

TA14388A

SIL 439.01

April 29, 2011

Page 1 of 17

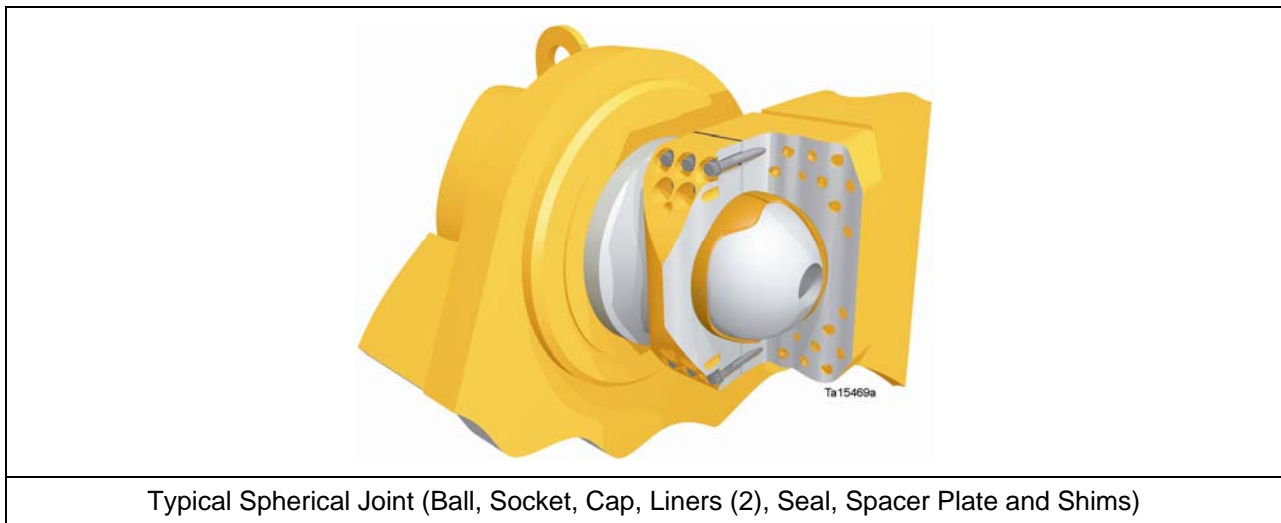
TO: LeTourneau Technologies Dealers and Users

FROM: LeTourneau Technologies Product Support

SUBJECT: Spherical Ball Bearing Joints

MODELS: All Machines

The purpose of this Service Information Letter revision 01 was to add information that emphasizes the importance of ball cap to socket alignment in reducing 12" or 14" lift arm ball cap operating temperatures. This revision also advises dealers and users of temperature parameters for the spherical ball joints



Typical Spherical Joint (Ball, Socket, Cap, Liners (2), Seal, Spacer Plate and Shims)

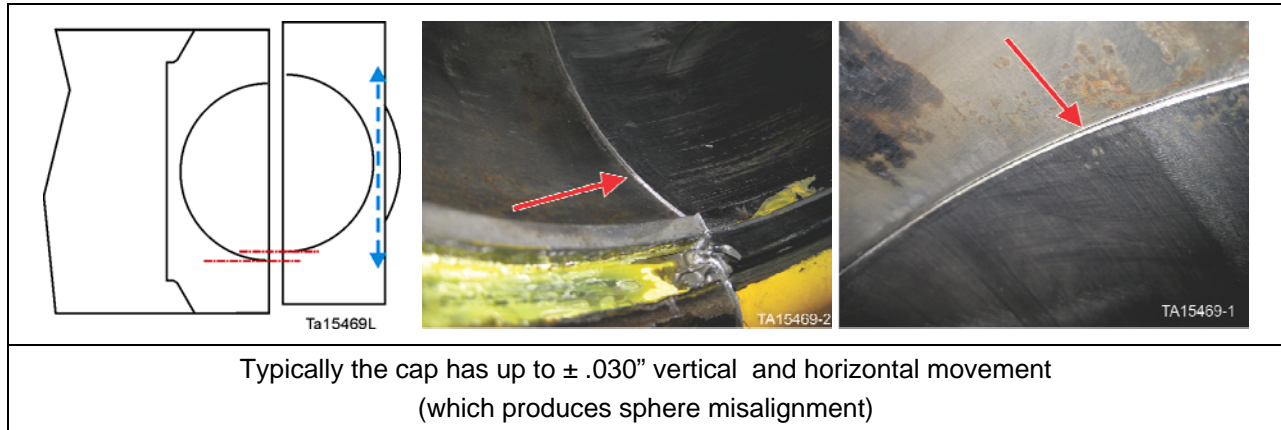
The spherical ball bearing surface absorbs loads from all directions. The spherical ball bearing joint is simple to maintain with easily replaceable liners. The liner is made from a special aluminum bronze material which is harder than normal bushing material. The joint has long life if properly lubricated by the auto lube system. Shims allow the joint clearance to be adjusted on a periodic basis with normal wear of the liners. The joint also features a seal to keep contamination out of the joint. The ball is hardened, heat treated and carburized.

This document provides information on the following areas related to the spherical ball joint:

1	Ball cap to socket alignment	These items apply primarily to the 12" and 14" spherical ball joints.
2	Temperature limits	
3	Bronze liner thickness	
4	Bronze liner edge chamfer	
5	Socket flatness	
6	Grease recommendations	These items apply to all sizes of spherical ball joints
7	Ball Lubrication Methods	
8	Clearance recommendations	

1) BALL CAP TO SOCKET ALIGNMENT

Testing has shown that the alignment of the cap and socket is important and misalignment may contribute to excessive heat. A certain amount of manufacturing tolerance is required so that threaded holes in the socket and the drilled holes in the cap will align properly. This tolerance means that the cap has some up, down and/or side to side movement prior to tightening the bolts. Testing has shown that this tolerance is typically in the $\pm .030$ " range. If the cap is positioned improperly it can cause the joint clearances to be reduced and may cause excessive heating.



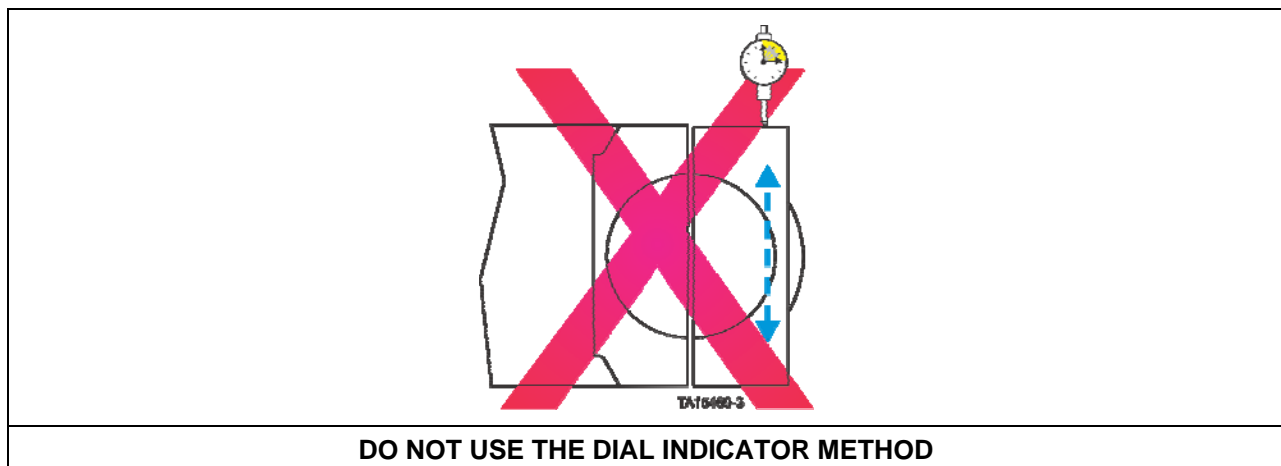
Testing has shown that self centering does not happen in most cases because the ball joint clearances are too loose.

The socket and cap should be checked prior to installation. The cap should be centered and match marked with the socket. During installation onto the machine, the match marks should be lined up prior to tightening the capscrews.

The manufacturing process at the Factory has been changed. New machines have the caps and sockets matched visually and marked at the time of manufacturing. If a cap is replaced in the field, the cap should be matched to the existing socket. This SIL contains the instructions for the proper matching of the cap to the socket.

NOTE

In the previous release of this SIL, it was recommended that the cap be aligned based on dial indicator measurements. Further research and testing found that the spheres are not perfectly centered with the bolt holes because of normal dimensional tolerances. The dial indicator method is not reliable and SHOULD NOT BE USED.



