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# Investigating the Relationship between the Components involved in the 1-Component Polyurethane Foam Dispensing Gun System

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## Introduction

Since the introduction of a dispensing gun for one component polyurethane foam (OCF), there have been issues related to the interaction and fit of the gun collar, valve and the dispensing gun's basket. I believe these issues arose because no standards were developed for the system. Thus, every manufacturer had to determine for themselves the dimensional and functional requirements. Based on the desires of each manufacturer and marketer of the system, variations were designed into the systems that prevented interchangeability of components. Although the OCF Dispensing Gun System has been in use for more than 20 years, new problems continue to be found in the system. This paper will review some of the past problems and the current situation of the OCF Dispensing Gun System while attempting to provide information and suggestions for eliminating the problems.

## Basic Operation of a Dispensing Gun System

A can of OCF is fitted with a collar (see Figure 1) that allows its attachment to a dispensing gun (see Figure 2). The union of the can of OCF and dispensing gun form the dispensing gun system (see Figure 3). The threads on the collar are aligned with the threads of the gun basket and as the can is screwed on to the gun basket, the hub of the gun basket descends and encompasses the stem and rubber seal of the valve. Eventually the hub contacts the stem shoulder or tip of the valve and begins to depress and open the valve. As the valve opens, the upper tube of the valve's rubber seal expands (billows out) creating a seal within the seal fit diameter of the gun basket hub. Consequently, the opened valve allows product to flow into the gun. When the user pulls the trigger, an internal rod moves away from the barrels tip allowing OCF to flow from the tip of the gun.

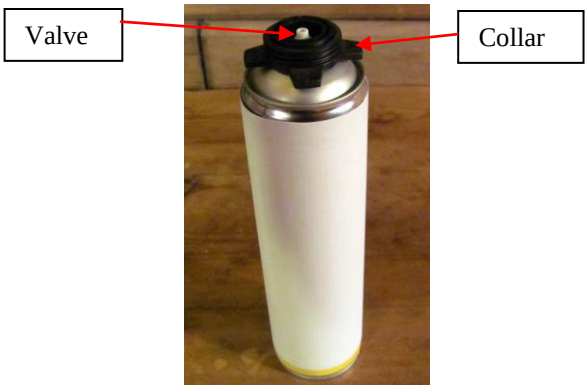



Figure 1 – Gun Foam Can

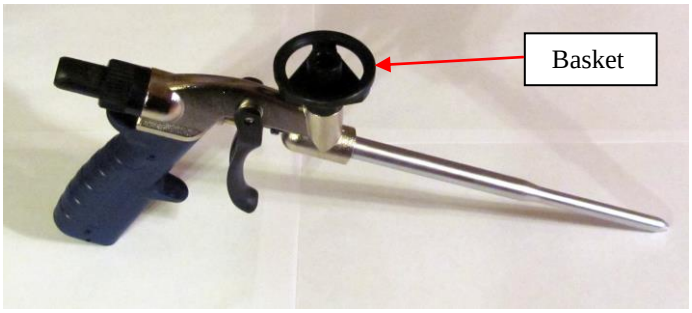



Figure 2 – Dispensing Gun

Figure 3 – OCF Dispensing Gun System

There are some required variations in the dispensing gun systems resulting from the two valve types used, rubber and plastic. For the purposes of this paper, I will review the system which uses the rubber style valve. We need only review the rubber style valve because the plastic valve requires a precise matching collar and gun basket. Thus let's begin by identifying the three (3) main components involved in the dispensing gun system and some of the terminology used in this paper:

1. Gun Valve (see Figure 4)

2. Gun Collar (see Figure 5) and

3. Dispensing Gun's Basket (see Figure 6).

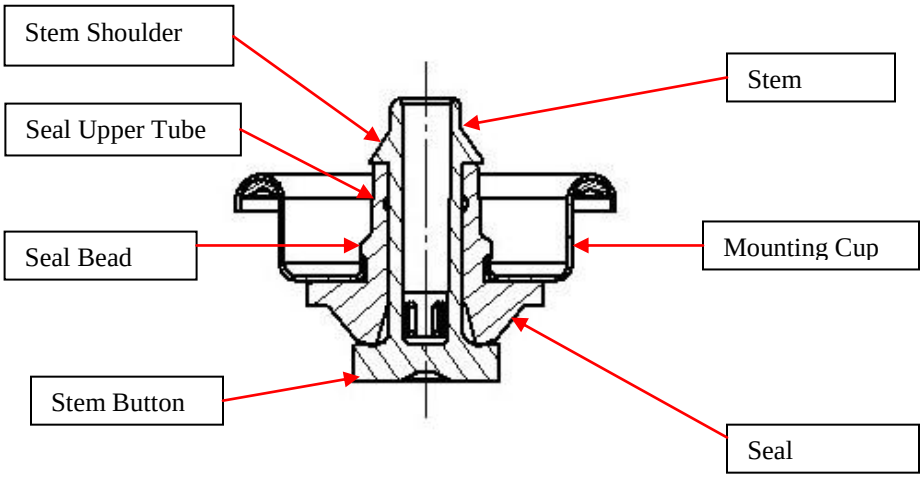



Figure 4 - Gun Valve

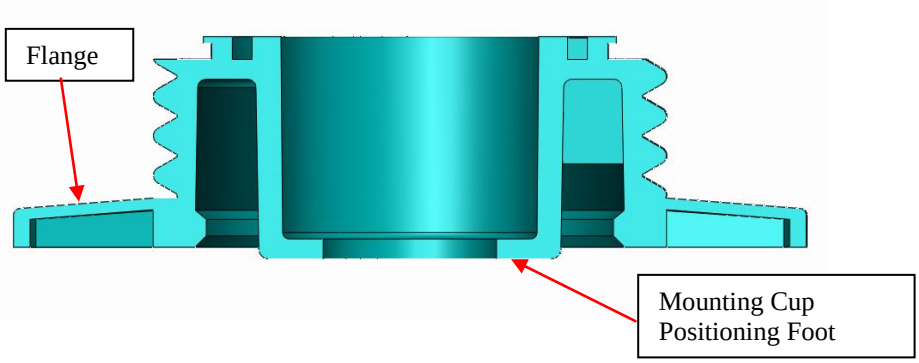



Figure 5 – Collar

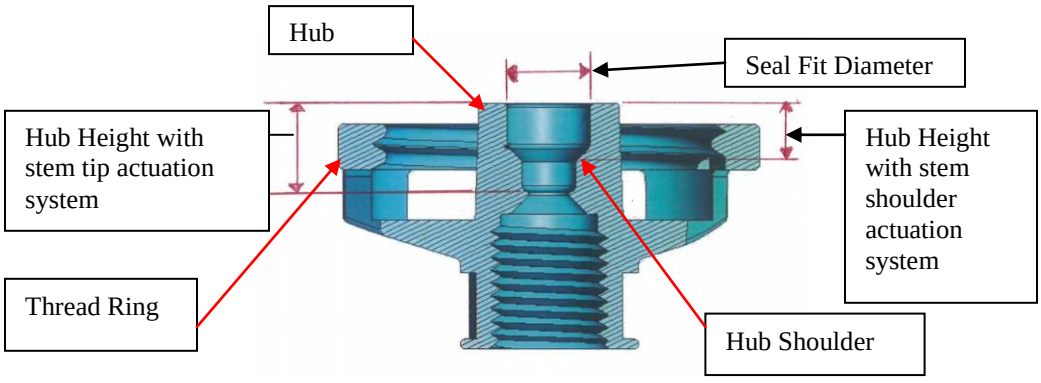



Figure 6 - Dispensing Gun Basket

## A History of Problems

While the dispensing gun system is a very useful tool for the professional application of polyurethane foam, the system has had a history of problems. Some of the major problems were the result of:

