Honeywell Reference Pressure Regulator

Operation and Maintenance Manual

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TABLE OF CONTENTS

DISCLAIMER

INTRODUCTION

The Honeywell Pressure Regulator Team is assisting in the development of a different type of reference air pressure regulator for use on commercial airliners. Most of the controls and actuators on commercial airliners are pneumatically controlled. For pneumatics to function, they need to reference a specific amount of pressure. This is achieved through the use of a reference pressure regulator. The reference pressure regulator takes in different levels of inlet pressure and outputs at a constant pressure level.

Honeywell has been building upon a legacy reference pressure regulator design for the last 60 years. They have slowly worked out inefficiencies and design flaws in this design. However, their current design has inherent flaws which limit its overall performance. The job of the Pressure Regulator team is to establish a new solution to the reference pressure regulator.

Improving the regulator design would increase the accuracy of pneumatic controls on the aircraft, which could increase economy of the system and safety to the passengers. The economy would also be increased through the improved durability and longevity of the system leading to less replacement parts and maintenance. There are about 15 reference pressure regulators on B737, one of the most common commercial airliners in the world. For a large company such as Honeywell, with products produced on a large scale, the small decrease in maintenance or production cost can benefit the companies' profits greatly. The main issue Honeywell is facing with their current regulator design is hysteresis caused by the introduction of contaminants such as air pollution and silica dust.

To correct this problem, the team has created a new type of closure element to be used in a pressure regulator called a bellows valve. The bellows valve achieves pressure regulation similarly to the current Honeywell design. A stem attached to a diaphragm uses a pressure balance in the diaphragm to open and close the valve. The difference is that the valve closes around the stem as compared to the current design where the stem moves through the valve. This eliminates the surface area from the regulator where contaminants are accumulating and interfering with the function of the valve.

Bill of materials

Part #	Part Name	Qty	Description	Functions	Material	Dimensions (mm)	Cost
001	Case Half Left	1	Left Half of the Aluminum Case	Pressure Vessel	Aluminum	230 x 150 x 75	$111.14
002	Case Half Right	1	Right Half of the Aluminum Case	Pressure Vessel	Aluminum	230 x 150 x 75	$111.14
003	Bellows Valve	1	Bellow with Integral Orifice	Nozzle Flow	Soft PLA	130 x 30	$5.00
004	Diaphram	1	Sensing Diaphragm for Pressure Balance	Outlet Pressure Sensing	PLA	78 Diam.	$3.00
005	Case Bolts	11	Bolts to Secure Case Halves Together	Fixes Case Halves	Steel	3/8" x 6"	$19.47
006	Gasket	1	Seal the Gap Between the Case Halves	Seal Pressure Vessel	RTV	230 x 150	$10.00
007	Adjustment Bolts	3	Long Bolts Used for Adjustment	Adjust Bellows Position	Steel	1/4" x 6"	$1.62
Total Cost Estimate:							$259.74