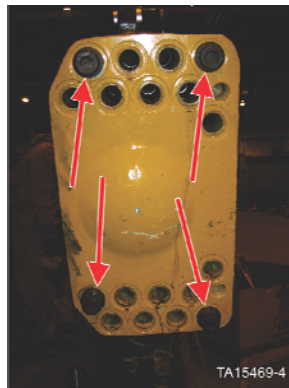
Ball Cap Alignment Procedure:

1. Position the liftarms in a position so that the ball cap and ball socket can be checked.
 - i. This is typically done with the lift arms removed from the machine.
 - ii. If this is done with lift arms on the machine – the arms must be pulled back far enough from the balls so that the cap can be installed on the socket

CAUTION

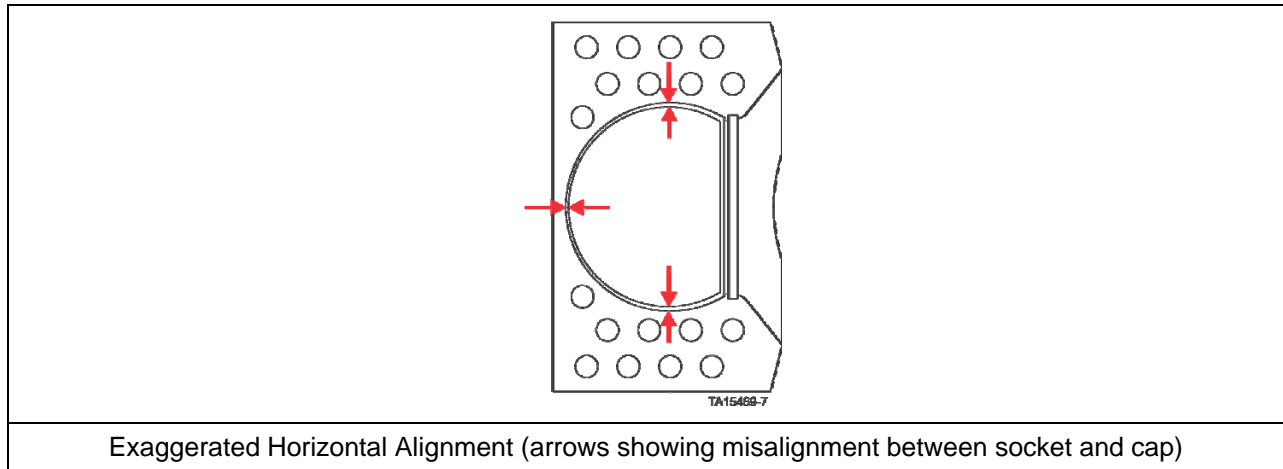
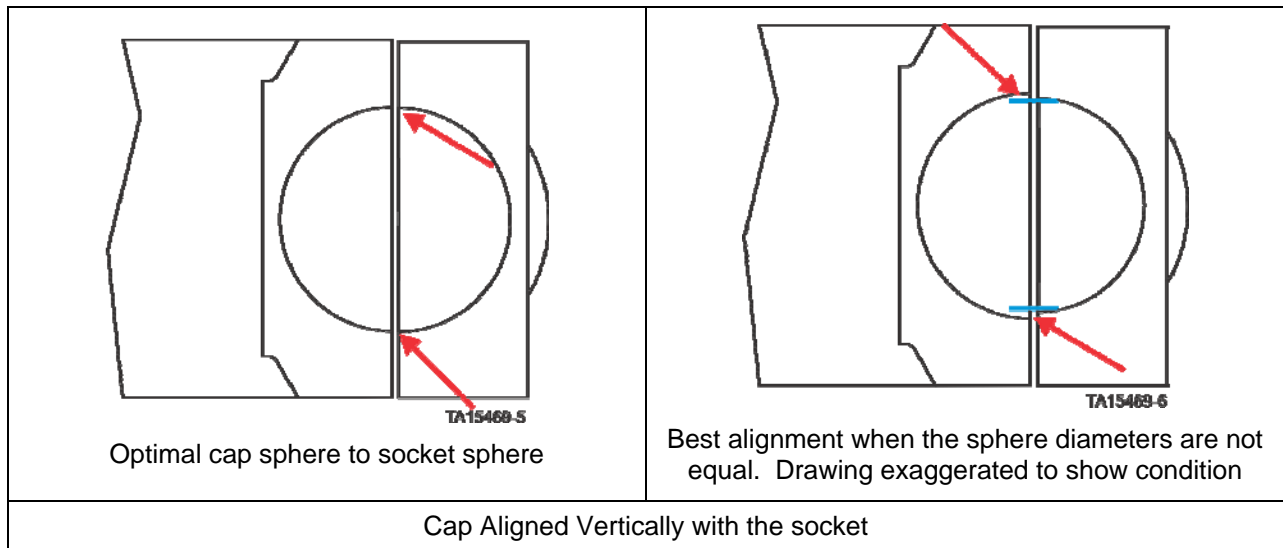
If the alignment is done with the lift arms on the machine – a thorough risk assessment should be done to assure that the job can be done safely. The lift arms must be securely supported so they cannot move. The cap must be properly lifted and supported. The personnel assembling and inspecting the cap and socket must use appropriate fall prevention equipment. All local mine site regulations must be obeyed.

2. Remove the shims, spacer plate, and brass liners from the socket and cap.
3. Thoroughly clean all mating surfaces. One half of the lip seal in either the socket or the cap will have to be removed.
4. Place the ball cap into position on the ball socket. Secure the cap to the socket by installing 4 bolts into the four corners of the cap. The bolt torque should only hold the cap from moving on the socket.

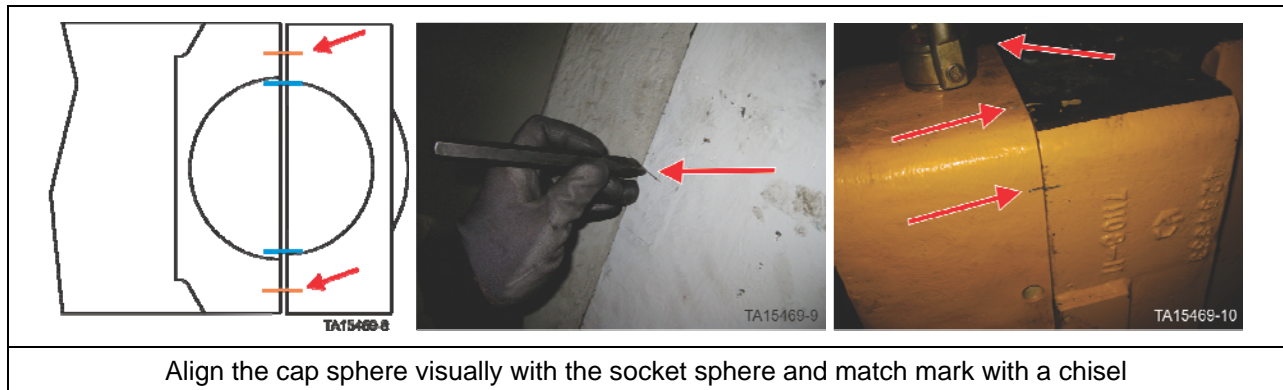


Four Corner Bolts

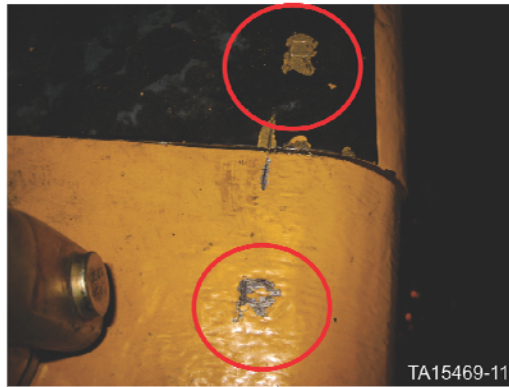
5. Visually look into the sphere area. Note any misalignment of the cap to the socket. Using a dead blow hammer, tap the cap into an optimal position that best aligns the sphere of the cap to the sphere of the socket. It is important that the sphere be checked both vertically and horizontally. Typically there will be a slight difference in size between the machined sphere in the socket and cap. If the socket and cap spheres are not the same diameter, then the cap should be positioned with an equal step amount in the top, bottom, and side positions.



6. Tighten the four corner bolts with a 3/4" air impact gun (approximately 600 to 900 ft lbs). The bolt torque only has to be sufficient to hold the cap from moving relative to the socket when the marks are made with a chisel in the next step. Recheck the alignment between the two spheres. Loosen and re-adjust if the cap moved during the tightening of the bolts.
7. Use a chisel to make two locating marks on top of the cap and the socket. Make an additional two marks on the side of the cap and socket.



- Using a letter stamp, mark the caps left or right to indicate the cap location on the lift arms.