1. Variations in the depth of the dispensing gun basket's hub shoulder and its location with respect to the gun basket threads (see Figure 7): If the hub shoulder dimension was too large or its location with respect to the threads was too deep, the valve's stem shoulder would not make contact and thus the valve would not open. If the shoulder was too shallow, the valve would start to open before the threads on the collar and gun basket were engaged. This condition could result in a poor seal between the can of foam and the dispensing gun resulting in foam leakage.

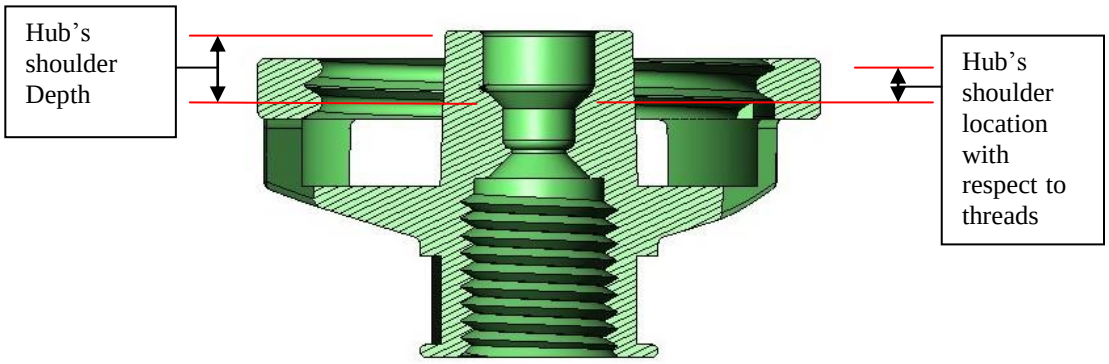



Figure 7 - Hub's Shoulder Location

2. The location of the tip of the valve stem with respect to the top of the gun collar (see Figure 8): If the valve's stem tip was too high above the top of the gun collar, the valve would start to open before the threads on the collar and gun basket were engaged. If the stem tip was too far below the top of the gun collar, the valve would not make contact and thus the valve would not open.

Figure 8 - Tip of valve stem with respect to top of collar

There are multiple reasons why the valve's stem tip didn't line up with the top of the gun collar. One reason is the fact that different valve suppliers have different dimensions for the depth of the mounting cup (see Figure 9). Because there are differences in this dimension from supplier to supplier, collar manufactures designed their collar to work with a specific valve's mounting cup. This resulted in valve specific non-interchangeable collars.

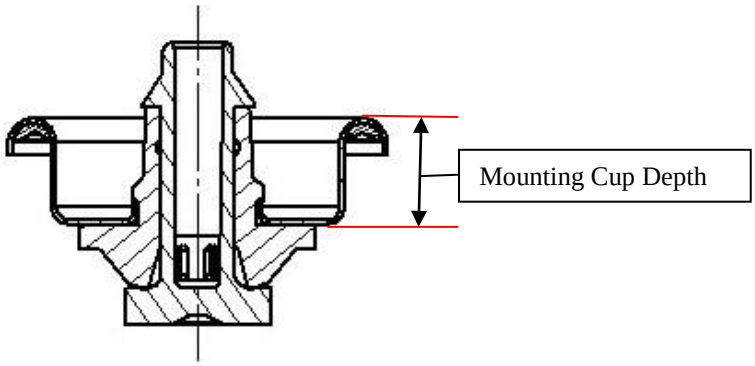



Figure 9 - Gun Valve's Mounting Cup Depth

A second reason for an improper stem tip location is due to the doming of the cup when the can is pressurized. When the can is pressurized the center of the valve rises (see Figure 10). How high the pressure goes in the can will affect how high the cup domes and thus the height of the stem tip. The higher the pressure in the can the higher the cup domes thereby affecting the height of the stem tip.

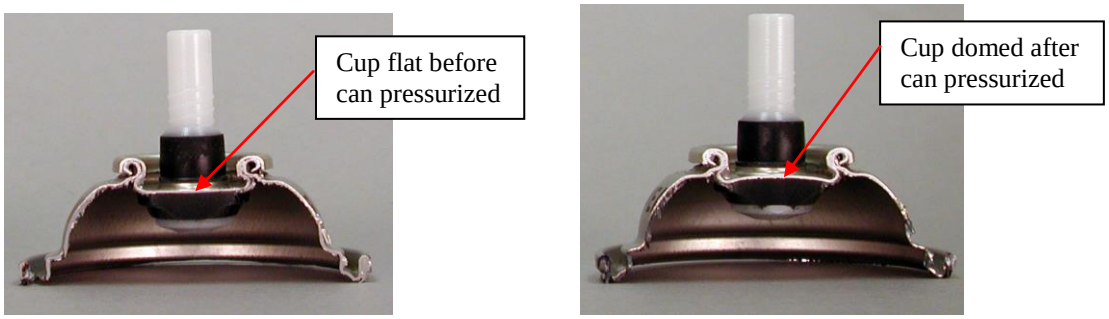



Figure 10 - Mounting Cup before and after Can is pressurized

At some point, someone realized one could control the location of the tip independent of the depth of the mounting cup and the amount of doming. This was accomplished by adding a **Mounting Cup Positioning Foot** in the collar that set the location of the tip by controlling the height of the valve's mounting cup with respect to the top of the collar (see Figure 11). This allowed the stem tip to end up in the same location with respect to the top of the collar independent of the cup's depth or the amount of doming (provided that the collar's foot made contact with the bottom of the mounting cup).

When comparing a cross section of a collar supplied with a Mounting Cup Positioning Foot and a collar without a positioning foot, one can see the difference (see Figure 11 & 12). The collar with the Mounting Cup Positioning Foot controls the position of the mounting cup because the foot extends down into the mounting cup making contact with the bottom. By positioning the bottom of the mounting cup with respect to the top of the collar, the tip of the valve always ends up at the same location with respect to the top of the collar regardless of the can's pressure or mounting cup depth. Clayton suggests that the tip of the stem with respect to the top of the collar be 0.004" +/- 0.012" (0.1mm +/- 0.3mm).

