-load supply current I_o at U_e d./und.	(mA)	0
Observe polarity for correct LED function		

Mechanical Data

Housing material		Polyamide
Material of sensing face		Polyamide
Connection		PVC cable
Degree of Protection	IP	67
Rated shock: half-sinus, 50g, 11 ms		
Rated vibration environment: 10g, 10...2000 Hz. 90 min		

Electronic Switch (PNP NO), flying lead - HPNPS31, 8mm connector - HPNPQ31





Sensing Data

Ambient temperature range d	(°F/°C)	-13 to +158 (-25 to +70)
Temperature drift	(% of)	<= 0.3%/°C
Frequency of operating cycles f at U_e	(kHz)	10
Turn on time t	(ms)	.05
turn off time t	(ms)	.05
Utilization categories		DC13
Function–/supply voltage indication		YES

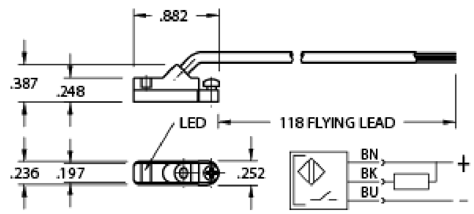
Electrical Data

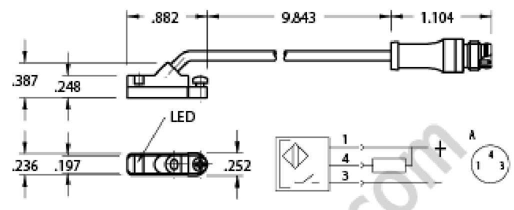
Rated operational voltage U_e	(V)	24 DC
Supply voltage U_B	(V)	10...30 DC
incl. ripple	(% of U_e)	15
Voltage drop U_d at I_e Stat./dyn.	(V)	1/–
Rated insulation volatage U_i	(V)	75 AC
Rated supply frequency	(Hz)	DC
Rated operational current I_e	(mA)	200
No-load supply current I_o at U_e d./und.	(mA)	25/13
Protected against polarity reversal		YES

Mechanical Data

Housing material		Polyamide
Material of sensing face		Polyamide
Connection		PVC cable
Degree of Protection	IP	67
Rated shock: half-sinus, 30 g, 11 ms		
Rated vibration environment: 55 Hz, 1mm amplitude, 3 x 30		

Electronic Switch (NPN NO), flying lead - HNPNS32, 8mm connector - HNPNQ32





Sensing Data

Ambient temperature range $_d$	(°F/°C)	-13 to +158 (-25 to +70)
Temperature drift	(% of S_r)	<= 0.3%/°C
Frequency of operating cycles f at U_e	(kHz)	10
Turn on time t	(ms)	.05
turn off time t	(ms)	.05
Utilization categories		DC13
Function–/supply voltage indication		YES

Electrical Data

Rated operational voltage U_e	(V)	24 DC
Supply voltage U_B	(V)	10...30 DC
incl. ripple	(% of U_e)	15
Voltage drop U_d at I_e Stat./dyn.	(V)	1/–
Rated insulation volatage U_i	(V)	75 AC
Rated supply frequency	(Hz)	DC
Rated operational current I_e	(mA)	200
No-load supply current I_o at U_e d./und.	(mA)	25/13
Protected against polarity reversal		YES

Mechanical Data

Housing material		Polyamide
Material of sensing face		Polyamide
Connection		PVC cable
Degree of Protection	IP	67

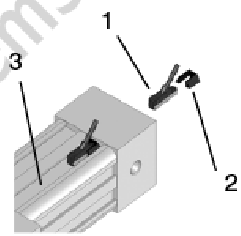
Rated shock: half-sinus, 30 g, 11 ms
Rated vibration environment: 55 Hz, 1mm amplitude, 3 x 30

CE

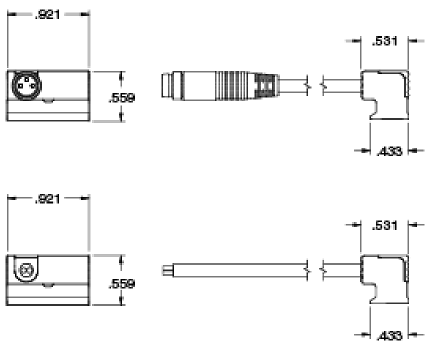
R series Global application Detail

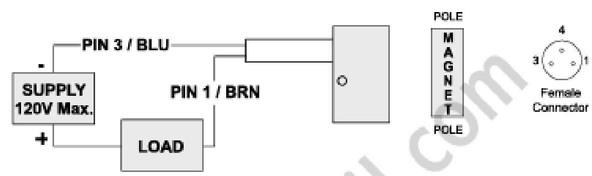
Profile Tube Detail

1. Global Switch
2. Included Dovetail adapter
3. Dove Tail extrusion



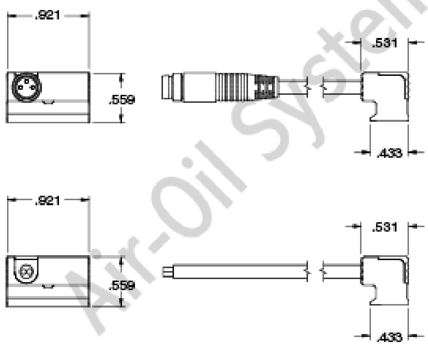
R Series World Switches
Reed Switch - Normally Open Type SR6