Letter Stamp

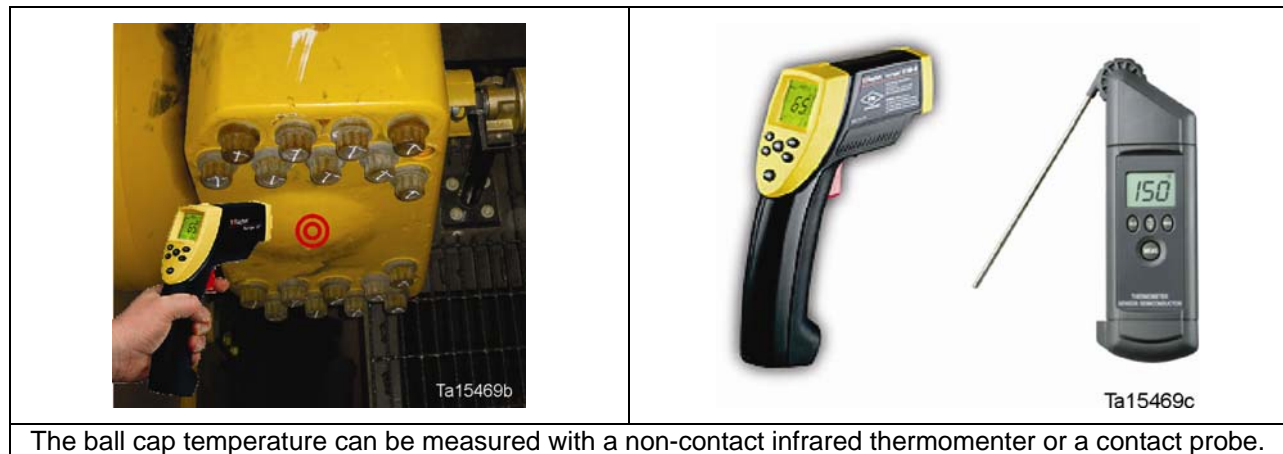
- Remove the four retainer bolts and reassemble the sockets with the capture plate, shims, and bronze liner on both left and right sides.
- Re-install the one half of the lip seal that was previously removed. Install the seal using a weather strip adhesive (P/N 151-0303)
- Install the liftarms on to the front frame.
- Install the ball caps onto the sockets aligning the chisel marks on the cap and socket as close as possible.
- Torque the ball cap screws.

NOTE

The alignment and marking procedure has been done by the factory on all new machines beginning in January 2011.

2) TEMPERATURE LIMITS

- The spherical ball joints are highly loaded in some severe applications.
- They are designed for intermittent high loading.
- It is normal for the highly loaded spherical ball bearing joints to warm up under hard usage.
- The limiting factor for joint temperature is the temperature capacity of the grease.
- The working temperature of a properly aligned spherical ball joint with the correct brass liners will vary depending on the severity of the application, the grease being used, the amount of grease, the cycle time of the auto lube system, etc.
- Average temperatures up to 125°F (52°C) above ambient temperature are typical and acceptable for most greases. (Temperature measured on the outside surface of the cap and socket)
 - For example – in an ambient temperature of 86°F (30°C) – a ball cap temperature up to 211°F (82°C) is acceptable with intermittent temperature spikes.
- Temperature spikes up to 170°F (77°C) above ambient temperature are acceptable.
 - For example – in an ambient temperature of 86°F (30°C) – a short term ball cap temperature up to 256°F (107°C) is acceptable.



The ball cap temperature can be measured with a non-contact infrared thermometer or a contact probe.

NOTE

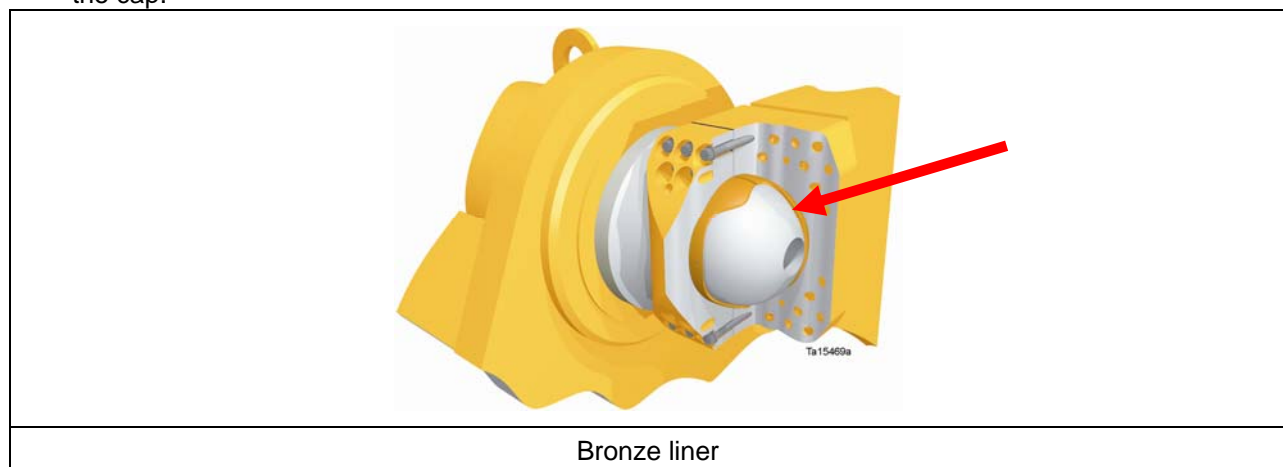
The average temperature limit of 125°F (52°C) and short term temperature limit of 170°F (77°C) above ambient are very conservative and are based on use of a low temperature grease of minimum specification. Higher quality auto lube greases used in most locations permit a much higher temperature limit prior to concern. The specifications for the grease used should be examined to determine the temperature limits for your application.

If the ball cap alignment is correct and temperature continually rises above these limits then the joints should have the following parameters checked:

- **Bronze liner thickness**
- **Clearance**
- **Grease quality and quantity**
- **Socket flatness**

3) BRONZE LINER THICKNESS

The bronze liner is designed to be the wear component in the spherical joint. The bronze liner sits between the ball and socket/cap. One liner is secured to the socket and a second liner is secured to the cap.

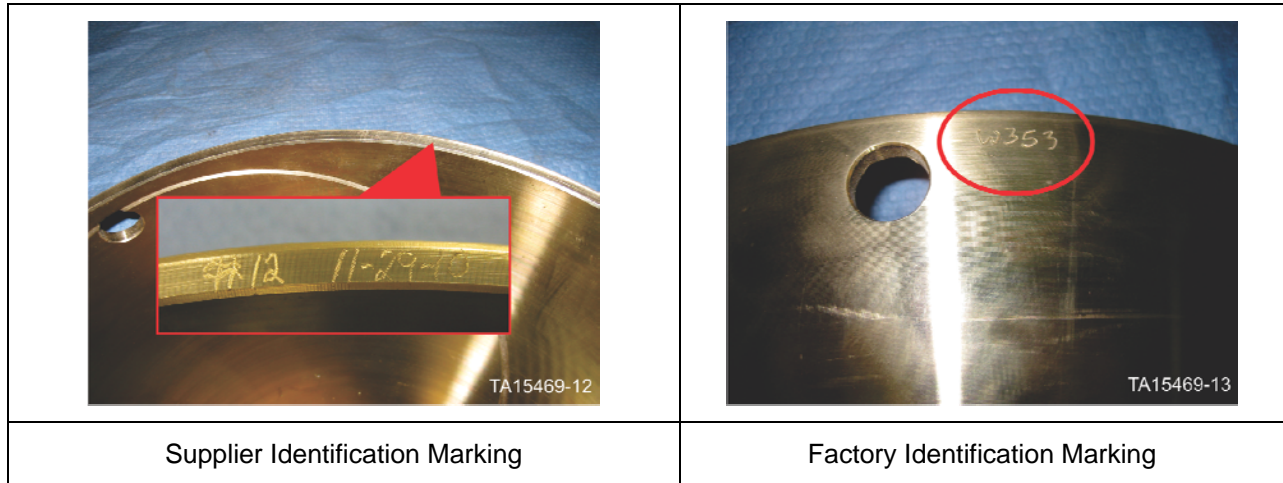


It has been found that some bronze liners produced during the last few years may not have met LeTourneau specifications for thickness. An improved quality control process has been implemented to assure that the brass liners meet LeTourneau specifications.