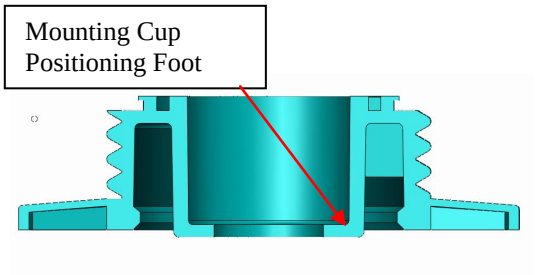



Figure 11 - Collar with Mounting Cup Positioning Foot

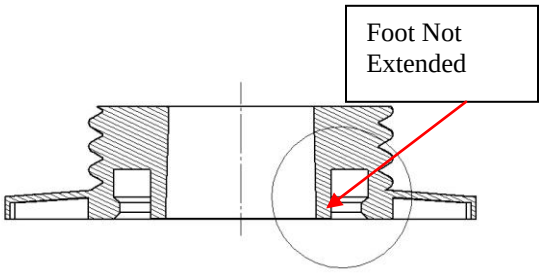



Figure 12 - Collar without a Mounting Cup Positioning Foot

Other areas of concern and differences:

1. <u>The angle of the Hub Shoulder in the Gun Basket (reference Figure 6):</u> Variations in the angle have resulted in point contact instead of surface contact between the stem shoulder and hub shoulder. This, at one time, was the main sealing location that prevented leakage between the can of foam and the dispensing gun. If good contact was not accomplished, foam would leak.

2. <u>The finish on the Hub Shoulder surface in the Gun Basket (reference Figure 6):</u> As above, this surface once provided the seal between the can of foam and the gun. Roughness or damage on this surface caused leaking.

3. <u>Variations in the Gun Basket's seal fit diameter (reference Figure 6):</u> Variations in this diameter affects how the valve's rubber seal forms a seal between the can of foam and dispensing gun. If the diameter is too small it can impact the stem shoulder and open the valve before creating a seal between the valve and gun basket. It can also restrict the expansion of the upper tube of the valve's rubber seal causing the stem and seal to become locked together and move as a unit. This situation puts added pressure on the cup bead of the valve's rubber seal. If the diameter is too large, the valve can open before a seal between the valve and gun basket is achieved. This could result in a momentary leak when installing and removing the dispensing gun from the can.

4. Security of the attachment between the collar and valve: Improper dimensions or attachment of the two components results in the collar spinning on the valve or detachment from the valve. In some cases, the valve's mounting cup was damaged and leakage occurred between the valve and can.

The final historical problem to discuss resulted from stuck valves. Customers would report that the can leaked when attached to the dispensing gun. Leakage occurred because the valve's stem was glued to the rubber seal (stuck valve). Because the two components were glued together, when the can was screwed onto the dispensing gun the stem and rubber seal were pushed back as a single unit through the valve's mounting cup. This resulted in disengagement between the rubber seal and the mounting cup creating a gap which resulted in foam leakage.

## A New Problem

A couple of years ago, when examining a report of a gun foam can leaking after being attached to the dispensing gun, it was found that the valve was not stuck. Why then was there foam leakage? In order to answer the question, Clayton's lab studied the relationship between the gun collar, the valve and the dispensing gun's basket. It was determined that new problems were lurking in the dispensing gun system. The problems were identified as:

1. The gun basket's hub height.

2. The distance the system opens the valve.

The design in these areas of the dispensing gun system can result in valve damage when the can is attached to the dispensing gun. The damage inflicted on the valve results in the leakage of foam.

Examination of valves taken from cans that exhibited the problem was performed. There was damage to the valve seal's bead similar to when the stem and rubber seal of a stuck valve was pressed back through the valve's mounting cup (see Figures 13, 14 & 15). However, the valve was not stuck. Furthermore, close inspection of the samples revealed that the seal's bead was torn and pushed upward away from the mounting cup. Damage of this type indicates that a high degree of force was applied to the seal. It was theorized that the damage may have occurred: 1) during molding of the seal, 2) during the assembly of the valve or 3) when the can was screwed onto the dispensing gun.

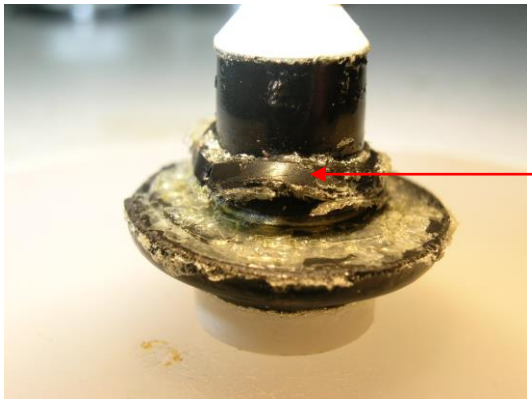



Figure 13 - From Customer showing damaged seal bead
(seal and stem removed from valve)

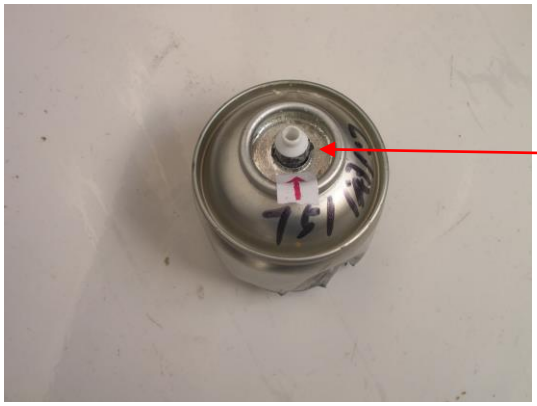
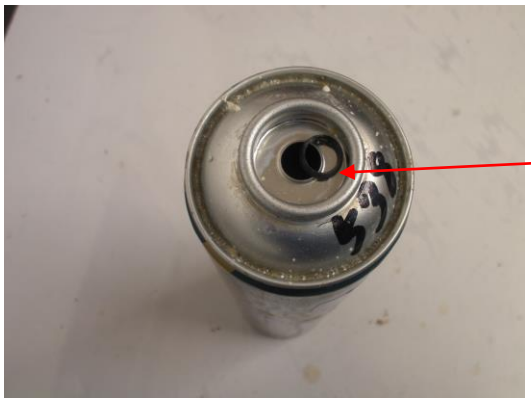



Figure 14 - From customer showing Damaged Seal bead




Figures 15 - From Customer Show Bead Completely Torn Off and Stem and Seal Pushed into Can

Step 1 of the investigation was to inspect seals for damage related to molding. Retained seals from the same lot numbers as those used to produce the valves were inspected and no damage was found. Receiving inspection reports were also checked to see if there were any notes of damage found when received. None were noted. The second step was to inspect samples of retained valves with the same lot number along with a carton of

valves returned by the customer. No damage was found in the assembled valves. It was concluded that if the seals were not damaged either as received from the supplier or in the valve assembly process then the damage must have occurred when the can was screwed onto a dispensing gun. Based on this data, Clayton initiated an investigation of the interaction and relationship between the valve, gun collar and dispensing gun basket. The investigation covered the following:

1. Valve Opening Distance: The minimum and maximum amount the valve should be opened for proper function.

2. Dispensing Gun to Valve Fit: Determine the fit relationships between the gun basket and valve for proper fit and sealing.

