TECHNICAL ASSISTANCE BULLETIN

TOPIC: STEEL CLOSURE OPERATING GUIDELINES

NUMBER: 004 REVISION: B ISSUED: April 7th, 2022

Purpose

This bulletin provides an overview of best operating practices for optimal closure performance. This document includes general guidelines intended to cover all steel closures Silgan sells. Every packaging process and product is unique and requires attention from Silgan and the customer to provide optimal closure performance.

In addition to these operating guidelines, there are several other technical documents for reference for optimal closure performance:

- Closure specific Technical Data Sheet (TDS)
- Closure drawing
- There are several additional Technical Assistance Bulletins (TABs) that provide more details on subjects outlined in this document:
  - TAB3 – Product Traceability
  - TAB5 – Steel Closure Quality Checks
  - TAB17 – Guidelines for Tray Packing Steel Closures on Glass Bottles
  - TAB20 – Steel Closure Button Guidelines

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1. Transportation, Shelf-Life, Storage, and Handling

1.1 Storage Temperatures

- Closure Storage Temperatures should be between 40°F (4°C) to 90°F (32°C) before use.
- High temperature storage should be avoided to reduce potential closure excessive lubricant blooming. Excessive lubricant blooming can lead to floating particles in the product.
- Closures should not be stored in trailers or metal shipping containers outdoors as temperatures can exceed 140°F (60°C) during summer months. Closures should be immediately unloaded upon receipt of shipments.

1.2 Pallet Stacking and Handling

- Pallets should be stacked at a maximum of two pallets high. The corrugated cartons and pallet stacking patterns are designed to withstand a certain amount of top load without collapsing the bottom layer of cases. Exceeding two pallet stack height can lead to collapsing cartons or pallet stacks, which can damage closures and cause pallet stack collapses.
- Pallet stacking should be performed with care. Excessive movement during forklift transit can shift the load, reducing carton compression strength. Pallet misalignment when stacking pallets will reduce carton compression strength. Any other carton damage during transit/stacking can reduce compression strength and lead to closure damage.
- Cartons should not be subjected to dropping or rough handling that alters the carton design structure. Damaged cartons can result in damaged closures.

1.3 Storage Environment

- Closures should be stored in a dry, clean, indoor space free from insects, exhaust fumes, other odors, and other ambient contamination. The same conditions should be maintained during shipment of closures.
- High humidity storage should be avoided if possible. Extended high humidity storage can lead to steel closure raw cut edge corrosion.
- Corrugated cartons will absorb moisture over time and will lose stacking strength with increased storage time and humidity. In high humidity conditions, pallet stacks should be checked for overall integrity. If cartons become damp, corrugated cartons can generate odors that permeate to the closures inside.

1.4 Shelf Life

- Closures should be used within two years (730 days) of the manufacturing date listed on the side panel of the carton. FIFO (first in-first out) practices should be maintained.

1.5 Traceability

- Closure traceability should always be maintained for root cause analysis on any potential closure/application issues. See TAB3 for more Product Traceability information.

2. Closure Conveyance

- Hoppers should not be overfilled. Overfilling hoppers can interrupt proper conveyance and can lead to closure damage.
- Chute work used to convey closures must be dimensioned properly for both height and width to ensure a smooth and uninterrupted flow of closures during capping.
- The velocity of the closures should be controlled and matched to the speed requirements of the line. Excessive velocity and insufficient deceleration can result in damage to the closure.
- Tube style air conveying systems are not recommended for handling steel closures.

3. Glass Containers

3.1 Standardization

- Silgan steel closures were originally designed to be applied to standardized Glass Packaging Institute (GPI) finishes. For information regarding the correct GPI finish to use, refer to the closure Technical Data Sheet (TDS).

3.2 Introduction

- Silgan steel lug closures primarily use two thread profiles listed below based on the closure diameter. Silgan also provides closures that fit regular, medium, or deep Lug finishes. The difference is dependent on the finish “K” value, or thread start height.
  - Angle flat finish (30mm – 48mm closures)
  - Helix (53mm – 110mm closures)
- Silgan Press on Twist off closures primarily use two thread profiles, CT (continuous thread) or a helix thread design.

3.3 Coatings

- During glass manufacturing, glass is coated on both the hot and cold end. Hot end coatings help close any glass micro cracks and allows cold end coating to adhere. The cold end coating protects glass from scuffing when contacting each other as they move down conveyors.
- A lack of hot end coatings on the glass finish can lead to hard to apply/high removal torque scenarios. The presence of cold end coatings on the glass finish can lead to low removal torques and should be avoided.