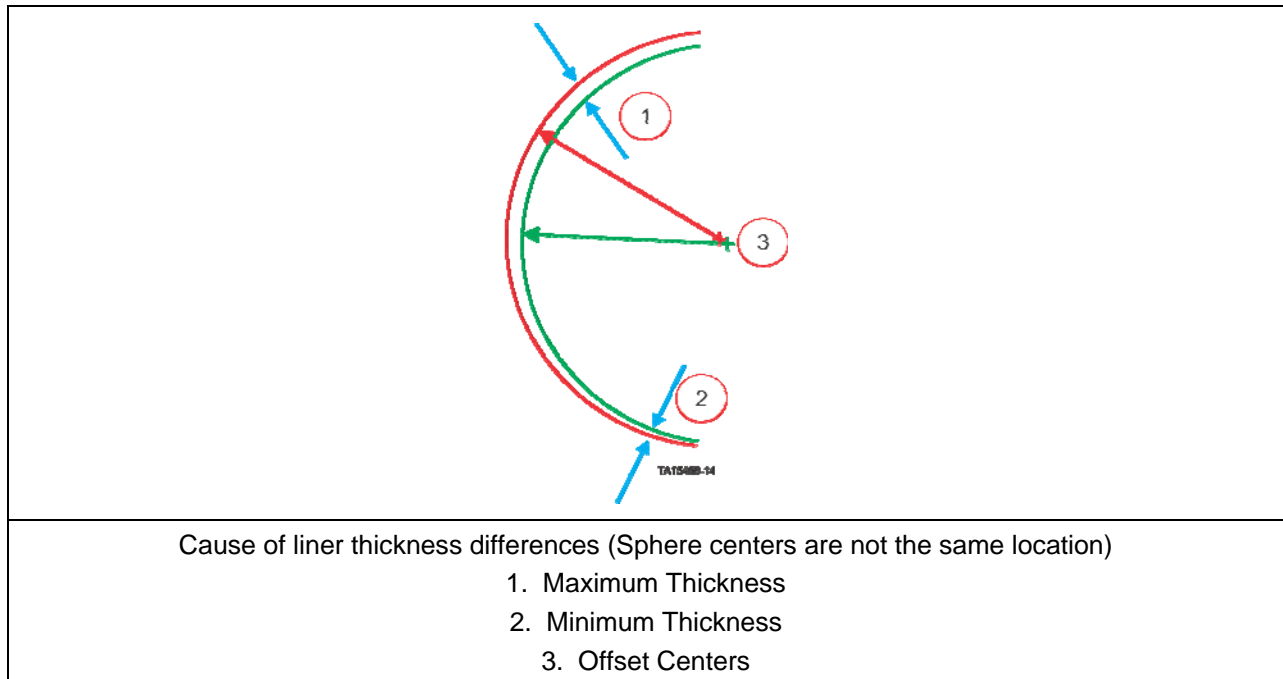
NOTE

Any liner that has either the Supplier Identification mark or the Factory Identification mark, or both, has been through the enhanced quality control process. IF no identification marks can be found on the liner, then a thorough review of the following liner thickness and chamfer checks should be performed.

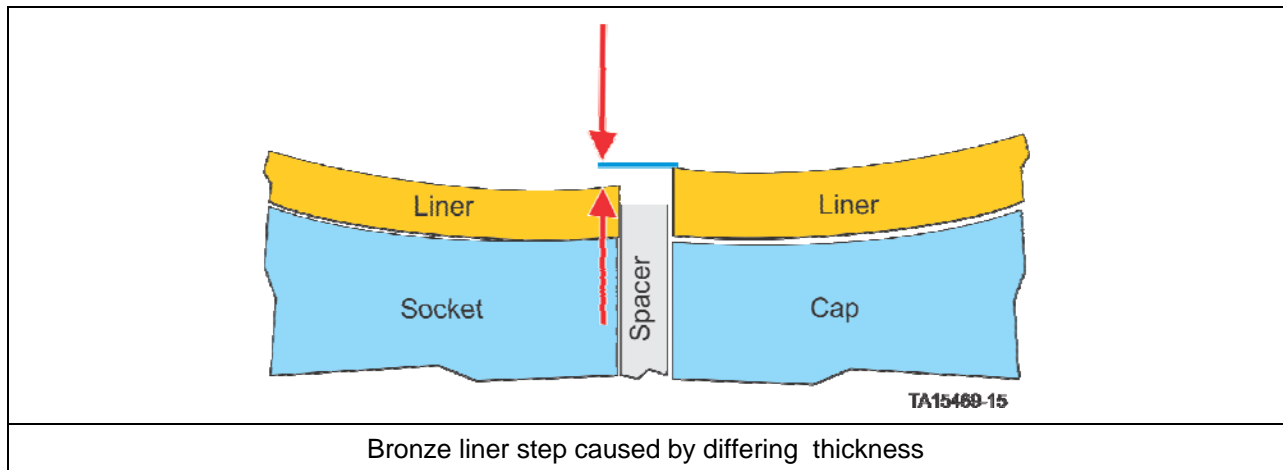
The supplier and factory identification marks are shown in the following pictures. The supplier marks are typically on one of the edges. The factory marks are typically on the outside of the sphere.



If the liner is too thick – the clearance in the joint will be reduced and excessive heat may be a result. Variation in the liner thickness is an indicator that the true center positions of the outer and inner spheres are not aligned.



When the liners in the socket and cap are assembled into a spherical joint - a major thickness difference will cause a step that creates a high load area on one liner. This condition can lead to high temperatures and if left uncorrected, can cause failures of the spacer plate and shim pack. This condition is shown exaggerated in the following drawing.

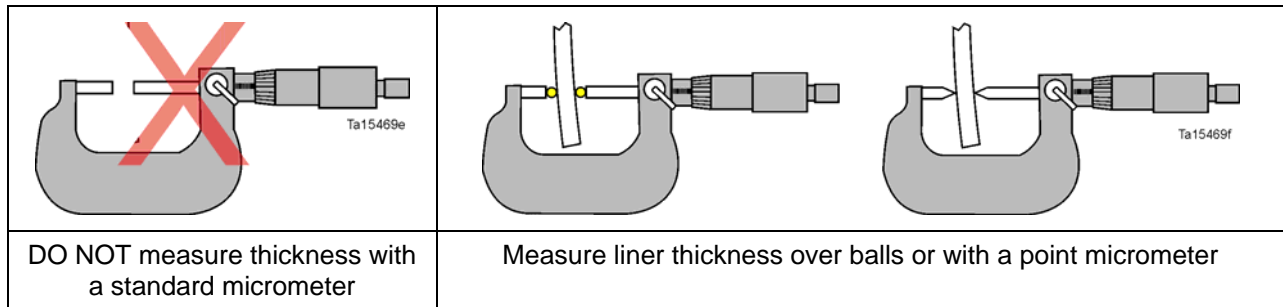


Typical bronze liner thickness specifications are listed in the following table.

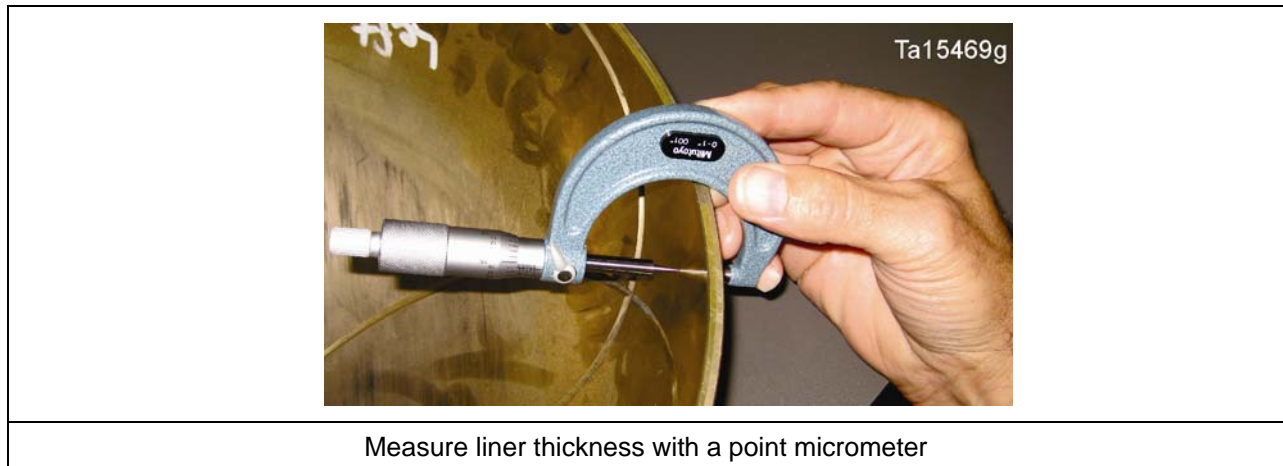
Bronze liner nominal diameter	Bronze liner thickness tolerance
7.5"	.239" - .249"
9"	.239" - .249"
12"	.237" - .247"
14"	.236" - .246"

NOTE

The bronze liner thickness cannot be checked directly with a standard micrometer or caliper due to the curved spherical surface.

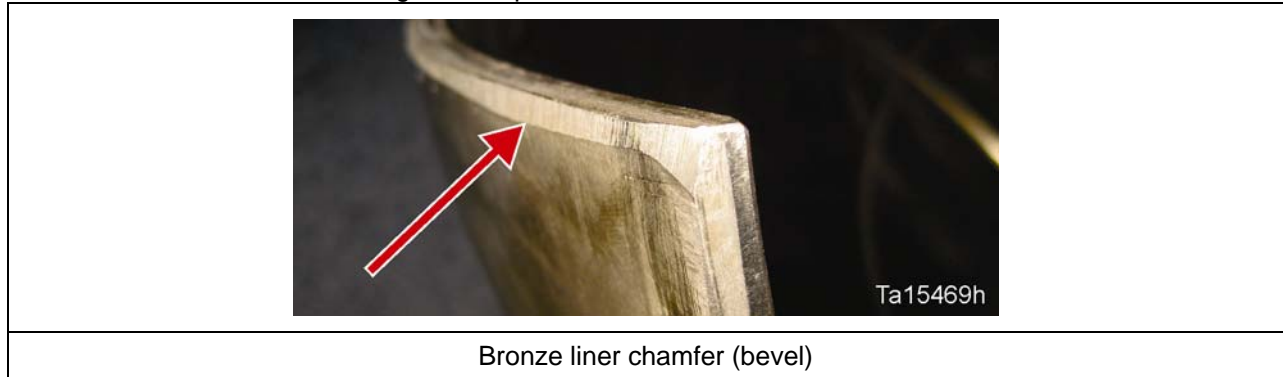


The bronze liner thickness can be checked with a micrometer over balls or with a point micrometer. Check multiple locations near the edge and as far in as the micrometer frame will allow. If the thicknesses measured are outside of the tolerance chart, then the liner should not be used.