3. Gun Collar and Its Affect on Valve Opening Distance: Evaluate the relationship between the collar/gun basket and the valve opening distance.

Valve Opening Distance

Based on the conclusion; a valve could be damaged during attachment to a dispensing gun if the system tries to open the valve farther than is physically possible, the first step of the investigation was to determine the minimum and maximum opening distances (see Figure 16).

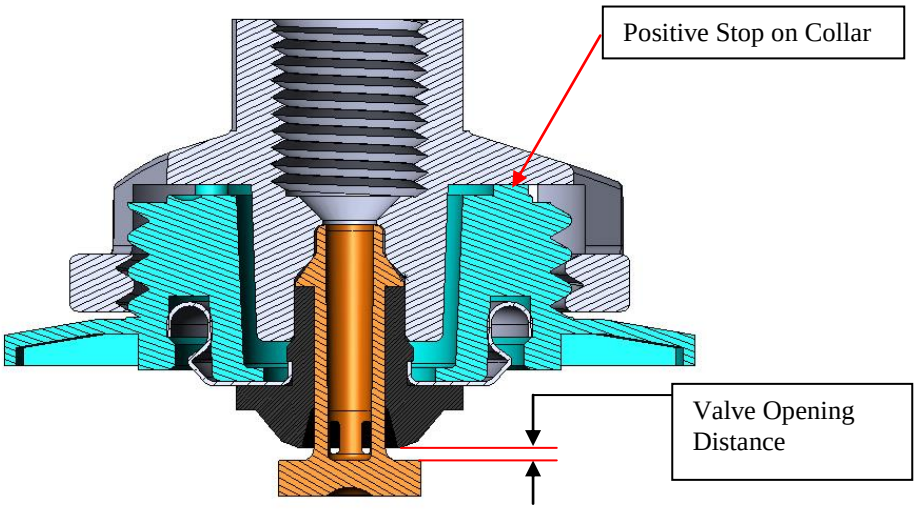



Figure 16 – Measurement Location of Valve Opening Distance

The minimum distance is where the gap between the stem button and seal is large enough to allow full flow during dispensing. The maximum opening distance is the distance achieved just prior to distorting the valve. The resulting investigation provided the following information:

Minimum Opening: 0.040” (1.0mm)
Maximum Opening: 0.100” (2.5mm)

Dispensing Gun to Valve Fit

Theoretically the seal's bead could have been damaged if the gun basket pinched the bead between the hub and mounting cup. Thus, it can be seen in Figure 17, that if the gun basket's hub is too long or the collar allows the valve to move too far into the hub, the seal's bead can be pinched between the hub and mounting cup. Pinching the seal's bead between these two points may result in the mounting cup's pierce hole edge cutting into the seal's bead.

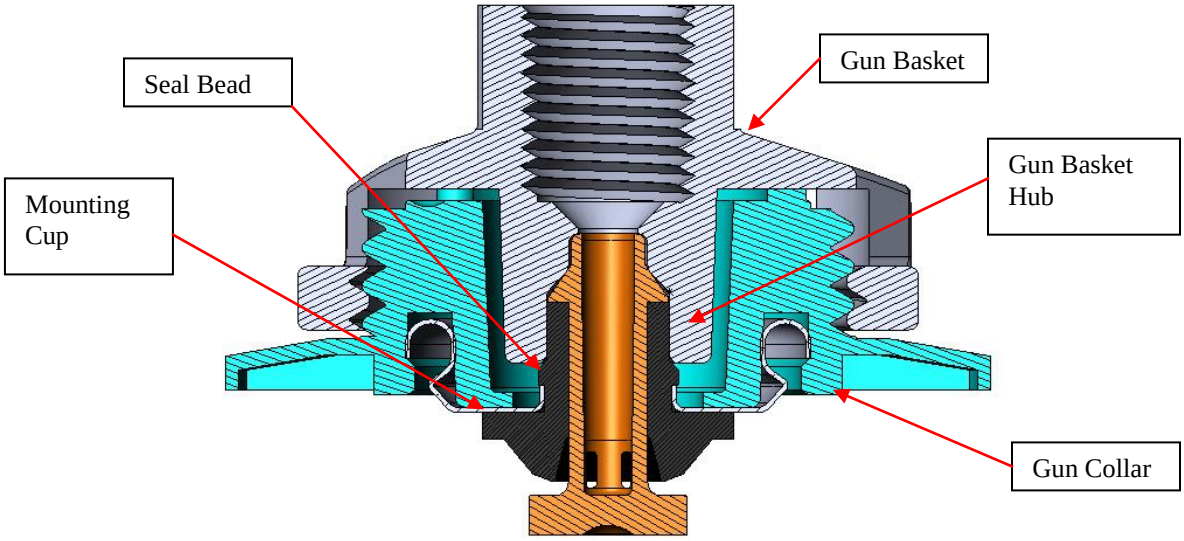



Figure 17 - Seal Bead fit between Mounting Cup and Gun Basket Hub

Prior to examining the relationships between various types of gun baskets and collars, the valve's stem and seal were removed from the mounting cup for dimensional purposes. This allowed the inspection of the relationship of the gun basket hub to the area of the valve's mounting cup where the rubber seal's bead fits. It was found that some combinations of collars and gun baskets allowed the hub of the basket to almost touch the mounting cup when fully engaged. Under this condition, there isn't any clearance for the valve's rubber seal bead (see Figure 18).

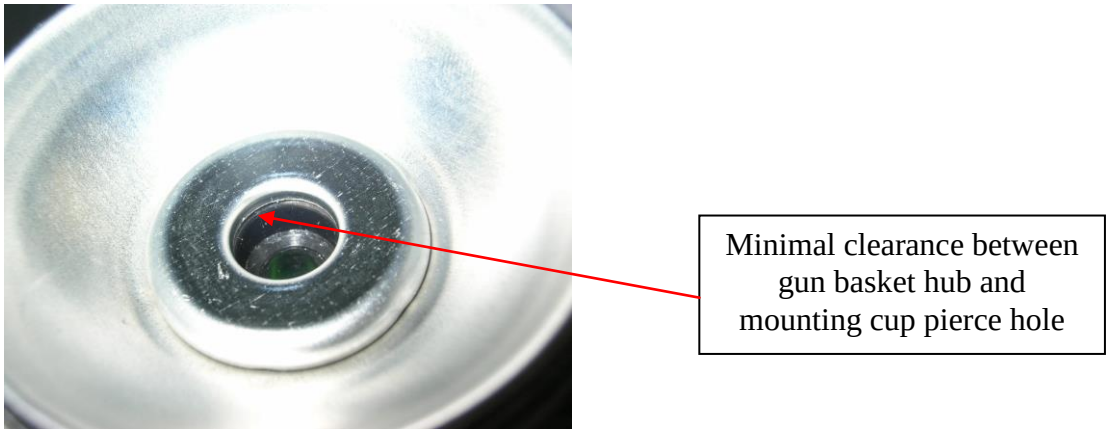



Figure 18 – No Clearance for the Bead of the Rubber Seal

In comparison, the same inspection found that some combinations of collars and gun baskets provided a large clearance for the rubber seal's bead (see Figure 19).

