Technical Guide

Helpful Technical Information For Semco Plunger Tips, Shot Sleeves, and Shot End Components.

TECHNICAL INFORMATION

Guidelines for Plunger Tips, Shot Sleeves and Shot End Components

CONTENTS

DESIGN GUIDELINES FOR SHOT TIPS, SLEEVES, RODS, FOR BETTER COOLING AND LONGER LIFE

BACKGROUND

Many die casters in the aluminum and magnesium die casting process experience problems associated with hot running and/or sticking shot tips. These problems usually lead to defective casting production, and unacceptable or costly reduction in tip life, as well as a decrease in part production due to down time. SEMCO has produced our Be-10S™ and Be-20 shot tips for almost three decades. During this time, SEMCO has seen many process problems firsthand and assisted die casters in addressing these situations. As a result, SEMCO has published these guidelines to help alleviate shot tip related problems.

Die casters frequently suspect shot end alignment as the initial cause for premature plunger tips wear. Although this may not be the case with newly purchased machines, older machines that have been operating for longer periods of time could incur more shot end alignment problems. These problems are a result of worn shot end components and misalignment contributed by other mechanical factors. After the machine is properly aligned, the shot end alignment is rarely the cause of shot tip problems.

Another common problem SEMCO has observed is improper or poorly designed shot delivery components including the shot sleeves, shot tips, and plunger rods. These special components, if designed in-house, may fail to recognize some of the important aspects of the design that are regularly addressed by specialized manufacturers. Specialized manufacturers and/or OEM type shot end components consistently produce higher quality, better performing materials.

Assuming that the shot end alignment is correct and there are quality shot delivery components, a more detailed analysis of shot related problems is required.

The following are some of the more common problems related to shot end components and how to address these issues.

COMMON PROBLEMS

This is a summary of some problem areas in the shot process. Subsequently, these will be discussed in detail.

1) **Shot Tips:** Require proper design for adequate performance. The size of the internal cooling chamber and the wall thickness of the tip is very important. Inadequate cooling chambers will result in higher temperatures in the shot cycle. Proper shot tip wall thickness is critical to maximize heat dissipation and minimize the risk of wall failure.

2) **Shot Tip Clearance:** Very critical in the shot process. The Outside Diameter (O.D.) of the shot tip in relation to the Inside Diameter (I.D.) of the shot sleeve is very important. Proper working clearances change with the size of the tip, temperatures, cooling effectiveness and the type of alloy being cast.

3) **Coolant Volume:** The volume of the coolant must be adequate and properly maintained as it passes through the shot tip and plunger rod, at a known rate of flow.

4) **Coolant Temperature:** Coolant (usually water) temperature is very important. Should the water temperature be too high upon entering the shot rod, the plunger tip will run hotter than normal even thought the water volume may be adequate.

5) **Shot end components:** Improper setup and design of shot end components also causes problems in the shot process. The improper use of the shot stroke spacers may result in the use of several different length sleeves. This necessitates different plunger rod lengths and produces longer and more costly setup/changeover times.

6) **Compression stresses:** The shot end components must not exceed the compression strengths of the materials used in the shot process. Excess force causes compression failures and bent plunger rods. It is important to maintain sufficient area between the shot tip shoulder and the plunger rod shoulder to keep stresses below the yield point of the materials.

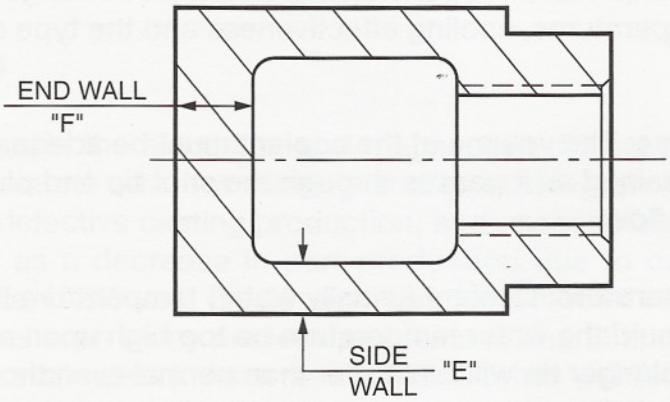
7) **Shot Tip and Rod Guiding:** Should be designed to allow greater than one inch engagement in sleeve. Anything less than one inch promotes rapid tip wear especially coupled with a universal joint type floating rod coupling.

8) **Shot Sleeve Design:** Should have proper wall thickness to facilitate heat transfer and minimize bowing and pour hole washout. Thin wall sleeves many times fail to account for the faster cycles of autoladles or the higher temperatures created by modern die casting practices.

SOLUTIONS

The following addresses in more detail the problems outlined above. SEMCO has worked with die casters for years and has found a number of suggestions and guidelines that have proved useful.

Figure 1



The following tabular data has been reproduced from the SDCE standards.

Table 1

Tip Dia	Ref Area	End Wall "F"	Side Wall "E"	I.D. Ref	I.D. Area	Ref. Cooling Area %
1.75	2.40	.50	.38	1.00	.78	32.5%
2.00	3.14	.50	.50	1.00	.78	24.8%
2.25	3.97	.50	.50	125	1.22	30.7%
2.50	4.91	.63	.63	1.25	1.22	24.8%
2.75	5.94	.63	.63	1.50	1.76	296%
3.00	7.07	.63	.63	1.75	2.40	33.9%
3.25	8.29	.63	.63	2.00	3.14	37.8%
3.50	9.62	.75	.75	2.00	3.14	32.6%
3.75	11.04	.75	.75	2.25	3.97	35.9%
4.00	12.56	.75	.75	2.50	4.91	39.0%
4.25	14.18	.88	.88	2.50	4.91	34.6%
4.50	15.89	.88	.88	2.75	5.94	37.3%
4.75	17.71	.88	.88	3.00	7.07	39.9%
5.00	19.62	1.00	1.00	3.00	7.07	36.0%
5.25	21.63	1.00	1.00	3.25	8.29	38.3%
5.50	23.74	1.00	1.00	3.50	9.62	40.5%
5.75	25.95	1.00	1.00	3.75	11.04	42.5%
6.00	28.26	1.13	1.13	3.75	11.04	30.0%

I. Shot Tip Designs

Proper tip design will allow adequate cooling and strength, and will facilitate better performance. The former SDCE Standards Committee recommended minimum dimensions for shot tip designs. The recommendations for end wall and side wall thickness are to promote sufficient nominal cooling and adequate stock to resist the sizeable pressures from the molten side and columnar forces. See Figure 1 and Table 1.

An examination of these figures reveals aspects concerning the strength and cooling ability of the shot tip.

The END WALL "F" dimension, based upon a tip made from beryllium copper, indicates the minimum recommended thickness necessary to withstand standard alloy pressures and to provide adequate heat dissipation. These are recommendations only. The "F" wall thickness may vary to facilitate better cooling or to allow for additional machining. These guidelines are a good starting point in tip design. Die casters that re-machine or turn down shot tips should maintain these recommended minimums to avoid risk of tip failure. The risk of failure increases if there is evidence of heat checking.