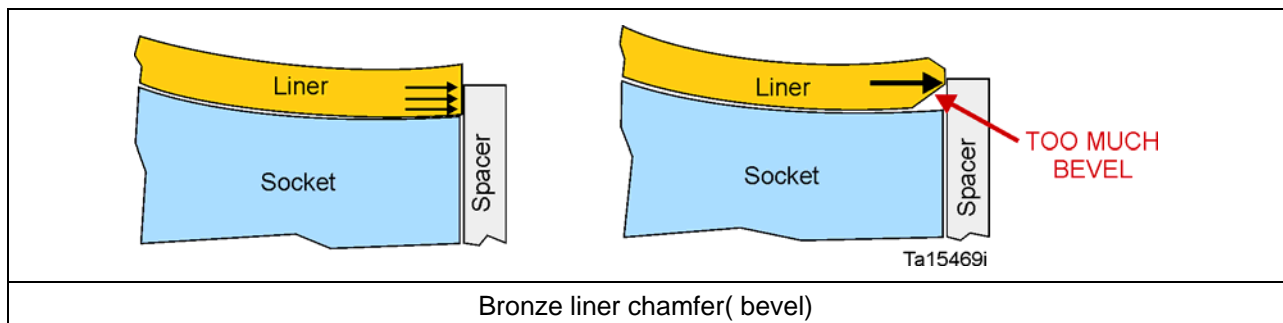


4) BRONZE LINER EDGE CHAMFER

A maximum 1/16" (1.5 mm) X 45° chamfer is called out for the edge of the bronze liner. LeTourneau has found that the corners on some 14" liners were chamfered using a grinder or sander and the size of the chamfer are much larger than specified.

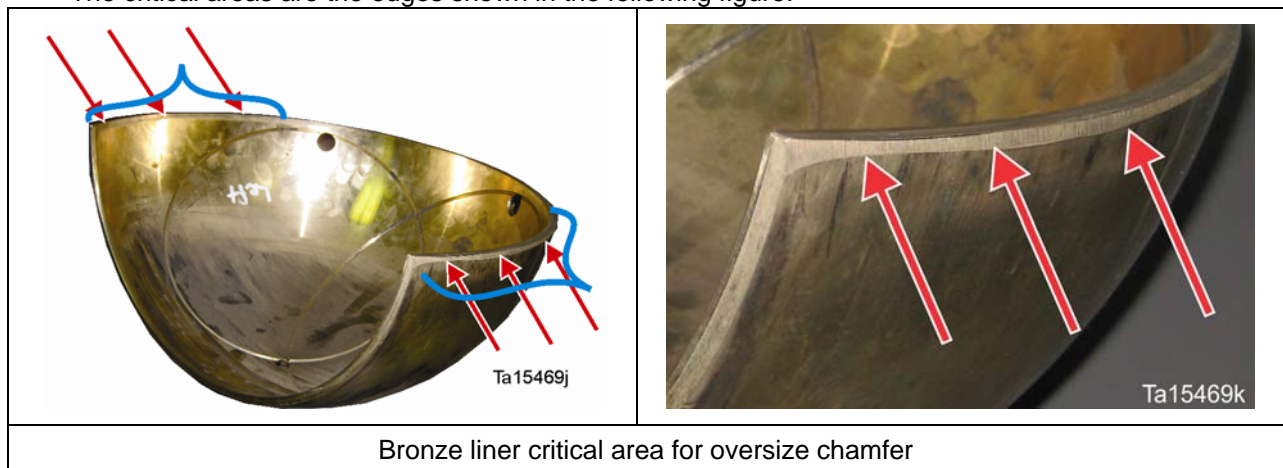


If the chamfer is too large in certain areas of the bronze liner, the liner can rotate and wedge underneath the spacer, break the spacer and shims and cause damage to the seal retainer in the socket and cap.



Any 14" bronze liners that are found to have excess machining in the critical areas shown in the following figure should not be used.

The critical areas are the edges shown in the following figure:

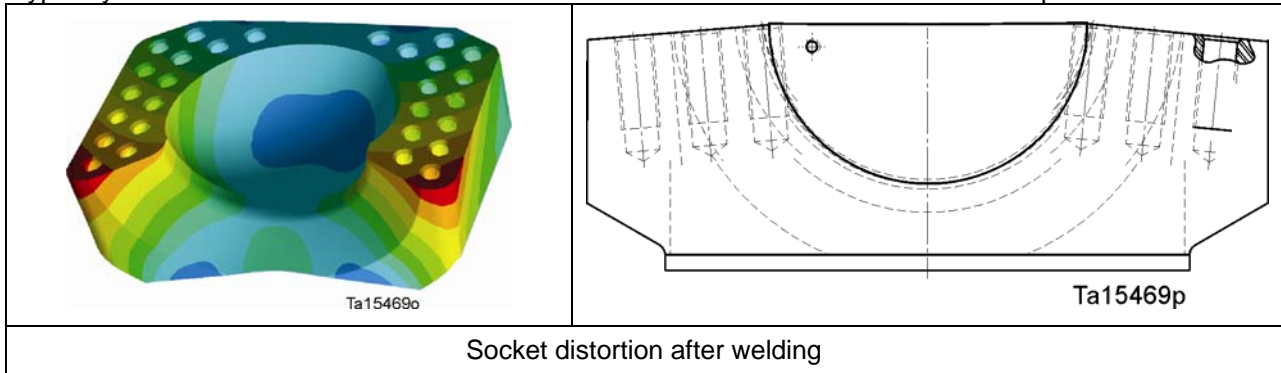


The critical areas shown are:

- On the outside edge of the sphere (not the inside edge)
- On the edge of the sphere against the spacer (not the neck)
- On the edge that is closest to the neck opening (not the neck opening)

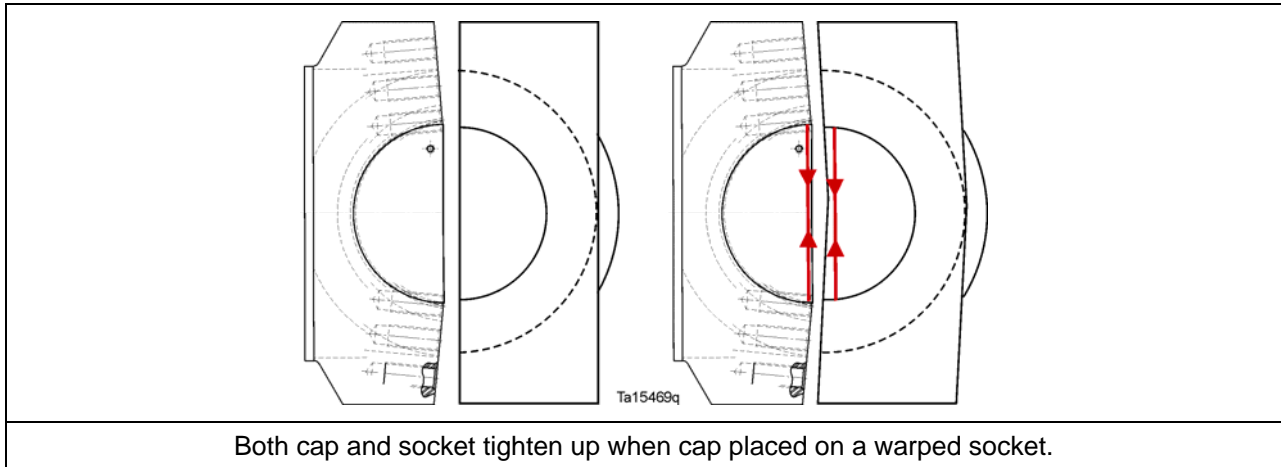
5) SOCKET FLATNESS

There has been some variance with the welding processes used to install the socket into the lift arm. LeTourneau has found that the socket can warp during the installation welding process. In most cases the socket will warp open. In the following picture the colors represent the type of distortion that typically occurs. The light blue represents minimal distortion and the red represents where the maximum distortion typically occurs. There is more distortion on the neck side of the socket because it is open.