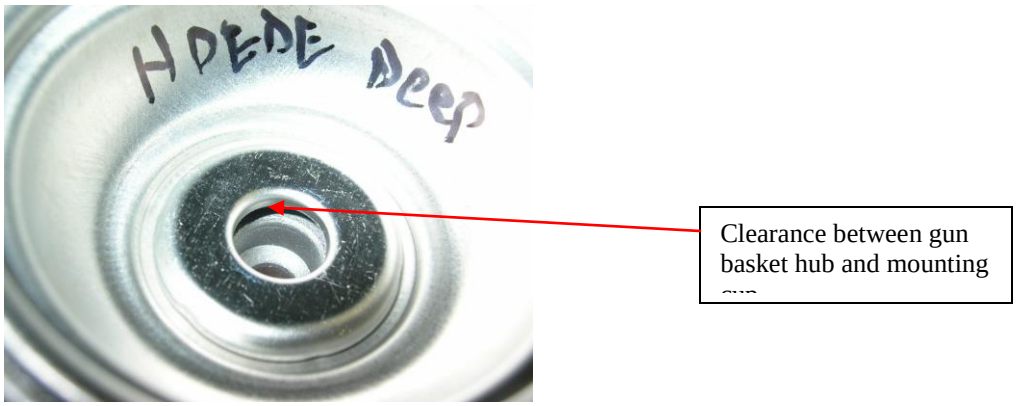



Figure 19 - A Gun Basket and Collar combination that allows Clearance for the Seal's Bead to fit between the Gun Basket Hub and Mounting Cup

In the case where there isn't enough clearance for the Seal's bead, as the can is screwed onto the dispensing gun, the bead of the seal is pinched between the Gun Basket's Hub and the Mounting Cup. In this situation, it is possible to cut the bead from the seal. If the bead is removed, nothing prevents the stem and rubber seal from being pushed back into the can causing a leak. To further illustrate the direct contact between the hub and seal bead, a section was cut from one of the domes, and the dome was mounted onto the basket of a gun. Figure 20 shows how the bead is compressed and at the same time the force pushes the seal back away from the mounting cup. This is easily seen because the bead is bulging and there is a gap between the seal and mounting cup.

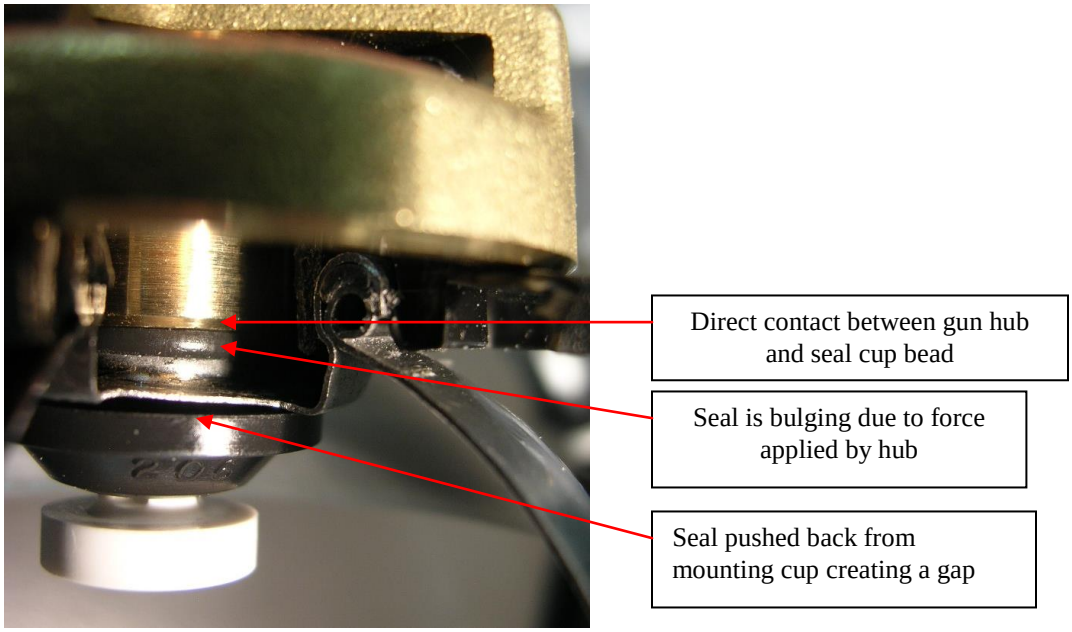



Figure 20 - Dome mounted onto a dispensing gun basket without proper clearance for the rubber seal's bead

Note: The distance that the seal is pushed back into the can will be greater in a pressurized can than is shown in Figure 20, because the valve stem is pushed upward due to the pressure in the can. Thus, the higher stem will contact the dispensing gun's basket earlier and thus be opened farther.

There are two possible reasons why there isn't enough space for the seal's bead between the gun basket hub and mounting cup:

1. The hub height is too large (reference Figure 6).

2. The collar allows the can to be screwed too far into the gun basket (This will be discussed in the section "Gun Collar and Its Affect on Valve Opening Distance").

To insure there is enough space between the gun basket's hub and mounting cup, when the can is attached onto a gun, the hub height (reference Figure 6) plus the opening distance must be less than Dimension A as shown in Figure 21.

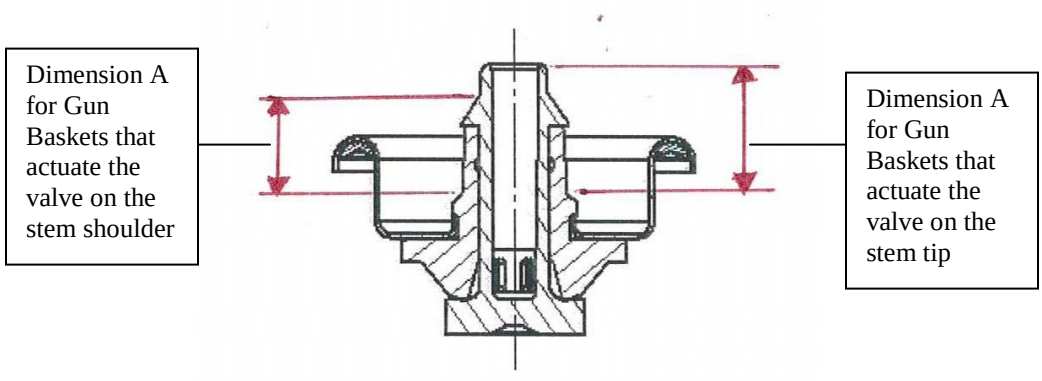



Figure 21 - Valve Dimension A

With Clayton's valve, Dimension A is as follows:

Dimension A for gun baskets that actuate the valve on the stem shoulder: 0.34" (8.6mm)

Dimension A for gun baskets that actuate the valve on the stem tip: 0.45" (11.4mm)

Calculate the gun baskets maximum hub height using the valve's maximum opening distance as follows:

Maximum Hub Height = Dimension A – Maximum Valve Opening

<u>For gun baskets that actuate the valve on the stem tip</u>

Maximum Hub Height = 0.34" - 0.100" = 0.24" (6.1mm)

For gun baskets that actuate the valve on the stem shoulder

Maximum Hub Height = 0.45” - 0.100” = 0.35” (8.9mm)

In addition to damaging the seal bead by pinching it between the gun basket hub and the mounting cup, it is also possible to stop free movement of the stem inside the seal. In this situation the two components move as one and the opening force created, as the can is screwed onto the dispensing gun basket pushes both the stem and seal into the can. To understand how this is a possibility, one must first understand the mechanics of opening the valve. When the stem contacts the gun basket either on the stem shoulder or tip, a force is created that moves the stem downward. In order for the stem to move downward, the seal walls balloon outward increasing the seal’s diameter (see Figures 22 & 23).