The SIDE WALL "E" dimensions indicate the recommended thickness necessary to withstand the columnar forces from most standard die cast machines. The thickness of the wall must prevent failure but must also allow for an adequate size cooling chamber. The balance between wall thickness (tip strength) and cooling chamber becomes very important. If the cooling chamber is not able to dissipate the heat, the tip will expand and it will wear prematurely. This may cause the tip to screech or stick in the shot sleeve. The end result is more wear on all shot end components (and thus higher costs) and lower production as a result of down time.

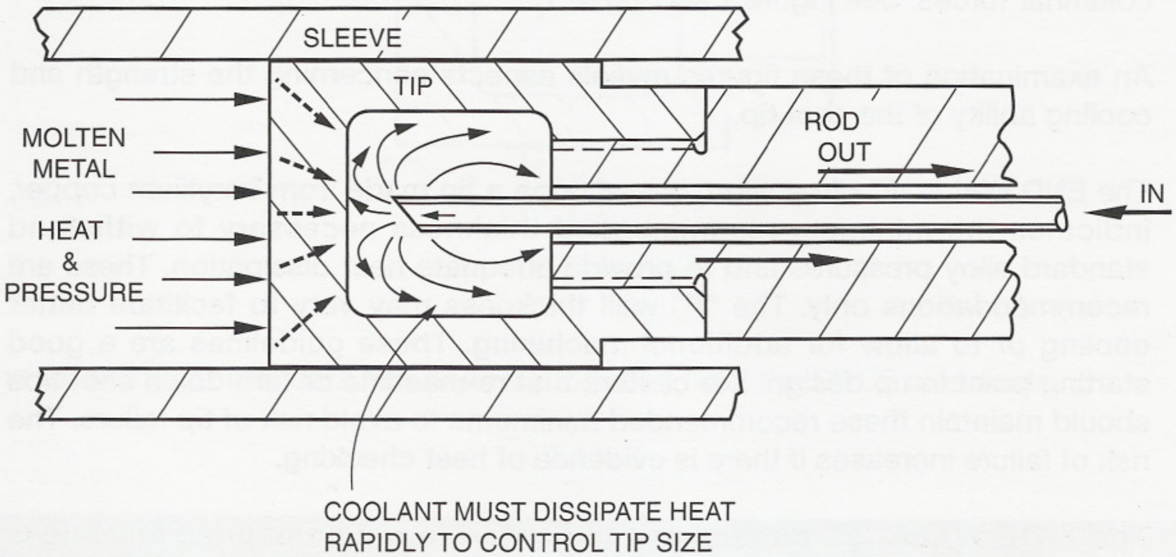
A common practice among die casters does not keep those factors in mind. Many die casters design shots tips with extra stock on the O.D. based on the theory that a large thick walled tip can be progressively turned down to much smaller diameters to save money.

This improper design practice results in the larger diameter size running hot and sticky from the outset. The die caster will never achieve the optimum performance at this diameter because the tip is not adequately cooled. This will also increase tip, sleeve, and rod wear and will affect the ability to produce quality parts. The cooling chamber must remain proportional to the O.D. of the shot tip.

SEMCO Beryllium Copper Plunger Tips are provided with the proper relationship between front face, side wall, and cooling chamber diameter and length that insures optimum cooling design for both SEMCO Beryllium Copper Be-10S™ and Be-20 alloy plunger tips. This is a result of SEMCO's years of

Figure 2 shows how the water flows through the plunger rod into the tip cooling chamber to control the temperature.

Figure 2



experience in producing plunger tips from diameters of 1 1/2" to over 7" and lengths of 3 1/2" to 10" long.

Example: If a 3" tip was machined with a cooling chamber of a 2" tip (1" = .78in_), the ratio would be .78/7.07 = 11%. If the percentage is increased to 25-30%, the tip will run much cooler, causing less sticking and flashing.

Proportional cooling chambers are essential to achieve the optimum performance from die casting components. Note the Cooling Area Ratio in Table 1. The ratio is calculated by dividing the I.D. by the O.D. and expressed as a percentage of the cooled versus heated area. Note that the recommended ratios range from 25% to 40%. If a tip is running hot, examining the ratio of the tip design may reveal the problem. A ratio less than 25% will produce a hot tip.

Final Tip Design Comments

Some die casters prefer not to use shot tips that have been cast with the cooling chamber to increase the side wall thickness. They prefer tips that are drill tapped to insert a cooling chamber. This will limit the performance of the tip but there are other benefits of cast cooling chambers. The radius in the cooling chamber provides additional strength. The rough interior also facilitates turbulence in the water flow that enhances the cooling property of the tip.

Tips may also be machined from round bar stock. Bar stock is not only more costly but die casters must also maintain tooling and personnel to machine the tips. Additionally, the cooling chamber is often not properly undercut which inhibits the cooling property of the tip. Machining an appropriate radius at the deepest part of the cooling chamber is difficult, but also essential to deliver adequate water flow to the "F" wall of the tip.

SEMCO cast tips allow the designer to establish optimized cooling chambers for each tip size or particular applications. The cast design also eliminates the need for machining and/or drilling the cooling chamber and thus eliminates possible errors during these steps. SEMCO has designed shot tips since 1976 and has shown that the cast cooling chambers reduce raw material loss, reduce finish machining time, allowing larger cast cooling chambers that make tips run longer. SEMCO also has designed families of castings from 2" to 5" diameter and lengths of 4, 4 1/2, 5, and 6" long for versatility in plunger tip size and performance.

II. Tip to Sleeve Clearances

For Beryllium Copper Plunger Tips and in particular, those with the proper cooling chambers, a general rule exists for clearance between the shot sleeve and plunger tips.

This clearance is suggested as an allowance of 0.001" per inch of tip diameter. Thus, for a 2" tip the clearance is 0.002, and for a 3" tip; 0.003, etc. This is the total clearance between the tip and sleeve. While a definite standard for clearances does not exist, the above is a good starting point. For plunger tip sizes above 4" diameter, the working clearances can vary, and require an additional 0.0005" clearance. Operating temperatures of the sleeve and tip combinations can be variable, influenced by the aluminum or magnesium casting alloy, its temperature, and fluidity.

The area of the shot sleeve that is buried in the platen and cover die will have metal to metal contact and can be assured to stay in a more reasonably round (concentric) condition. Some discrepancy in clearance and concentricity can be tolerated between the tip and sleeve in the exposed area, since this is a zone of low pressure. But if the sleeve is "bowing" due to thin wall construction, and/or has a hot spot under the pour hole, then extra tip clearance may have to be developed to get beyond this spot with minimum friction.

As before, a general starting rule works well for tips up to 3"–3 1/4". Starting at 3 1/2" and going up to perhaps 6" diameter tips, new ground rules must be developed. Some tip clearances in the 4"–6" diameter range may need to be controlled by special devices to modulate or change the temperature of the tip coolant. In point, if a very cold tip is needed to control a friction-free size in the late stages of the shot, the clearance may be excessive due to tip shrinkage in the early (pour hole close) stage of the shot. Critical clearance applications might require a "warm" tip to start, then changing to "cold" cooling during the strike and solidification stage.

Some operating clues indicating the need for tip temperature control and/or changed clearances will be the sight and sound of the tip action. Shuddering or outright stoppage in the final stroke phase (or pullback phase) will indicate a clearance adjustment and/or more cooling; perhaps even a lubrication adjustment.