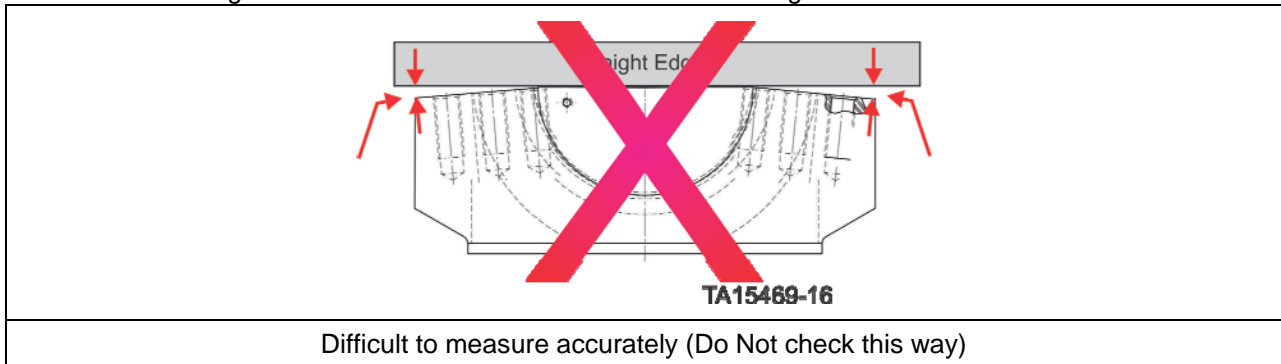


The joint design and bronze liner can tolerate the sphere opening up. However the flat mating surface needs to be flat with in .010" or distortion of the cap can occur.

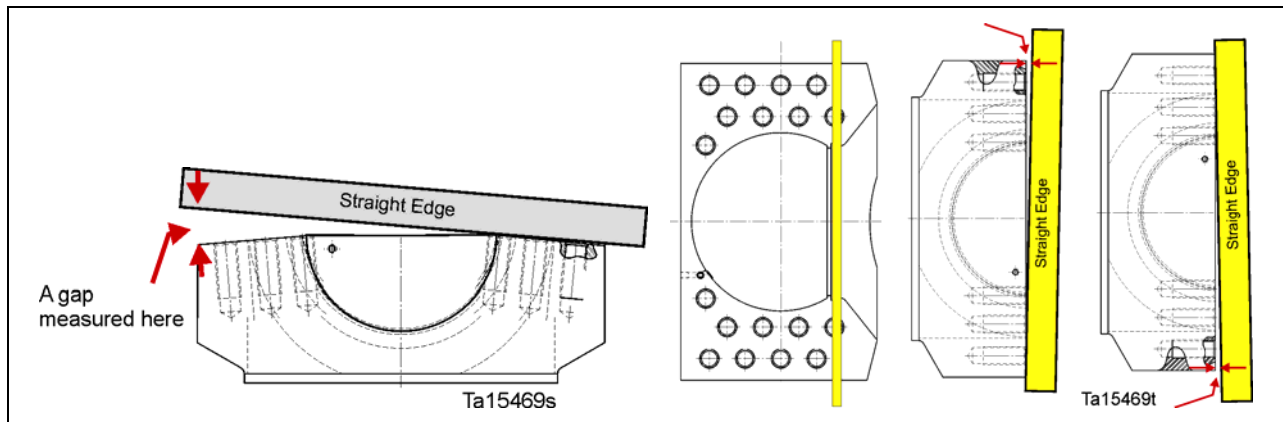
When the cap is installed onto a warped socket – the cap and the socket will both move and tighten up the sphere when the capscrews are tightened. This will make the sphere in the cap undersize causing interference and heat.



Because the distortion is in multiple directions - it is difficult to check for .010" distortion directly without the use of a milling machine/dial indicator or coordinate measuring machine.



We have found that this distortion can be amplified into something that is easily measurable with the use of a straight edge and feeler gauges.



Amplified measurement
Measure across the neck opening and measure the gap on both directions to determine

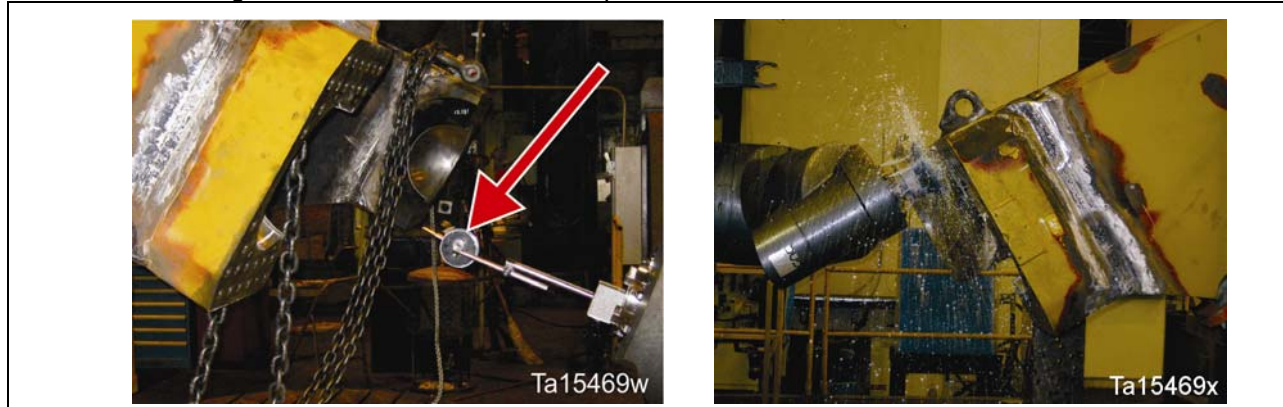
The straight edge is placed on one side of the flat surface and the gap on the opposite side is measured with feeler gauges. This is done in the area of the socket near the neck as shown. The gap is checked on both sides.

Typically the amount measured in this manner is approximately 3 times the actual. .025" measured in this manner equivalent to .008 to .010" out of tolerance on the flat face.



Feeler gauges under straight edge

When excessive distortion (>.025") is found with this test during fabrication of new lift arms – it is first verified with milling machine and dial indicator inspection and then milled flat.



Machining face of socket

Field repair of excessively distorted sockets requires inspecting, set up and machining of the face in a similar manner.

6) GREASE REQUIREMENTS

The spherical ball joints are greased by the auto lube system. The grease used in the auto lube system should meet the specifications called out in the following lubrication chart.

**Type of Grease	**Minimum ambient temperature	**Grease grade
Pumpable auto lube grease fortified with extremely high pressure and anti-wear properties for slow speed high shock application The grease is required to have between 3% and 5% MoS ₂ "Molybdenum Disulfide" additive.	+70°F (+20°C) and above	NLGI #2 grease
	+50°F (+10°C) and above	NLGI #1 grease
	+10°F(-12°C) to +50°F(+10°C),	NLGI #0 grease
	-30°F(-34°C) to +10°F(-12°C)	NLGI #00 grease

CAUTION

** The values listed for grade and temperature in the above table are only general guidelines for grease grade. Grease specifications can vary widely depending on the manufacturer, location where the grease was blended and local conditions. Each grease meeting the 3-5% Molybdenum Disulfide requirement should also have the Lincoln ventmeter number verified to make sure it meets system requirements. Use of incorrect grease that does not meet the ventmeter specification may cause pump problems and the injectors may not cycle and refill properly.

Depending on the characteristics of the grease – it is possible that a thicker NLGI grade of grease may be suitable for use at lower temperatures than shown in the table above – as long as the grease meets the following Lincoln ventmeter specifications.

LINCOLN VENTMETER SPECIFICATIONS:

NOTE

When using Lincoln SL-1 grease injectors - the maximum Lincoln ventmeter reading should be 500 psi (or less) at a temperature that is 10°F (5°C) below the minimum ambient temperature the machine will see.

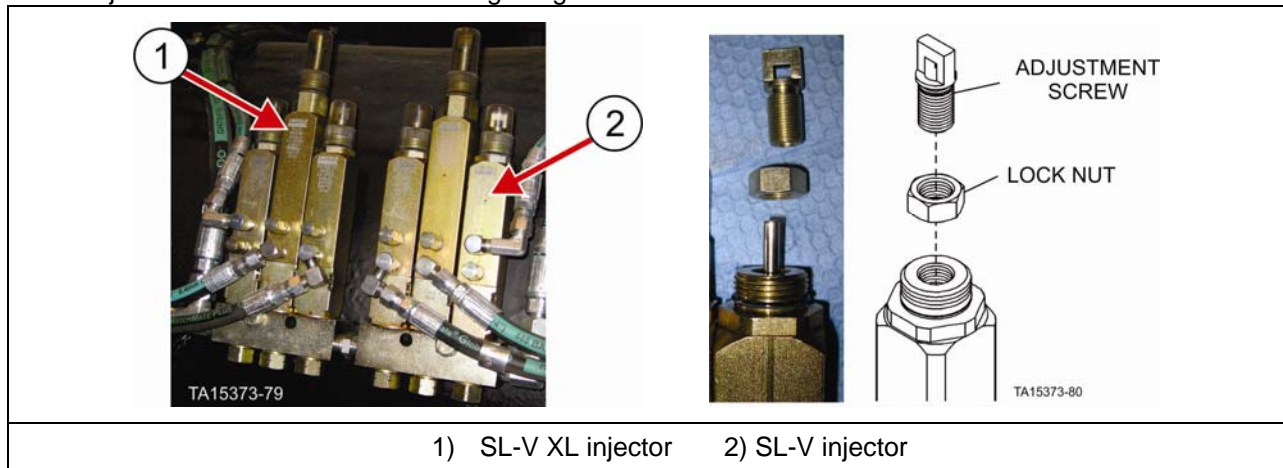
NOTE

When using Lincoln SL-V grease injectors – the maximum Lincoln ventmeter reading should be 1000 psi (or less) at a temperature that is 10°F (5°C) below the minimum ambient temperature the machine will see.