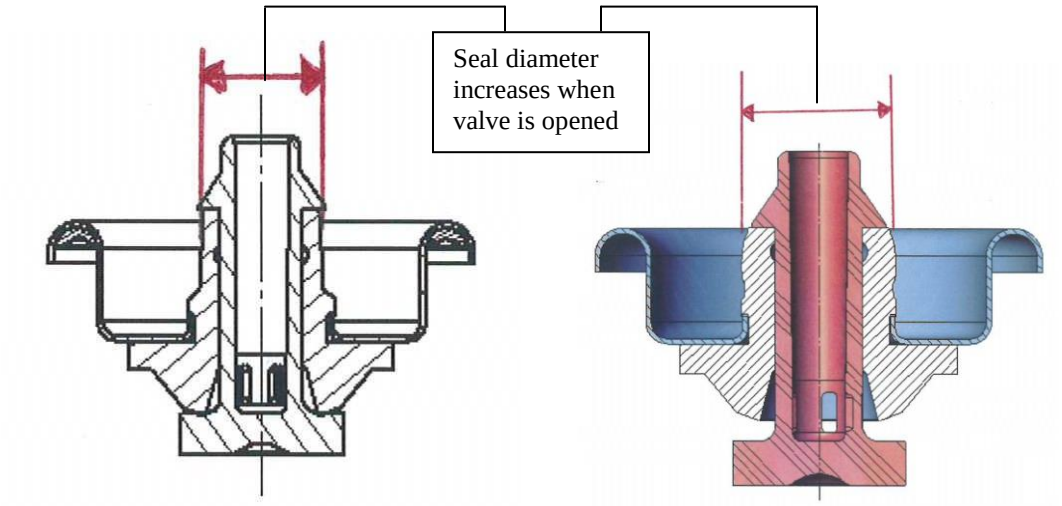



Figure 22 - Seal Diameter with Valve Closed Figure 23 - Seal Diameter with Valve Open

The increasing diameter of the seal contacts the inside of the gun basket’s seal fit diameter (reference Figure 6). The contact between the seal and the gun basket is one method that prevents foam leakage. The further the valve is opened, the larger the seal diameter becomes. At a certain point, the seal can no longer move outward because it is wedged tightly in the gun basket hub’s seal fit diameter. If the can is screwed beyond this point, all the applied force is directed toward simultaneously moving the stem and rubber seal downward. This downward movement attempts to push stem/seal through the mounting cup. In this situation, a very high force is exerted on the seal’s bead causing the seal to move away from the mounting cup (see Figure 24). When the seal moves back and off the mounting cup, it is possible to open a leak path between the mounting cup and seal. Experience has shown that as long as one does not try to open the valve further than the maximum, the valve’s stem and rubber seal will not be pushed back into the can even when the gun basket’s seal fit diameter is the same as the seal’s diameter.

Gun Collar and Its Affect on Valve Opening Distance

Previously it was believed that as long as the tip of the valve was at the same level as the top of the gun collar, the valve would be opened the proper distance. This approach worked well to provide consistent opening of the valve with a given collar and gun basket combination. However, this relationship has been found not to be universal for all collar and gun basket combinations. Originally it was thought to be true because the collar/gun basket combinations at that time limited the opening of the valve by reaching a positive stop. It has now been found that some collars on the market allow the valve to be opened to distances that physically distort and damage the valve. These large opening distances were designed to provide extra force to the valve's stem as a means of freeing stuck valves. However, as shown in Figure 24, when the valve is excessively opened it is distorted resulting in possible damage and leakage.

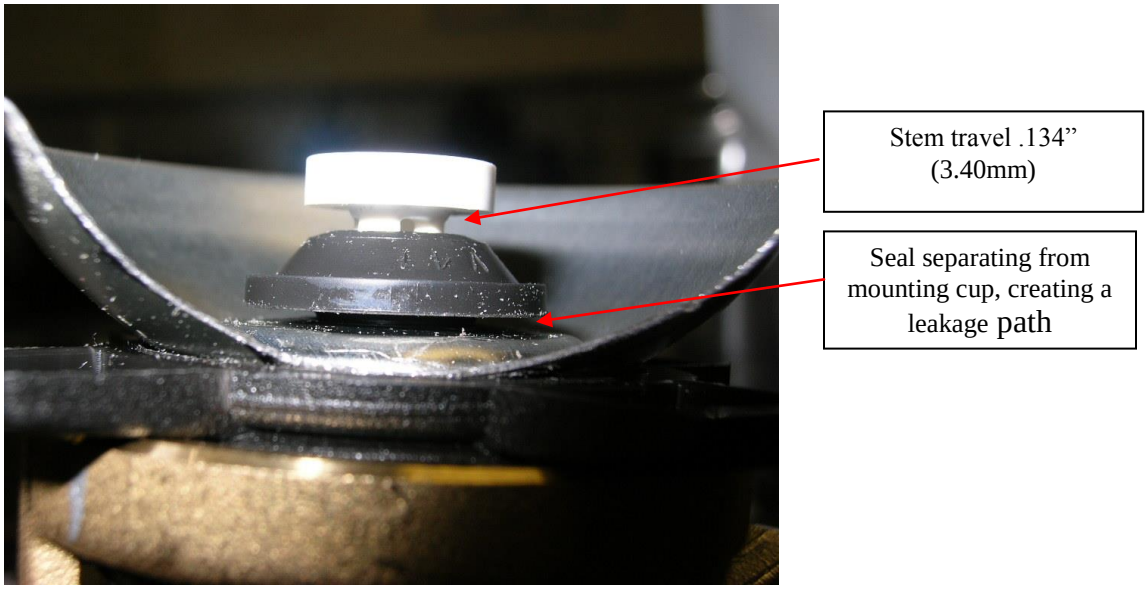



Figure 24 - Stem opening distance of 0.134" (3.40mm) causes seal to lift off mounting cup

In order to limit the distance that the valve can be opened, Clayton suggests a positive stop be designed on the collar. The positive stop (see Figure 25) limits how far the can of foam can be screwed onto the gun basket. In Figure 25, the positive stop is on the top of the collar causing contact with the bottom of the gun basket. It is also possible to put the positive stop on the collar's flange so that it contacts the gun basket thread ring.