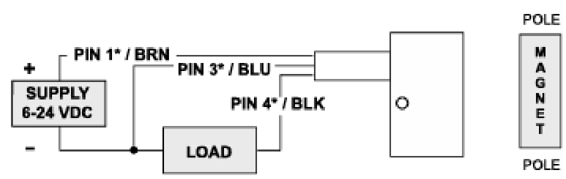




P/N	Switch Style	Switch Type	Function	Switching Voltage	Switching Current	Switching Power	Voltage Drop
SR6-002	3m Wire Version	Reed Switch, LED	SPST Normally Open	5 -120V AC/DC	0.025 Amps Max. 0.001 Amps Min.	3 Watts Max.	3.5 Volts
SR6-004	3m Wire Version	Reed Switch, LED & MOV	SPST Normally Open	5 -120V AC/DC	0.5 Amps Max. 0.005 Amps Min.	10 Watts Max.	3.0 Volts
SR6-021	8mm Pigtail	Reed Switch	SPST Normally Open	0 -120V AC/DC	0.5 Amps Max.	10 Watts Max.	0 Volts
SR6-022	8mm Pigtail	Reed Switch, LED	SPST Normally Open	5 -120V AC/DC	0.025 Amps Max. 0.001 Amps Min.	3 Watts Max.	3.5 Volts
SR6-024	8mm Pigtail	Reed Switch, LED & MOV	SPST Normally Open	5 -120V AC/DC	0.5 Amps Max. 0.005 Amps Min.	10 Watts Max.	3.0 Volts

Hall Effect Switch - Sourcing Type SH6





* Pin out for 8 mm connector version

P/N	Switch Style	Switch Type	Function	Switching Voltage	Switching Current	Switching Power	Voltage Drop
SH6-031	3m Wire Version	Hall Effect for Reed Magnet & Light Sourcing	Normally Open Sourcing (PNP)	6 -24 VDC	0.3 Amps Max.	7.2 Watts Max.	0.5 Volts
SH6-021	8m Connector Pigtail	Hall Effect for Reed Magnet & Light Sourcing	Normally Open Sourcing (PNP)	6 -24 VDC	0.3 Amps Max.	7.2 Watts Max.	0.5 Volts

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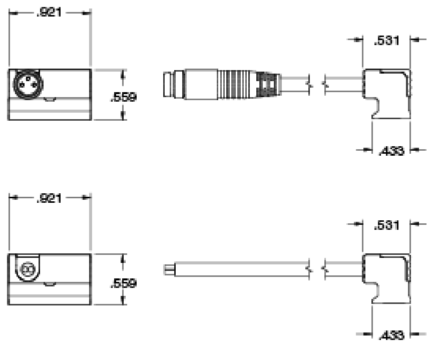
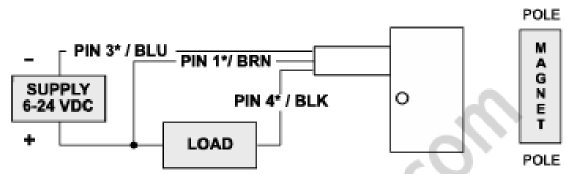
Hall Effect Switch - Sinking Type SH6





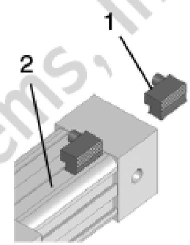
* Pin out for 8 mm connector version

P/N	Switch Style	Switch Type	Function	Switching Voltage	Switching Current	Switching Power	Voltage Drop
SH6-032	3m Wire Version	Hall Effect for Reed Magnet & Light Sourcing	Normally Open Sourcing (NPN)	6 -24 VDC	0.3 Amps Max.	7.2 Watts Max.	0.5 Volts
SH6-022	8m Connector Pigtail	Hall Effect for Reed Magnet & Light Sourcing	Normally Open Sourcing (NPN)	6 -24 VDC	0.3 Amps Max.	7.2 Watts Max.	0.5 Volts

R series World application Detail

Profile Tube Detail

1. World Switch
2. Dove Tail extrusion



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