The minimum grease interval and volume requirements for the spherical ball joints are as follows:

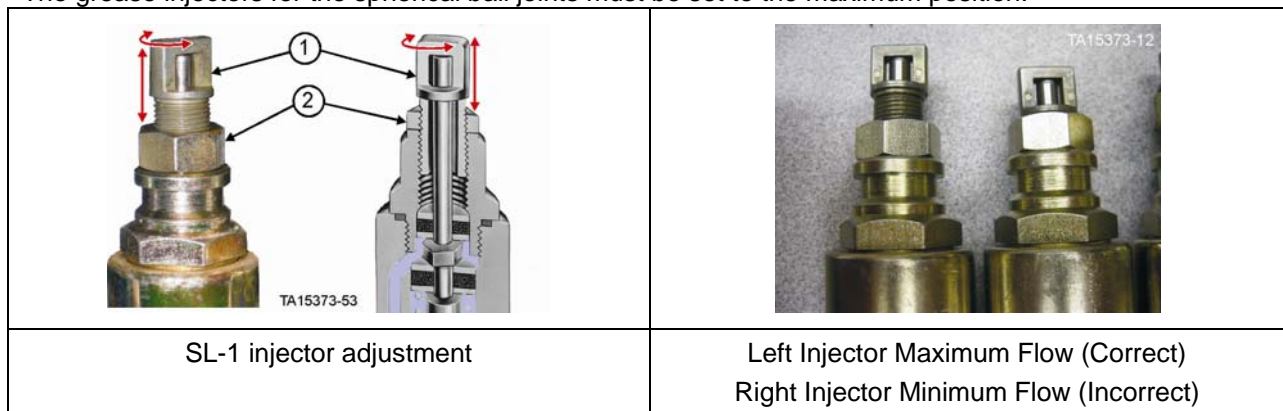
Ball Size	Grease injector volume per cycle	# of SL-1 or SL-V injectors (set to maximum)	Time interval (maximum)
7.5" 9"	.080 cu in (.131 cc)	1	15 minutes or less
12" 14"	.160 cu in (.262 cc)	2 (a single SL-V XL may also be used)	15 minutes or less

SL-V injectors are shown in the following image.



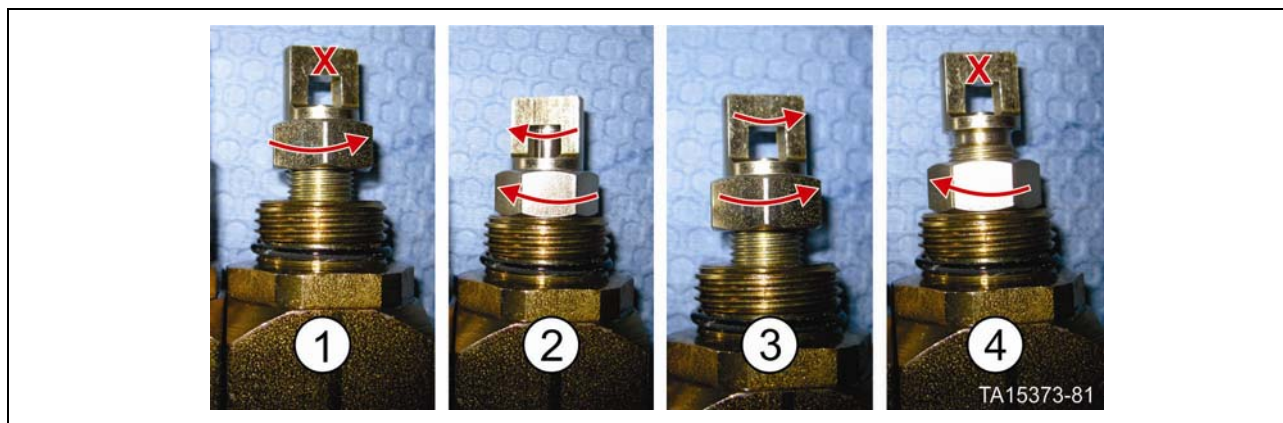
1) SL-V XL injector 2) SL-V injector

The grease injectors for the spherical ball joints must be set to the maximum position.



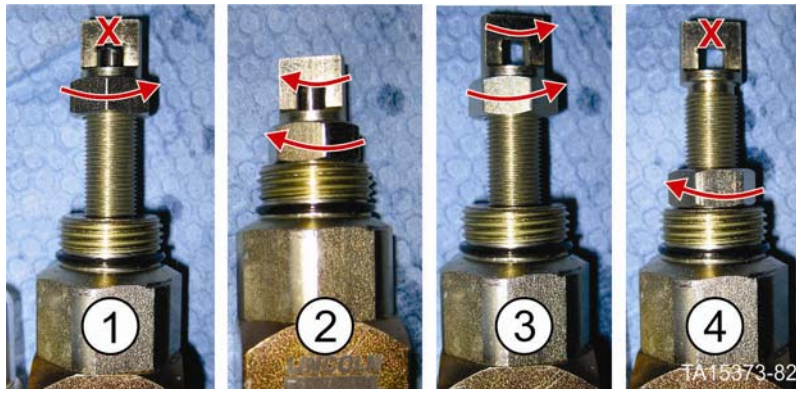
SL-1 injector adjustment

Left Injector Maximum Flow (Correct)
Right Injector Minimum Flow (Incorrect)



SL-V injector set to maximum flow

1. Turn lock nut against the shoulder on the adjustment screw.
2. Tighten the adjustment screw completely till it bottoms out on the lock nut.
3. Turn the adjustment screw out 5 turns for the maximum setting. (2 ½ turns would be 50% output)
4. Hold the adjustment screw stationary and tighten the lock nut.

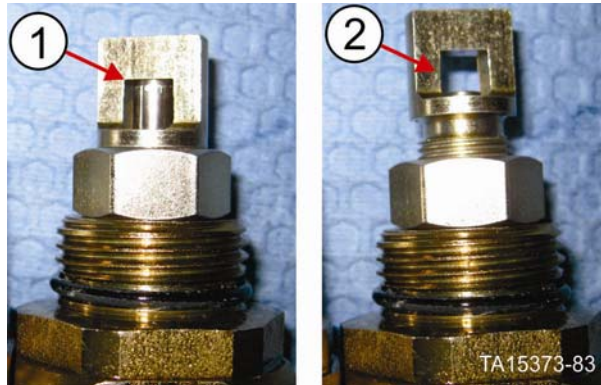


SL-V XL injector set to maximum flow

1. Turn lock nut against the shoulder on the adjustment screw.
2. Tighten the adjustment screw completely till it bottoms out on the lock nut.
3. Turn the adjustment screw out 20 ½ turns for the maximum setting. (10 turns would be 50% output)
4. Hold the adjustment screw stationary and tighten the lock nut.

NOTE

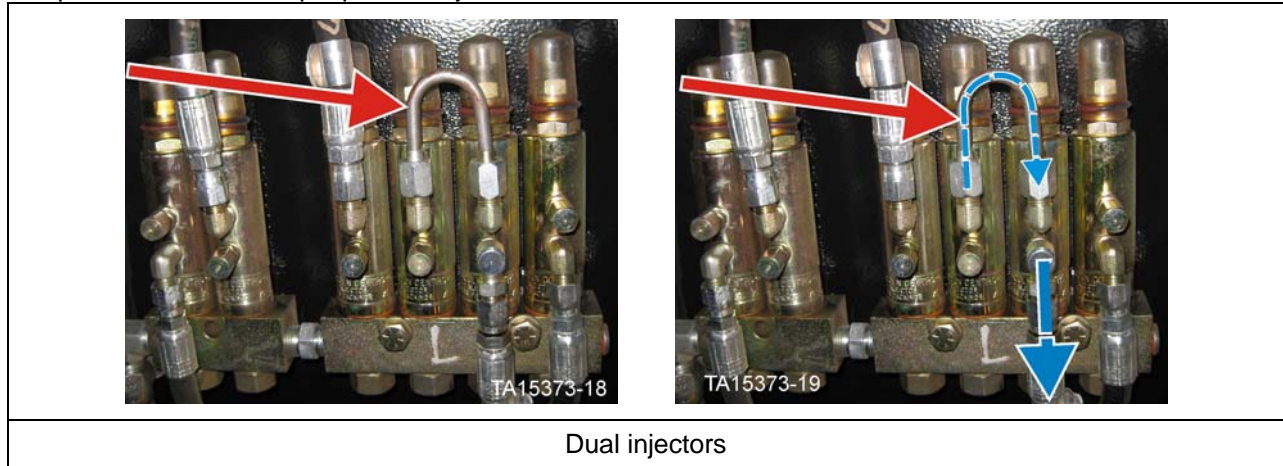
When using Lincoln SL-V grease injectors – the direction of the indicator stem is opposite from the older SL-1 injectors. The indicator stem is normally down in the SL-V when the system is not pressurized. When the system is pressurized - the indicator stem moves up until it contacts the top of the adjusting screw.