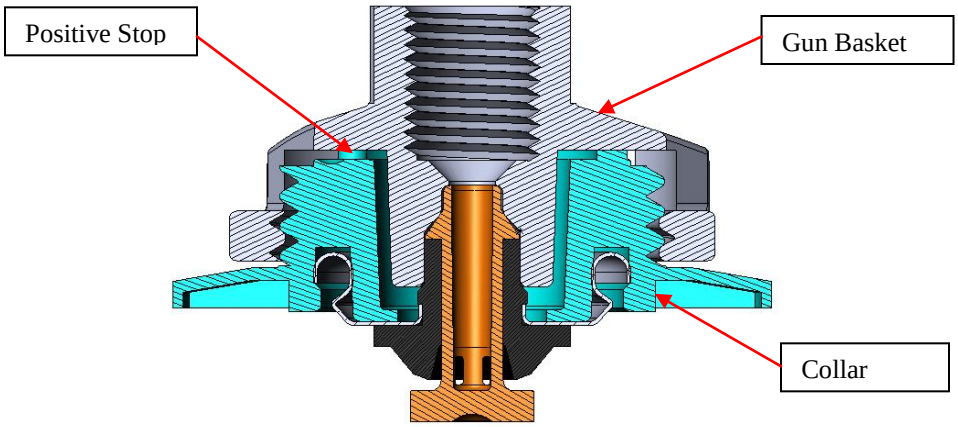



Figure 25 - Positive stop on gun collar

Because of the dependent nature of the dimensions of all the components in a properly functioning system it is impossible to provide absolute collar dimensions that would provide a positive stop when the valve is opened the proper distance. However, what can be stated is: When the valve's stem first contacts the actuation point of the gun basket's hub, there should be a gap ranging from 0.040" (1.0mm) to 0.100" (2.5mm) between the positive stop on the collar and the corresponding contact point on the gun basket (see Figure 26).

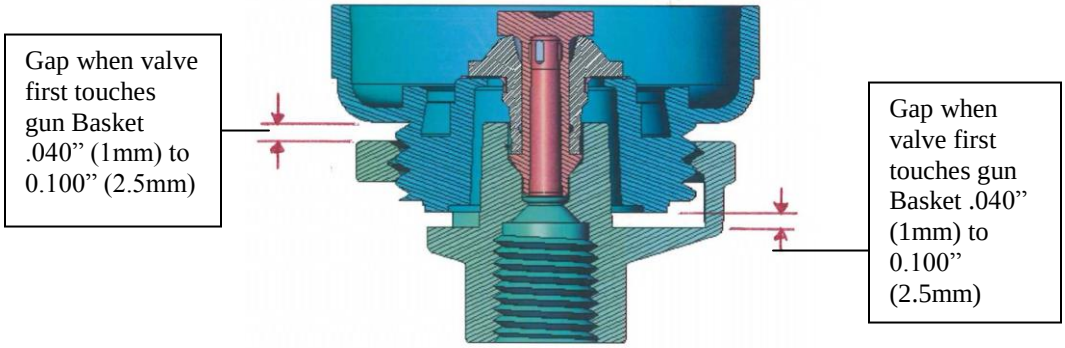



Figure 26 - Gap between collar and Gun Basket at the potential positive stop locations at first contact between Valve and Gun Basket

## A System Starting Point

Over the years while working with numerous customers, Clayton has evaluated many designs and dimensions for the collar and dispensing gun's basket. While Clayton cannot provide dimensions for one component independent of the others, a combination recommendation can be provided for the overall system. Therefore, Clayton offers a combination collar/ gun basket design that addresses the discussed problems when used in conjunction with Clayton's gun valves. Furthermore, Clayton has also successfully tested its designs with competitive rubber style valves. However, due to the possibility that other suppliers may change their products, testing must be done on an individual

bases. The primary lesson to remember is that the dimensions for the collar and gun basket work in tandem.

Collar Design

Clayton believes the following dimensions are important to the proper function of the collar with respect to the gun basket design shown below and Clayton's gun valves (see Figure 27).