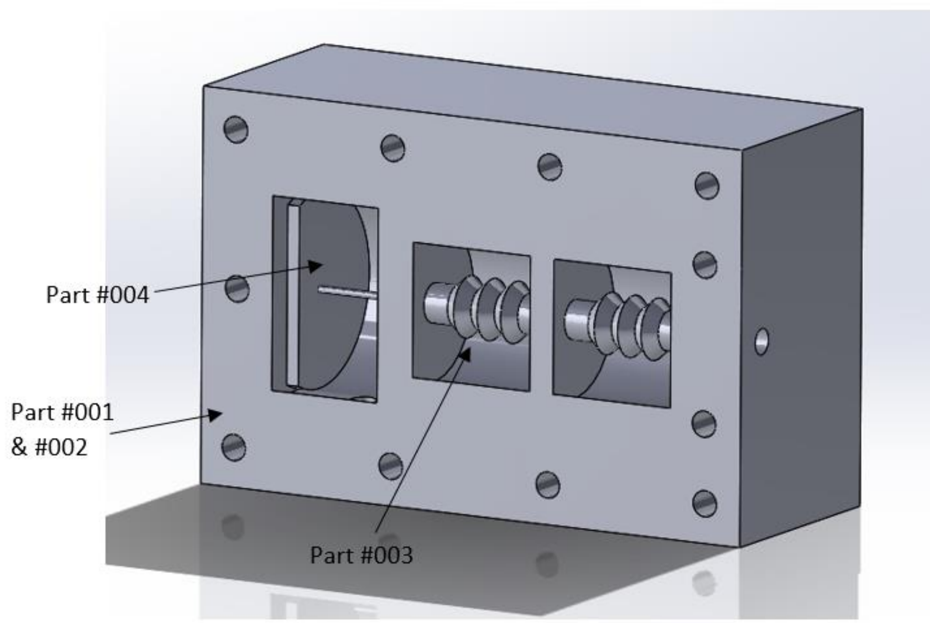

Figure 1: Labeled Assembly

MANUFACTURING AND ASSEMBLY

Case Manufacturing – Parts #001 and #002

The prototype casing is manufactured from a solid block of aluminum using a CNC mill. The use of aluminum for the outer casing allows high pressures to be run through the regulator during testing. The casing has an engraved cutout between case halves that allows a laser cut rubber gasket to be inserted, better enabling the casing to handle high pressures. After the CNC milling was completed, holes for the adjustment bolts on the rear of the casing were drilled and tapped.

Diaphragm Manufacturing – Part #004

The diaphragm was manufactured with 3D printing additive manufacturing. The diaphragm does not require high strength, so 3D printing in a PLA material allowed the creation of a functional part while also saving material.

Bellows Manufacturing – Part #003

The bellows currently being used is manufactured with 3D printing additive manufacturing. The bellows need to be flexible, and 3D printing using soft PLA material is a viable manufacturing method. However, the current bellows is a placeholder for a metal bellow being produced by Kinemotive Corporation. The incorporation of a metal bellow into this project is highly important because it will allow more rigorous testing at higher pressures of the regulator.

Assembly of Regulator

The regulator is assemble by the following steps:

1. Wear all necessary PPE including ANSI Z87.1 safety glasses and gloves to protect against pinch points. Perform an inspection of all tools before beginning work.
2. Attach the diaphragm (004) to the bellows (003) using JB weld. Place JB weld on the tip of the diaphragm and insert the diaphragm fully into the bellows. Ensure that the bellows is centered on the diaphragm and that the bellows is pressed firmly onto the diaphragm. Allow the JB weld to cure.
3. Place bellows/diaphragm assembly into the right half of the case (002).
4. Insert the adjustment bolts and record a zero stroke length (the point where the adjustment bolts do not compress or elongate the bellows). This will become very important during testing.
5. Spread a thin line of RTV sealant around surface of the right case half.
6. Place the left case half (001) on top of the right case half.
7. Insert and tighten the case bolts (005) so that the RTV sealant is compressed into a thin, even layer between the case halves.
8. Allow the RTV sealant to cure.
9. Insert the adjustment bolts (007).
10. The device can now be attached to a pressurized lines and pressure measuring devices for testing.

OPERATING AND TESTING

During operation the bellows valve is connected to an outlet from the compressor stage in a Brayton cycle engine. The device works autonomously and produces a constant outlet pressure by nozzling the flow area through the closure of a frustum. The frustum is closed when the bellows are compressed. The bellows are pulled close by a guide rod connected directly to the outlet pressure diaphragm, the guide rod passes through the frustum to allow for full area closure onto the rod. When the outlet pressure begins to rise the diaphragms large sensing area is subject to high force and compresses the spring behind it, this compression leads to the compression of the bellows and thus area reduction. As the outlet pressure lowers the spring pushes the diaphragm back and opens frustum.