If the tip needs temperature control, then "relieving" the tip becomes the proper thing to do—progressively in small amounts until the particular job runs well. The next job, even if the tip is the same nominal size, may not be the same. Remember that temperature affects the clearance. If the metal temperature and shot size changes, these can affect the proper shot tip clearance.

If the tip clearance is too excessive, flashing may occur. If the clearance has worn, producing longitudinal grooves on the O.D. of the shot tip, metal entry into the grooves will accelerate. This can erode a sizeable escape channel for the entire length of the tip sealing body. These channels resemble a river and are sometimes called "worming" or "needling." If the channel completely breaks through on one shot to sustain flow, a sizeable amount of molten metal at high velocity can escape toward the shot cylinder end. Washout or erosion in the bottom of the pour hole area is also a contributing factor.

In the next section, we will discuss beryllium copper shot tip materials that are supplied in a variety of alloy grades (Be-10S™, alloy 14 or 3, Be-20, and alloy 25). Alloy Be-10S™ and Be-20 are Semco alloys; alloys 14 or 3 and 25 are bar stock alloys.

Beryllium Copper Materials

Beryllium copper is a non-ferrous copper base alloy with a small addition of beryllium, usually 0.5 or 2.0%. The alloy has high thermal conductivity close to that of copper, but the addition of beryllium allows the alloy to be solution annealed and treated to the hardness levels of tool steels. SEMCO developed the Be-10S™ alloy that contains 0.5% beryllium and can be heat-treated to a hardness of 96-101 Rockwell "B". The corresponding Be-20 2.0% alloy can be heat-treated to 36-41 Rockwell "C".

When beryllium copper is used as a plunger tips, the tip life can be extended to 2 to 4 times that of other materials. The tip can be re-used several times upon turning to a smaller diameter.

Beryllium copper plunger tips also possess high thermal conductivity. SEMCO Be-10S™ has thermal conductivity 10 times that of steel, and Be-20 alloy is 4 to 5 times that of steel.

The composition and hardness values of SEMCO Be-10S™ and Be-20 alloys are presented in Table II.

Table II

SEMCO ALLOYS			
Alloy Designation	Chemical Name	Composition	Rockwell Hardness
Be-10S™	Beryllium Cobalt Nickel Copper	.45–.55 .35–.45 1.80–2.10 BAL.	B96-101
Be-20	Beryllium Cobalt Copper	1.90–2.15 .45–.55 BAL.	C38-43

III. Coolant Volume and Temperature

There can be cases where the tip and plunger rod coolant (usually water) may have to be temperature-controlled in the extreme cases. This is usually a result of water temperatures higher than 80°F.

A most common cause is simply warm water and/or insufficient flow and pressure, that causes tips to run hot and reduce tip life.

Many times this is caused by the reversal of the cooling inlet/outlet hoses. This, in the absence of other factors, is the first item to check. Typically, plunger rod cooling is accomplished by a "percolator" pipe. The cold water flows through a central pipe direct to the tip, then exits via a clearance surrounding the percolator pipe. The exit channel, on an area basis, is larger than the inlet pipe. This is to compensate for lime/scale/rust buildup that could cause a pressure drop. This will also ensure minimal restriction for heated water as it exits the plunger tip. If the connection are reversed, the jet pipe cooling to the interior tip surface is eliminated, and the system stops working. Check this elementary point first.

Figure 3

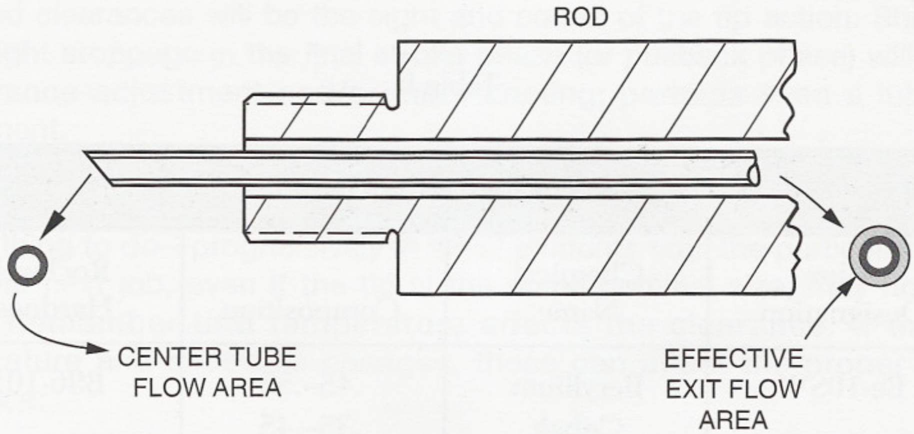


Table 3 lists the recommended tube sizes for different diameter tips.

Table 3

Tip Size	Tube Size	I.D. Area
to 2"	1/4" O.D. x .030 W.T. (tubing)	.028in^2
2-1/4"–3"	5/16" O.D. x .030 W.T. (tubing)	.049in^2
3-1/4"–4"	3/8" O.D. x .030 W.T. (tubing)	.078in^2
4-1/4"–5"	1/4" Pipe (.264 I.D.)	.104in^2
5-1/4"–6"	3/8" Pipe (.492 I.D.)	.190in^2

A typical shot rod has a jet pipe percolator tube in the center. It is important that the size of the tube be in proper proportion for the plunger tip being used. The tube and pipe sizes, and their corresponding I.D. area values, should be looked at closely in customer designs. There can be cases when "tower" water is used in excess of 80° F temperature, and pressures below 40 psi, that even these sizes will be marginal.

Now examine the exit center holes in the plunger rods. The area total between the center tube (pipe) size and the center hole I.D. must be equal or larger than the feeding tube area. Check that the center exit hole was established for proper water flow, and not selected just to be convenient for a drill or pipe tap size.

Table 4 calculates the effective flow area.

Table 4

Tip Size	Center Tube/Pipe	Tube Area	Exit Hole Diameter	Effective Flow Area	Ratio
to 2"	1/4" tube	.028in^2	.44	.100in^2	3.57
2-1/4"–3"	5/16" tube	.048in^2	.50	.120in^2	2.50
3-1/4"–4"	3/8" tube	.078in^2	.56	.136in^2	1.74
4-1/4"–5"	1/4" Pipe	.104in^2	.68	.141in^2	1.35
5-1/4"–6"	3/8" Pipe	.190in^2	.87	.243in^2	1.27

Note that the effective flow area is greater than the inside area of the center flow tube. The area is the difference between the exit hole diameter and the O.D. area of the center tube. All plunger rod designs should follow this guideline to ensure adequate water flow to and from the shot tip.

See the previous note concerning water temperature, volume, and pressure. Many times upon investigation of hot running sticky tips, "hot" water in excess of 80°F is being used, sometimes in combination with low flow and pressure, generally from recirculating or tower water systems. The solution may be as simple as connecting the plunger rod cooling inlet to a city water system. City water systems usually provide water at temperature 65°F or less and at an approximate pressure of 35 to 50 psi. If at times cooling is especially deficient, add a mixing valve to use part city water and part tower water.