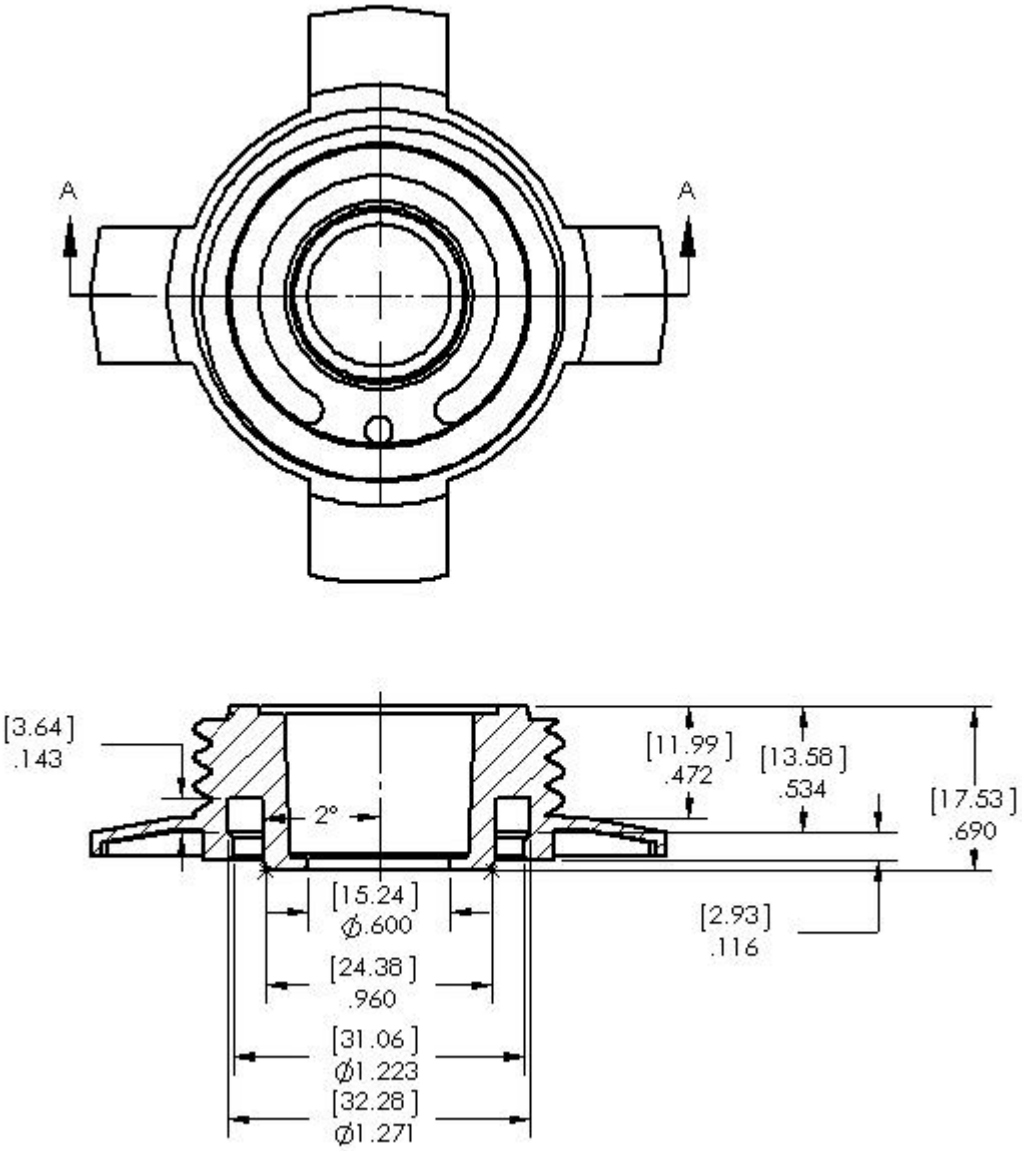



Figure 27 – Collar Dimensions

Dispensing Gun's Basket Design

Clayton believes the following dimensions are important to the proper function of the gun basket with respect to the collar design above and Clayton's gun valves (see Figure 28).

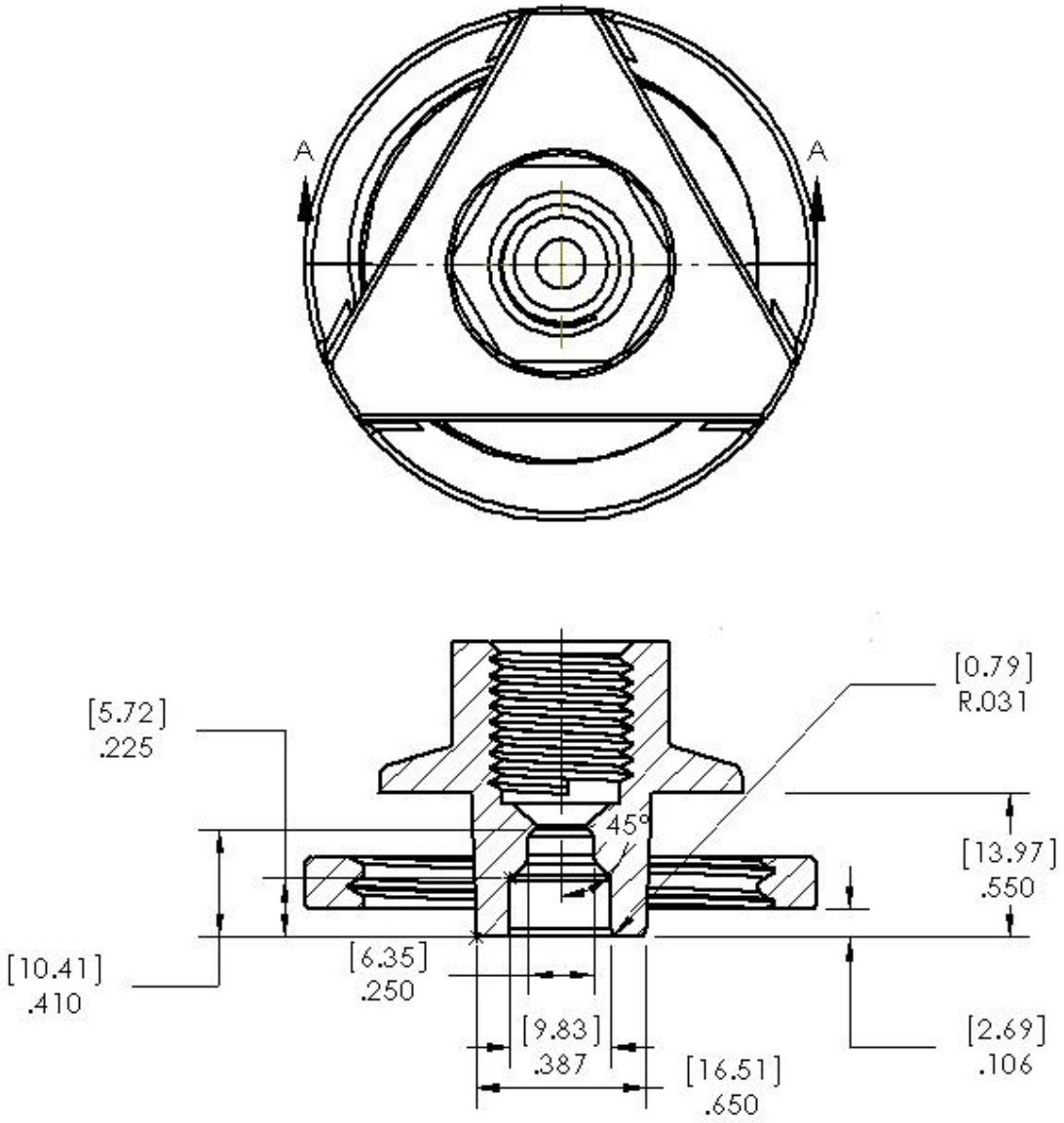



Figure 28 – Gun Basket Dimensions

## In Conclusion

While the Dispensing Gun System for OCF is a very useful tool for the application of PU foam, the system has had its share of problems over the years. Clayton believes that the problems arise from the fact that there is not and has not been a standard for the system or a complete understanding of how all the components interact. Clayton believes that by understanding past problems and the relationship/interactions between the components, current problems can be corrected and future ones avoided.

Therefore Clayton recommends all companies involved in the design, manufacture or use of one or more of these components examine and test their components/systems for:

1. A gun collar that positively positions the stem tip of the valve through the use of a Mounting Cup Positioning Foot.

2. Proper fit of the gun collar on the valve. (Make sure that the collar fits tightly and securely onto the valve.)

3. A gun basket hub shoulder that is smooth and at the proper depth such that the valve's stem fits into the hub and the threads of the collar and the gun basket engages before the valve begins to open.

4. A close fit between the diameter of the rubber seal and the seal fit diameter of the gun's basket.

5. Clearance between the gun basket hub and the bead of the valve's rubber seal. One can check this by the dimensions given previously for calculating maximum hub height.

6. Proper opening distance of the valve when the can is screwed onto the dispensing gun. This can be checked by empting a can, cutting off the dome and then screwing the can onto the gun basket. Check the distance the valve is opened and verify that the valve's rubber seal has not moved off the mounting cup.

7. A clean separation (no puffing of product) between the can of foam and dispensing gun when the can is attached and/or removed from the dispensing gun.

This article has provided some basic dimensions for the collar and gun basket. Clayton has found that these dimensions, when used with Clayton's gun valves, provide a system that will avoid the problems outlined in this paper. These dimensions may be used as a guide and comparison to your current system, or as a starting point for designing a system. However, relying on the supplied dimensions is not a substitute for functional testing with your components.

If you would be interested in discussing this subject further or would like to work with the Clayton team regarding your OCF Dispensing Gun System, please contact me.

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