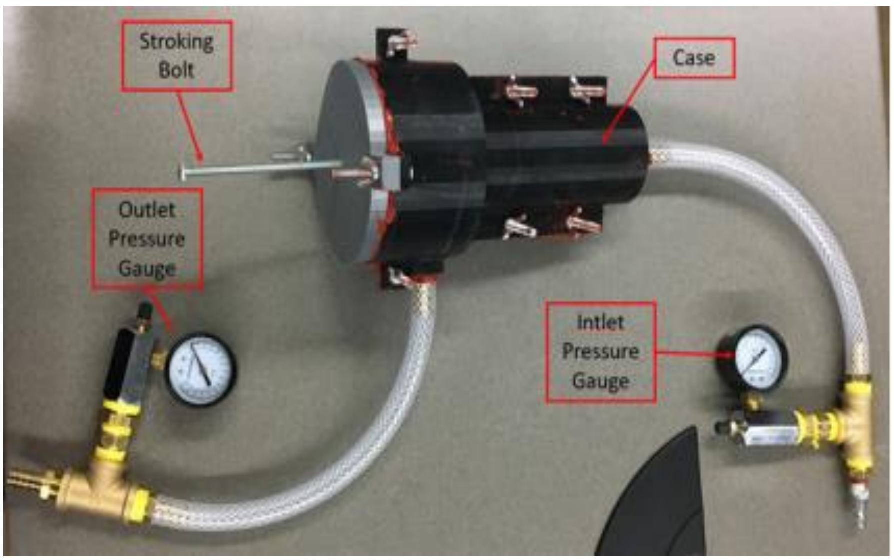

Figure 2: First Prototype Testing Set-Up

<u>Safety Check</u>

1. ANSI Z87.1 safety glasses must be worn at all times during testing.
2. Wear gloves during assembly to avoid pinch points.
3. Check the range of the regulator and ensure the application pressure is within the regulator's range. Do not over pressure the regulator. Generally, do not attach the regulator to systems capable of reaching over 100 psi.
4. Use consistent fittings with the regulator. Make sure all connections are well sealed without leaking. Use leak detector fluid to check for leaks.
5. Make sure the flow direction of the system matches the flow direction of the regulator.

Regulator Preparation Procedure

1. Fix the regulator on a rack or benchtop to ensure the regulator is stable during the operation.
2. Connect the inlet of the regulator to a pressurized line that has adjustable flow.
3. Connect hosing or pipe to the outlet of the regulator.
4. Install pressure transducer or pressure gauge on the inlet of the pressure regulator.
5. Install pressure transducer or pressure gauge on the outlet of the pressure regulator.
6. The transducer or gauges should be as close to the inlet and outlet of the regulator.
7. If a pressure transducer is perform calibration before installation.
8. Use leak detector fluid to perform a leak test.

Test procedure

1. Start with zero flow coming into the regulator. The inlet and outlet pressure should both be zero gauge or p_atm.
2. Tighten or loosen the adjustment bolt so the bellows is at zero stroke.
3. Slowly open the inlet valve and wait for the inlet pressure to stabilize.
4. Record the inlet and outlet pressure at zero stroke.
5. Use a wrench to slowly adjust the position of the stroking bolt by quarter turns. Record the inlet and outlet pressure, or just the change in pressure, at every position. Continue this until full stroke is reached.
6. Return the adjustment bolt to the zero stroke position. Change the flow in the pressurized line so that a different inlet pressure at zero stroke is achieved.
7. Repeat steps 4 and 5 at several flow rates.

MAINTENANCE AND BELLOW REPLACEMENT

For the maintenance of the bellow pressure regulator the bellows (003) may need to be replaced. The pressure regulator consists of two halves that come apart to allow for bellows replacement. The assembled case can been seen below in Figure 3.

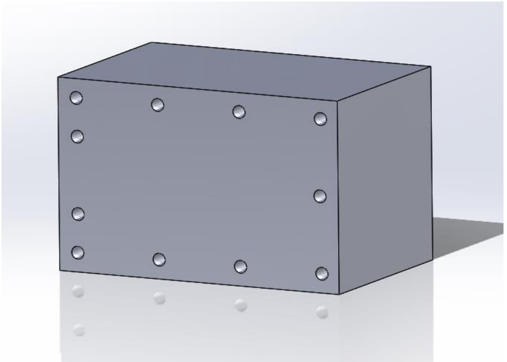

Figure 3: Assembled Pressure Regulator

There are two pieces that come apart from this case. The bellows is the main pieces that needs replacement but the diaphragm (004) will need to be replaced at the same time. These two pieces can be seen below in Figure 4 and Figure 5.

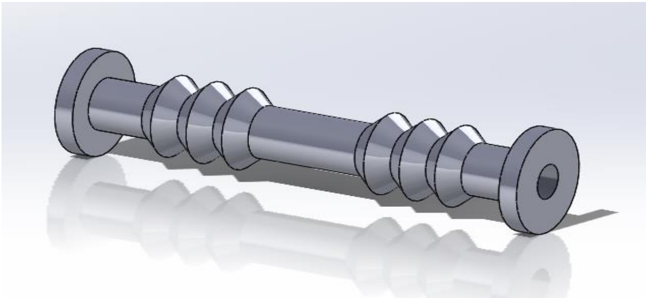

Figure 4: Bellows Valve (Part #003)

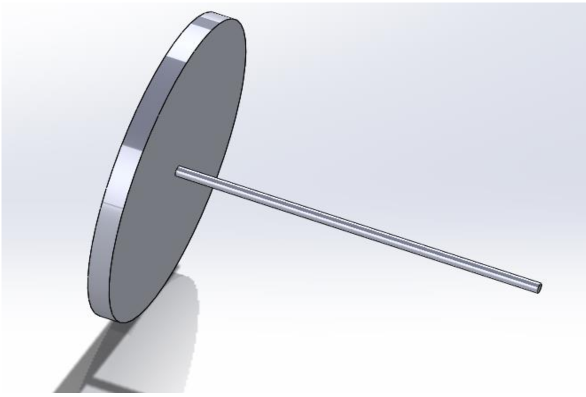

Figure 5: Diaphragm (Part #004)

To change out the bellow and diaphragm, be sure that the case is relieved of all pressure. After the pressure is released, begin my removing the 11 bolts (005) that hold the case together. After removing the bolts, the case will come apart into two pieces, as shown in Figure 6.