Finally, even when plunger rods have correct sizing relationships for the internal passages, a seemingly small mistake can render the cooling system marginal or ineffective.

Tapered (NPT) pipe threads are supplied on IN and OUT connection ports to the plunger rods. A correct method to insure adequate water flow is to use water pipe nipples for connections, then use a supply hose that will fit tightly over the nipples. The inside diameter of the nipples (and its flow area) then becomes the controlling restriction size. See the following Table 5.

Table 5

Pipe Size	Actual I.D.	I.D. Area	Actual O.D.	Use Hose Size
1/8" NPT	.269"	$.057in^2$	.405	3/8" (.375)
1/4" NPT	.364"	$.104in^2$	.540	1/2" (.500)
3/8" NPT	.492"	$.190in^2$	.675	5/8" (.625)
1/2" NPT	.622"	$.303in^2$	.840	3/4" (.750)

Review the I.D. Area column and compare to Table 4 showing tube areas and effective flow areas on page 9. The use of 1/8" pipe ports (I.D. area = $.057in^2$) can only be partially useful for the small tip jobs less than 2" diameter. The 1/4" pipe ports ($.104in^2$) are compatible to tip sizes through 3" size where the largest effective flow area is listed for $.136in^2$.

The 3/8" pipe ports ($.190in^2$) should be used for 3 1/4" through 5" sizes where the largest effective flow area goes to $.141in^2$.

The 1/2" pipe ports ($.303in^2$) should be used for the very large tips 5 1/4" – 6" sizes where the largest effective flow area goes to $.243in^2$.

Exact relationships do not have to exist, but they should be close. Ideally, the inlet and outlet flow areas of the pipe nipples should be slightly larger than the effective flow area of the plunger rod center exit hole.

Refer to the hose size recommendations to be used in conjunction with certain pipe sizes. These hose sizes will be a tight fit over the O.D. of the common water pipe nipple. Even so, hose clamps should be used to prevent leakage. In time, the hose I.D. will stretch and tend to blow off or leak when under pressure.

A common mistake, only being evident in marginal cases, is when an installation for plunger rod cooling will use brass "barb" fittings. Hoses will secure well and in some cases do not need further clamping. The problem with a barb fitting is that the inside controlling diameter (and area) of the barb fitting is much too small for adequate flow (for example, a typical barb fitting with 1/4" I.D. hose [$.049in^2$]). Review the figures showing that areas exceeding $.100in^2$ are desirable in this case. The same type of example should be analyzed for other sizes of barb fittings and hose sizes.

It is very important when sizing the cooling capacity for shot plunger systems to remember that the tip operates in the single most hostile point in the whole system. Molten metal is closely adjacent and the hydraulic shot system exerts forces to push the tip through the shot sleeve. Make the job easier by providing correctly sized adequate cooling.

IV. Design Versatility

Shot sleeves, plunger rods, stoke adjustments, cover die thickness, and shot weights, et.al.

See Figure 4A-C – This shows a standard shot end arrangement using a 600 ton for example. By 2" increments and use of the stroke adjustment feature, various shot tip penetrations, cover die thickness, and shot weights are afforded with one plunger rod design and 3 shot ram spacers. An important point is that the pour hole starting position is a constant to autoladle position unchanged for various setups.

See Figure 5 – This shows one variation of a customer special system that is based on using one shot sleeve design for 2 or more jobs by a variety of split ring flanges on the die locating side. The perceived advantage to cost saving for sleeves is offset by requiring extra plunger rods. When the sleeve is repositioned by split ring retainers, the pouring hole then moves from a fixed starting point.

From a time-saving standpoint, it takes longer to change over complete shot rods than the smaller and lighter shot rod spacers. Consider these points when special shot end arrangements are made.

Finally, with a fixed length shot sleeve, the shot volume is a relative constant due to the constant shot stroke that must be used. The only way to adjust shot weights is by variable filling levels.

See Figure 5 – Sometimes, the idea to use one shot sleeve design in multiple jobs ends up being short-sighted and more expensive in the long run.