SL-V Injectors

1. Grease system pressurized (grease metered to the grease points)
2. Grease system not pressurized

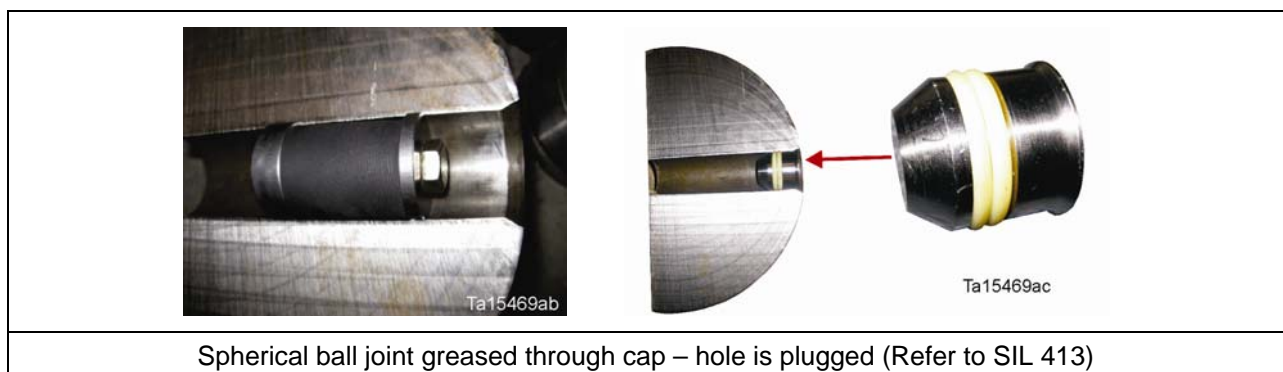
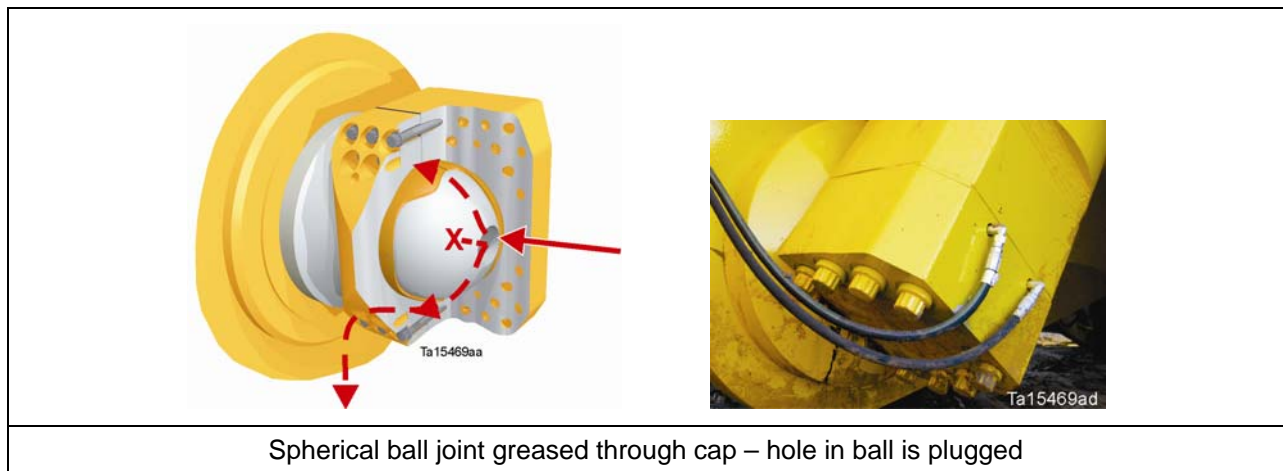
The 9" inch articulation, 12" inch and 14"inch joints require dual injectors in order to supply sufficient grease. The SL-1 injector will be connected in parallel as shown. A single SL-V XL high output injector set to maximum has 3.8 times the volume of either the SL-1 or SL-V injectors. A single SL-V XL can replace both dual or triple parallel injectors.

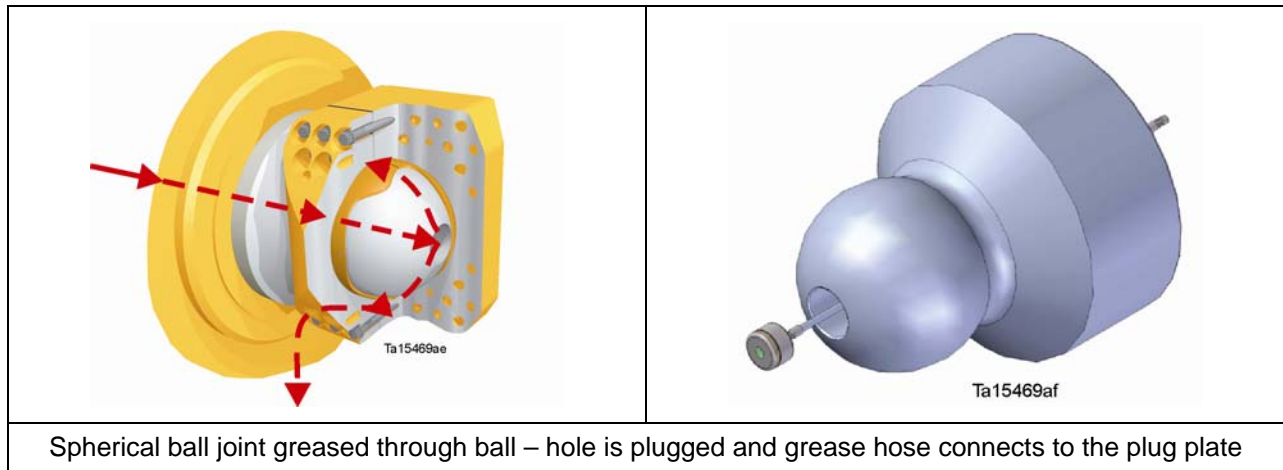


7) BALL LUBRICATION METHODS

The balls used in the spherical ball joints are constructed with a hole through the middle. A grease plug must be installed in the hole for proper greasing of the hoist cylinder or lift arm balls. Some spherical ball joints are greased through the ball while other joints are greased through the cap.

If a spherical ball joint for the lift arms or hoist cylinders does not appear to be getting sufficient grease then the location and function of the plugs must be verified. The plugs and hoses must be properly connected to injectors to assure that the grease is going through the bronze liners properly – and not into the ball mount tube.





8) CLEARANCE RECOMMENDATIONS

The ball joint clearances specified are base on the dial indicator snap measurements. The dial indicator will typically have a slow movement, snap and then slow movement as the machine is moved to check ball clearances. The snap movement is ball clearance of the joint. The rest is deflection of the various components.

- 1) **Green area** moves slowly in proportion to how much loader is moved, steered, hoisted, etc.

This is deflection

- 2) **Yellow area** – needle snaps quickly between low and high when the loader is moved, steered, hoisted, etc. This is repeatable each time.

This is the actual clearance

Snap movement of dial indicator = clearance

Recent recommendations for ball joint clearances in SIL 351.01 were opened up based on reports of heating of the spherical ball joints.

Research has shown that the root causes of the heating were not related to clearance but to items such as bronze liner thickness, distorted sockets and misaligned ball caps. The opened clearances were allowing the actual root causes to be ignored. It still may be necessary to use the opened clearance limits stated in SIL 351.01 if there are problems that cannot readily be resolved.

If the root causes have been corrected and the heating is within specification - then the ball clearances should be set as follows for maximum ball and liner life.

In general the clearances are calculated as:

Minimum clearance	1X ball diameter (in .001")
Target set up clearance	2X ball diameter (in .001")
Maximum clearance	3X ball diameter (in .001")

For example: 9" ball = .009" min, .018" target set up and .027" max.

Recommended Snap Clearance	Ball Joint Diameter			
	7.5"	9"	12"	14"
Minimum	.008"	.009"	.012"	.014"
Setup Target	.015" ± .002	.018" ± .002	.024" ± .003	.028" ± .003
Maximum	.023"	.027"	.036"	.042"

Revision	Description	Date
.00	Release	7/15/10
.01	Updated Cap to Socket Alignment with updates throughout	4/29/11