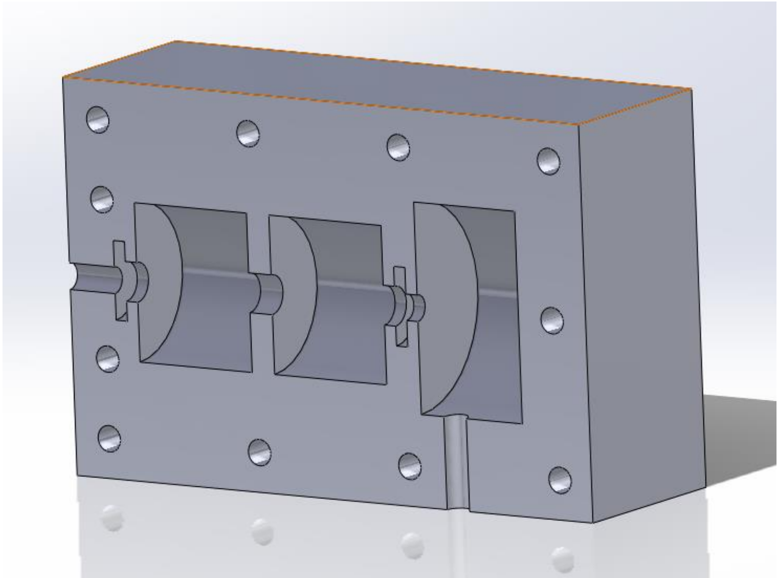

Figure 6: Disassembled Case Half (Part #001 & #002)

After the case is apart the bellow and the diaphragm can be exchanged. When the case is taken apart clean all RTV sealant from the case halves with a wire brush. The bellows fits into the circular slots machined into the case. The placement of these two pieces can be seen in Figure 7. After the bellows and diaphragm are in place, the case can be re-assembled. Follow the instructions in the assembly section to re-assemble the case.

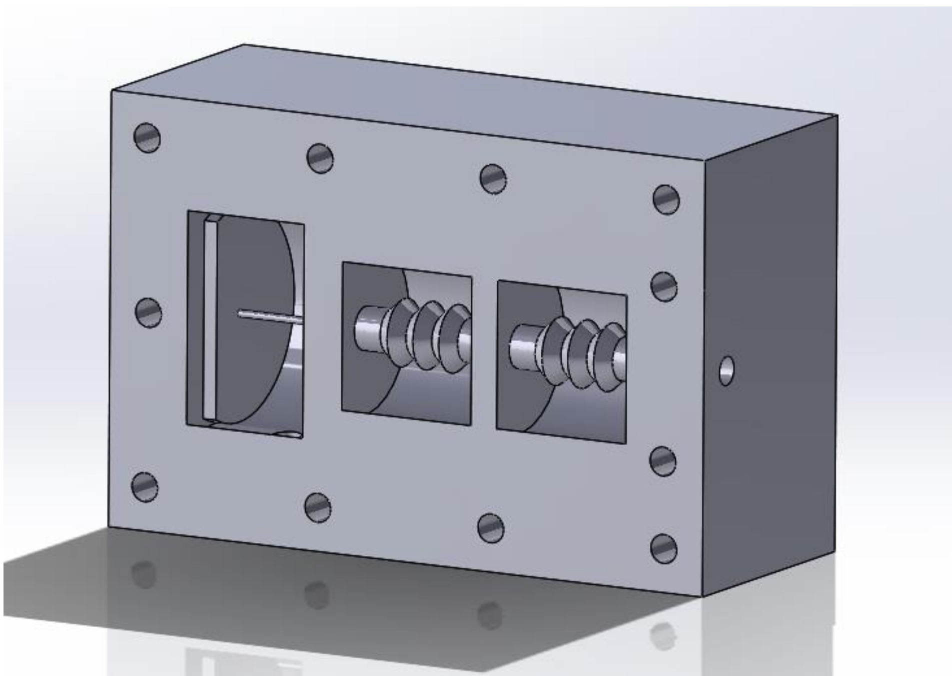

Figure 7: Bellow and Diaphragm Placement