Figure 4A

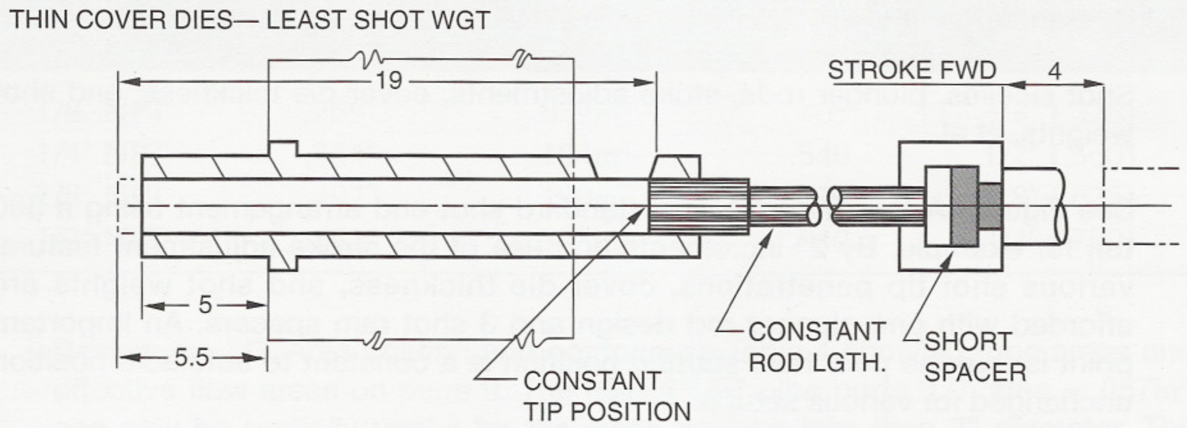


Figure 4B

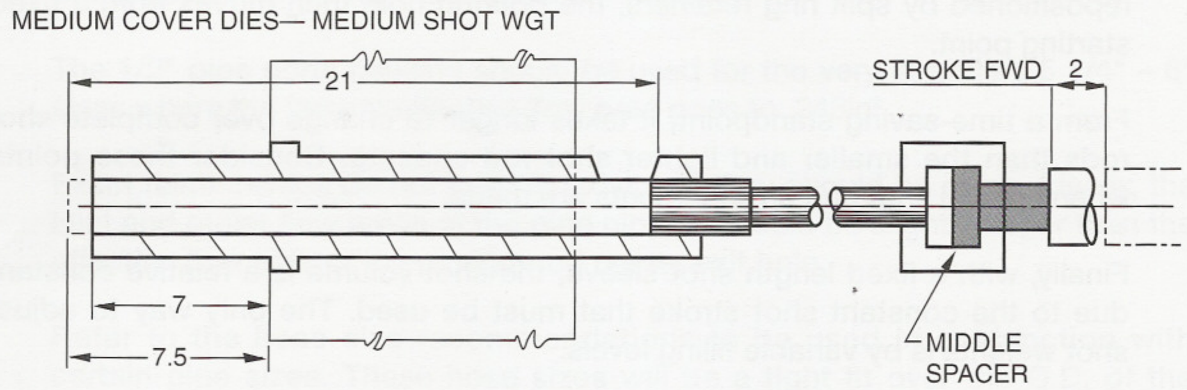


Figure 4C

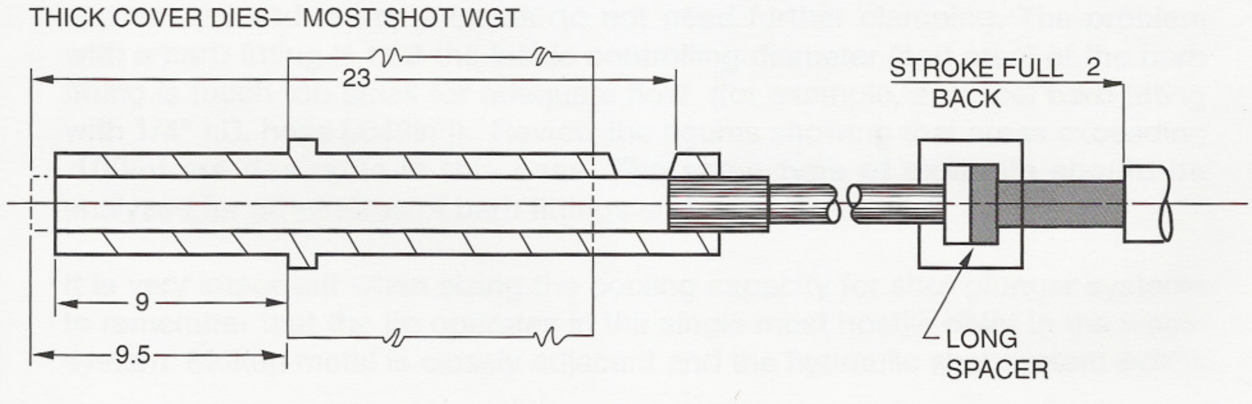


Figure 5A

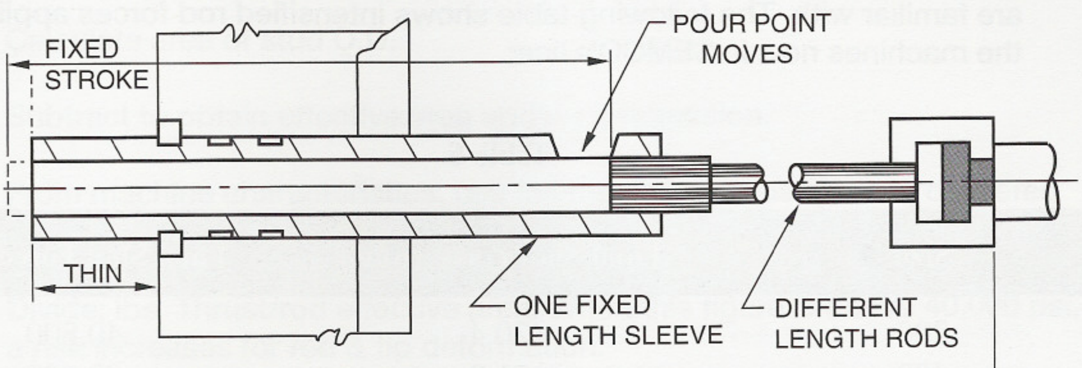


Figure 5B

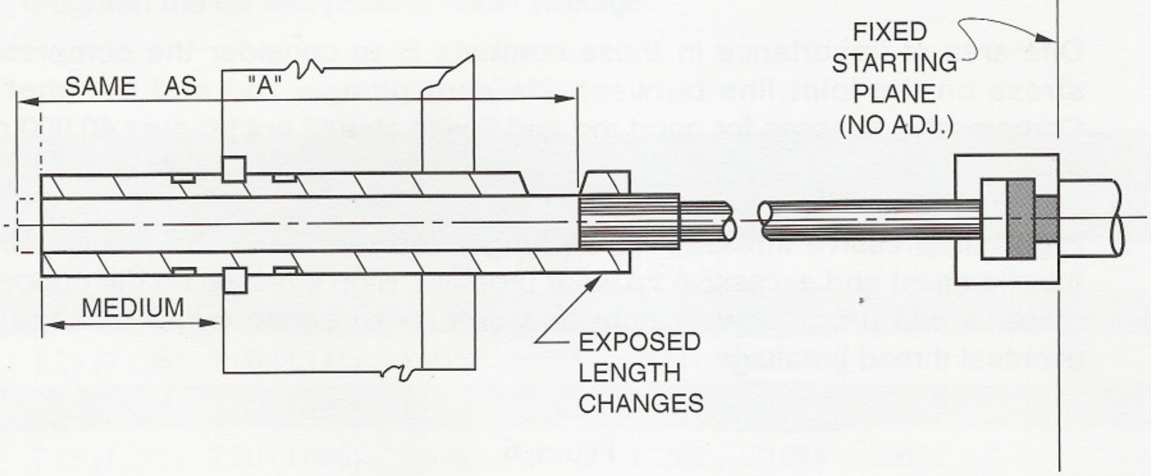
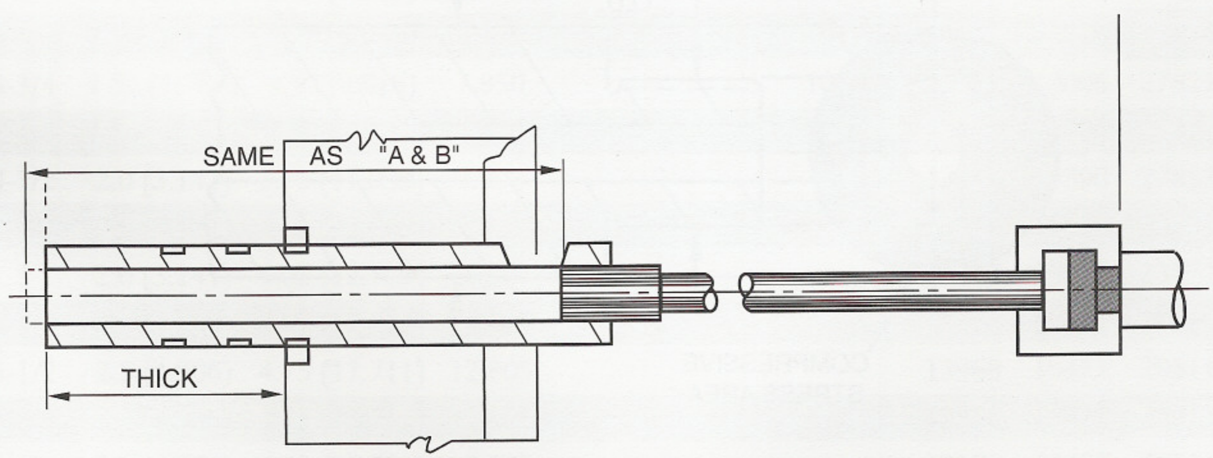


Figure 5C



V. Compressive Stresses

Modern machine shot end forces may be greater than what some customers are familiar with. The following table shows intensified rod forces applicable to the machines now in SEMCO's line:

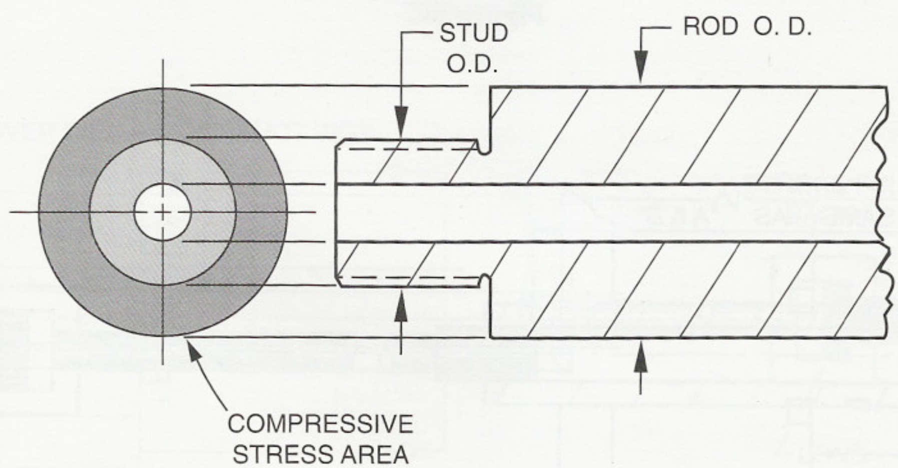
Table 6

Size	Final Shot Force (tons)	Final Shot Force (lbs)
200	20.4	40,800
400	31.8	63,600
600	39.9	79,800
900	53.5	107,000
1200	74.6	149,200
1800	109.2	218,400

One area of importance in these numbers is to consider the compressive stress on the joint line between the shot plunger rod and the shot tip. Compressive stresses for good rod and tip life should not go over 40,000 psi if possible.

High compressive stresses on a plunger rod can bend the rod causing a misalignment and excessive tip wear problem. High stresses on the copper tip material will progressively coin and deform to cause water leakage and eventual thread breakage.

Figure 6



If a situation requires special design, use these calculations:

1. Calculate area of rod O.D.

2. Calculate area of stud O.D.

3. Subtract to obtain effective area under compression.

4. From machine characteristics, use the maximum thrust (in lbs.) delivered by the shot system.

5. Divide: lbs. Thrust/rod effective area. When this figure is above 40,000 psi, a risk increases for rod & tip deformation.

NOTE: The 40,000 psi limit is suggested based on steel rod materials having yield points of 60,000–90,000 psi dependent on alloy and hardness. Some beryllium copper shot tips have a yield strength at 40,000 psi, so they will operate right at the limit. With stress figures at 40,000 psi and above, the shot tips will coin in progressive compression failure creating the need to frequently retighten the tip and prevent water leakage.

Table 7

Tip Size	(Area)	O.D. (Area)	Area	200	400	600	900	1200	1800
1-3/4	1.0 (.785)	1.63 (2.085)	1.300	31384	48923				
2	1.25 (1.226)	1.88 (2.774)	1.548	26356	41085	51550			
2-1/4	1.25 (1.226)	2.00 (3.141)	1.915	21305	33211	41671			
2-1/2	1.25 (1.226)	2.00 (3.141)	1.915	21305	33211	41671			
2-3/4	1.25 (1.226)	2.50 (4.096)	3.680		17282	21684	29076		
3	1.25 (1.226)	2.50 (4.096)	3.680		17282	21684	29076		
3-1/4	1.50 (1.766)	2.75 (5.936)	4.170			19136	25660	35779	
3-1/2	1.50 (1.766)	2.75 (5.936)	4.170			19136	25660	35779	52374
3-3/4	1.50 (1.766)	3.50 (9.616)	7.850			10165	13630	19006	27821
4	1.50 (1.766)	3.50 (9.616)	7.850			10165	13630	19006	27821
4-1/2	2.0 (3.141)	3.75 (11.039)	7.898				13547	18890	27652
4-3/4	2.0 (3.141)	4.00 (12.566)	9.425				11352	15830	23172
5	2.0 (3.141)	4.00 (12.566)	9.425				11352	15830	23172
5-1/4	2.5 (4.906)	4.75 (17.711)	12.805				13968	19477	28511
5-1/2	2.5 (4.906)	4.75 (17.711)	12.805				13968	19477	28511
5-3/4	2.5 (4.906)	4.75 (17.711)	12.805				13968	19477	28511
6	2.5 (4.906)	4.75 (17.711)	12.805				13968	19477	28511

In Table 7, certain figures are circled to show that they are over the advised compressive stress limit. Avoid these combinations where possible and/or reduce shot end forces if necessary to solve those unique problems. Plunger tip coining could occur if stresses are too high.

VI. Tip and Rod Guiding

Inadequate guiding of the shot tip and inadequate rod weight supporting is common in some customer designs.

See Figure 8A: The machine may have a guaranteed and checked shot end alignment between the platen sleeve hole and the shot cylinder end, but if the intermediate items of shot sleeve, shot tip, and plunger rod are not evaluated, each shot could occur with a relative misalignment.

Figure 8A

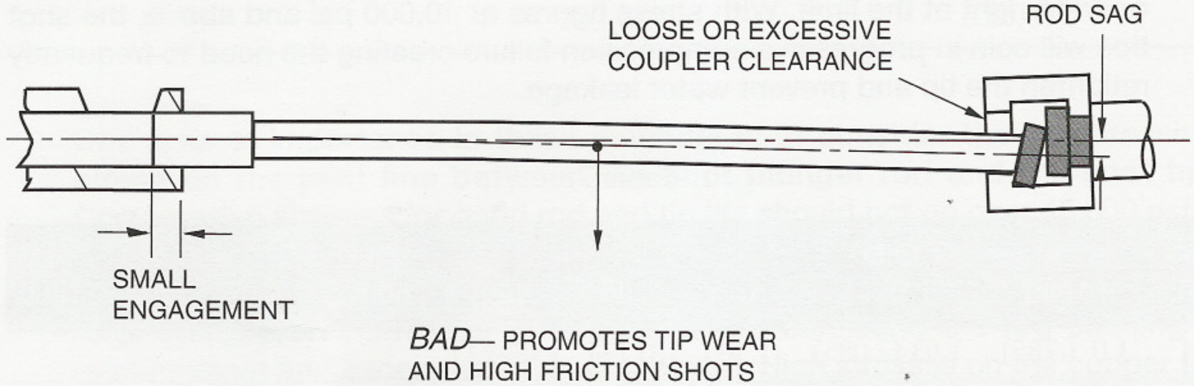


Figure 8-A shows a typical worse case encounter. The shot tip engages by a small amount, then a plunger rod having a loose rod coupler with excessive clearance, will ensure that the shot tip is starting on an angle, becoming especially bad in the first 3"–4" of stroke. In this early stroke phase, the shot tip O.D. bearing area must try to lift the plunger rod droop as it is moving. The critical point is where the front edge of the tip passes the pouring hole edge. An indication of this will be scrub marks and damage on the top leading edge of the tip and the bottom trailing edge.

Plunger rod weights range from a low of 20 lbs. (200 tons) to a high of about 275 lbs. (1800 tons). A 600 ton rod weight is approximately 80-90 lbs. If the securing area of the shot tip is slight (1"), together with a "loose" rod coupling for .060" drop, excessive plunger tip wear is likely.

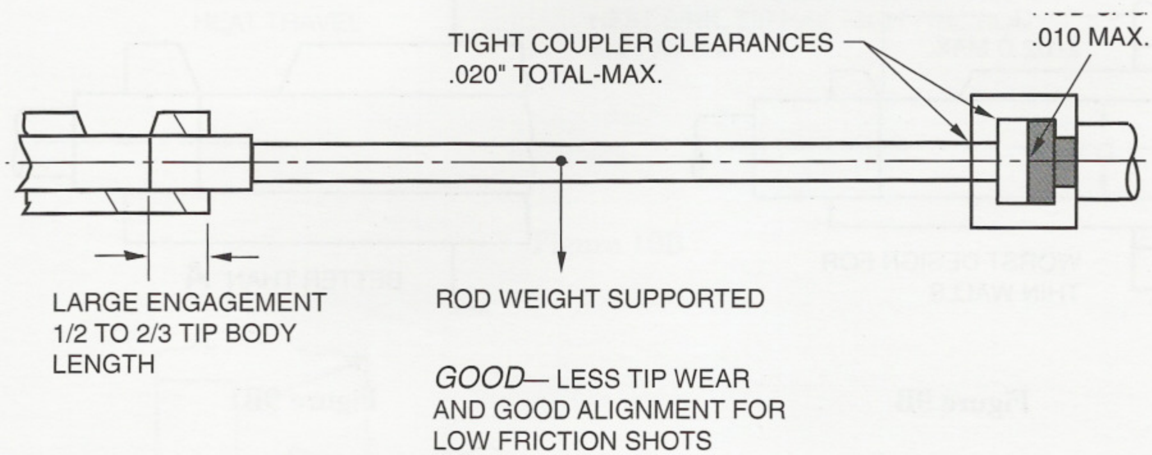
Some customers when queried will state these reasons for the practice:

1. Saving a little shot sleeve steel for cost reduction.

2. Better lubrication when a large part of the sleeve body is exposed.

3. Loose floating couplers to compensate for worn sleeve holes in the platen.

Figure 8B



Following these principles can produce a well-guided and more accurate shot alignment during the critical first stage of the shot movement. The shot tip should fully engage in the sleeve bore using a specification of 1/2 to 2/3 the distance of the O.D. bearing length. Lubrication systems can be made to work properly. The bearing stress pressure between the shot tip and the sleeve bore is also considerably reduced. This should help facilitate making the lubrication job easier.

On the coupling end, the maximum diametral clearance should practically be designed at .015"–.020", to indicate a theoretical rod droop of .008"–.010". Extra precision in this area, coupled with an accurate shot end alignment, will allow the shot to start with the least friction and rod lift.

Considering that some wear in the coupling area will eventually increase the clearances does not justify loosening just for convenience or easier assembly.

VII. Shot Sleeve Designs

SEMCO has encountered a large variety of customer designed shot sleeves. Some designs are good, some are marginally passable, and some are inferior.

From the standpoint of producing a good friction-free well-aligned shot, some of the good and bad points in a shot sleeve design are listed below:

Figure 9A

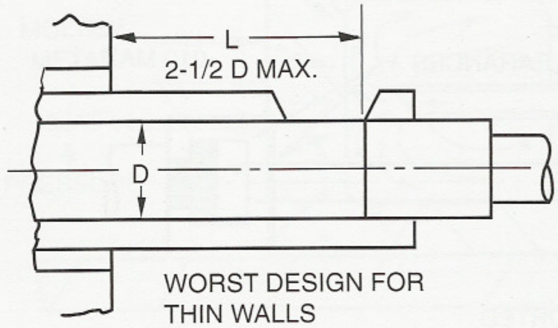


Figure 9A1

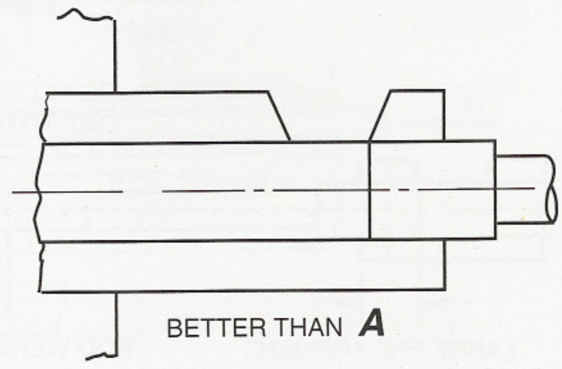


Figure 9B

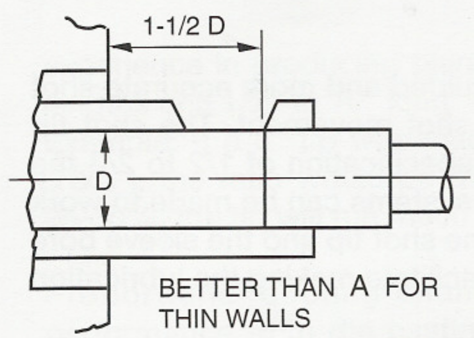


Figure 9B1

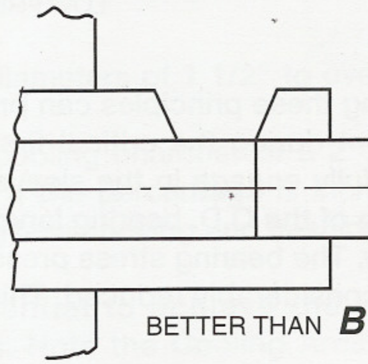


Figure 9C

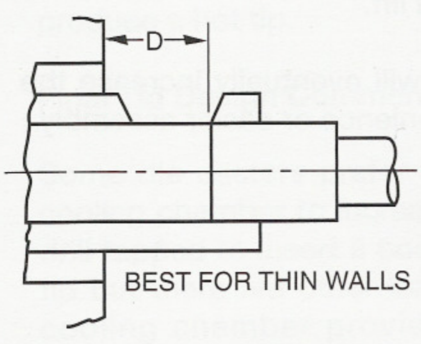


Figure 9C1

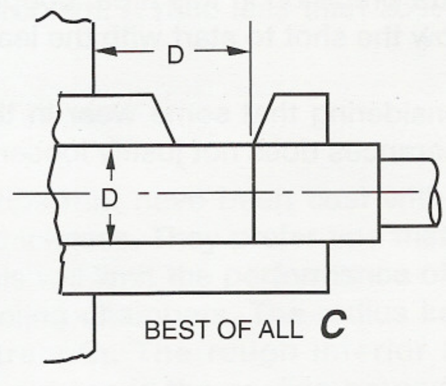


Figure 10A

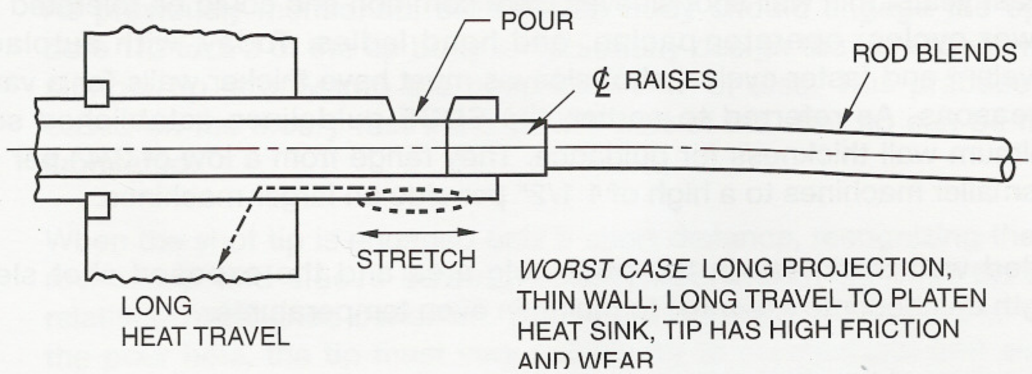


Figure 10B

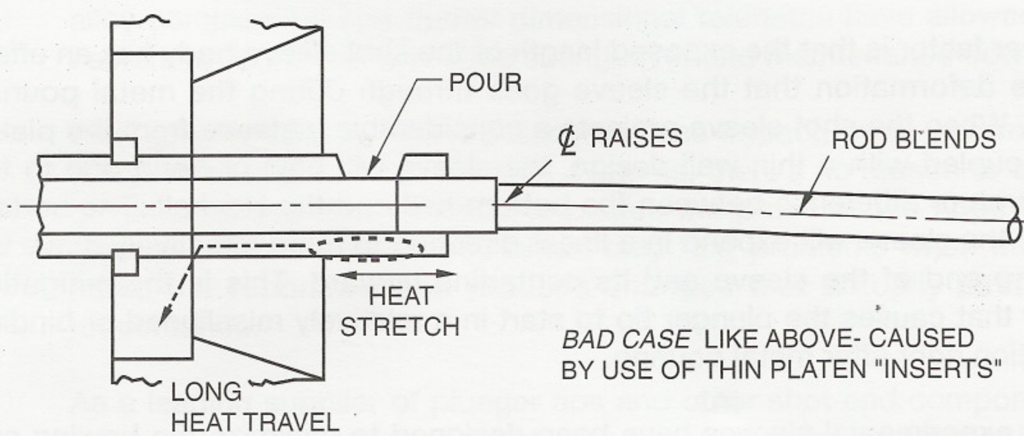
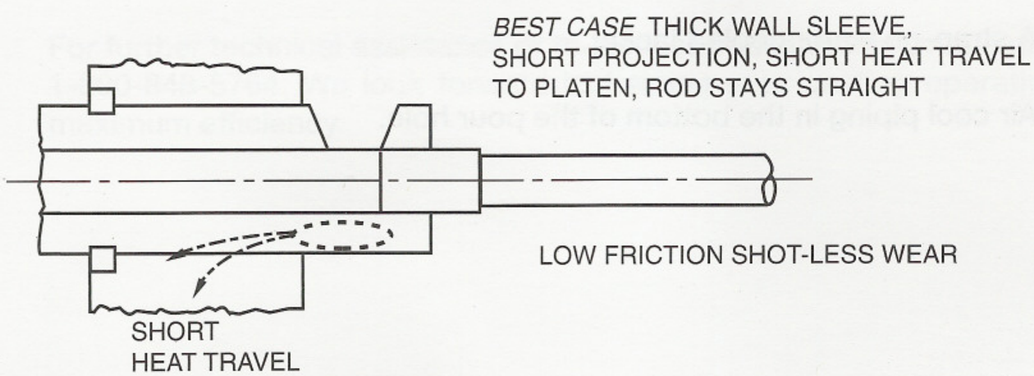


Figure 10C



VIII. Adequate Wall Stock

In past years, thin wall shot sleeves were common and could be tolerated with slower cycles, operator pacing, and hand ladles. Today, with autoladles prevalent and faster cycles, shot sleeves must have thicker walls for a variety of reasons. As referred to earlier, the SDCE guidelines established some minimum wall thickness for guidance. They range from a low of 3/4" per side on smaller machines to a high of 1 1/2" per side on larger machines.

Added wall thickness in the pour hole area and the exposed shot sleeve length has become essential to maintain even temperatures.

Metal poured into the shot sleeve from an autoladle hits the same point in the bottom of the sleeve on each and every cycle. Also, the metal pouring temperature is higher than used years ago. The effect is that the area under the pour hole is subjected to severe high temperature cycles, leading to erosion, heat check, and severe shot sleeve bore damage. A thick wall sleeve provides an even heat transfer to carry some of the excess temperature through the sleeve wall to the stationary platen.

Another factor is that the exposed length of the shot sleeve body has an effect on the deformation that the sleeve goes through during the metal pouring stage. When the shot sleeve projects a considerable distance from the platen and coupled with a thin wall design, the sleeve will bow or bend due to the temperature difference between the bottom half and the top half. The bottom half of the sleeve will expand in a linear direction to more effectively move the pouring end of the sleeve and its centerline upward. This is the mitigating factor that causes the plunger tip to start in a relatively misaligned or binding condition right after metal pouring.

Some experimental sleeves have been designed to minimize the bowing and ovality problems in the casting process:

1. Water cooling in the bottom of the pour hole.

2. A strap-on water cooled jacket.

3. Air cool piping in the bottom of the pour hole.

IX. Adequate Tip Engagement

As previously mentioned, the shot tip body should engage the open sleeve bore 1/2 to 2/3 of the tip body length. Many design the tip engagement so the plunger tip is only into the open sleeve 1" or less. This practice is usually based on the theory that the exposed part of the shot tip can be more easily lubricated.

When the shot tip is engaged only a short distance, recognizing the factors of rod droop and sleeve bowing from temperature, the shot tip starts in a relatively misaligned condition. During the initial part of the stroke to close off the pour hole, the tip must very quickly try to compensate and align the rod mass as the whole system moves. A more secure engagement during this critical starting stage will greatly reduce misalignment.

Summary: You can improve the quality of your shot process.

Technology advances in shot end components have made a significant impact on die casting productivity. Longer plunger tip cycles because of superior alloy composition and tighter dimensional tolerance have allowed leading die casters to significantly reduce changeover and maintenance downtime.

With greater speed, higher pressures, less impact, more control, and better component alignment in the shot systems, there's no reason to tolerate many of the problems that continue to plague the process. We hope the insight in this manual has allowed you to not only "fix" problems when they occur, but make the recommended process changes that actually circumvent their reoccurance.

As a leading supplier of plunger tips and other shot end components. Semco brings a unique understanding to the various factors that affect the efficiency of the process. Careful examination and evaluation of your shot end components is where it starts. The recommendations in this manual offer a powerful checklist for making lasting changes to your process.

For further technical assistance or to discuss your specific problems, call us at 1-800-848-5764. We look forward to helping your casting operation achieve maximum efficiency.

Semco Quality

Semco's trademarked BE-10S™ alloy and BE-20 alloy, have set the industry standard for long life and quality plunger tip performance. Add to that total in-house control of raw materials, CNC dimensional tolerance control and the industry's largest tip inventory, and the reasons for Semco's leadership become very clear.

Semco, Inc.
800-848-5764 • 740-387-2229
Fax: 740-387-6127 • Email: sales@semcotips.com

"WHEN THERE'S NO TIME FOR DOWNTIME" ™