3.4 Common Container Issues

- Glass dimensional deviations or defects can lead to application issues or loss of seal. Some common container issues are below:
  - Height variation of greater than 1/16” between glass from the same lot.
  - Greater than .1” jar tilt.
  - Excessive jar saddling.
  - Out of spec jar dimensions, for example, E, T, K, or L.
  - Lack of hot end coatings or the presence of cold end coatings on the finish.

4. PET Containers

4.1 Introduction

- Application of steel lug closures to PET finishes requires a very specific finish combination for favorable performance. Each packaging process requires further investigation to ensure the package will perform properly under the conditions. Contact your Silgan representative for more information.

4.2 Common Container Issues

- PET dimensional deviations and defects can lead to application issues or loss of seal. Some common container issues are below:
  - Mold step mismatch on the TSS.
  - TSS trim or cut irregularities.
  - Out of specification jar dimensions, for example, E, T, K, S, or TSS lip width.

5. Filling

5.1 Fill Control

- Fill control needs to be maintained and kept consistent between filler valves and production runs. Product should not contact the Top Sealing Surface (TSS) of the container as product entrapment can lead to loss of seal.
- Product protrusion (pepper, pickle products) above the TSS can also lead to misapplications via jar tilting in the capper.

5.2 Headspace

- Headspace is defined as the % by volume open space in a container, or the open area at the top of the container with no product.
- It is essential to control fill to ensure proper headspace is maintained. Headspace volume allows the package to form vacuum during capping. Vacuum is important in reducing internal pressure during post capping thermal processing and ensuring the button functions properly in button closures.
  - See TAB20 for more information regarding button closure guidelines.
- Headspace requirements can vary by application, but a general rule is that headspace volume should be above 6%. As headspace decreases below 6%, potential for acceptable vacuum decreases, and an exponential increase in internal pressure can occur during thermal processing.

5.3 Temperature

- Fill temperature will have a large impact on internal pressure development during thermal processing as well as the finished package vacuum.
  - A higher fill temperature will lower the internal pressure during thermal processing as the temperature differential between fill and thermal processing is lower.
  - A higher fill temperature will lead to higher finished package vacuums. This can be especially important in button closure applications.

6. Sealing

6.1 Cap Temperature

- All closures should be above 40°F (4°C) before use.
- Sufficient cap chute steam must be used to properly soften the plastisol sealing material prior to capping to achieve recommended application parameters. Cap chute steam is not meant as a means of sterilizing closures. Cap chute steam requirements can vary by line speed. In general, faster line speeds will require more cap chute steam to properly soften the plastisol.

6.2 Cold Water Vacuum Efficiency Checks

- In addition to headspace and fill temperature, capper vacuum efficiency can impact final package vacuums.
- It's essential to perform cold water efficiency checks at regular intervals (at a minimum, once per shift) to ensure the capper is providing adequate steam flow for vacuum formation.
  - See TAB22 for further details regarding the correct procedure for performing cold water efficiency checks.

6.3 Nitrogen or gas headspace purging

- Some cappers utilize gas injection (nitrogen for example) to displace oxygen in the package headspace. When utilizing this method, gas injection needs to be considered for final package vacuum.

6.4 Vacuum

- Capper exit package vacuum
  - Capper exit package vacuums are important for post sealing thermal processing applications. Low vacuums could lead to closure back off in pasteurization or retort applications. High vacuums could lead to closure cut through in retort applications.
  - Capper exit package vacuums at sealing temperatures will determine the final package vacuum.
- Final package vacuum
  - Final package vacuum minimum requirements need to be met for proper tamper evident button function and each closure may have different minimum requirements. Refer to the closure specific Technical Data Sheet for minimum vacuum requirements.

6.5 Cap Application Quality Checks

- Cap application quality checks need to be completed at periodic intervals during every production period to ensure a proper seal is being maintained.
  - See TAB22 for further details regarding quality checks.

6.6 Pull-up

- Pull-up is a quality check on angled flat finishes and lug finishes only. It is a measurement of the degree of application of a closure to the bottle finish threads. It is important to note that Pull-up is a reference measurement and should not be used to replace security measurements on a lug helix finish closure.

- Closures with a shallow pull-up suggest underapplication. Pull-up values should always be positive. A negative pull-up suggests the closure has been overapplied.

6.7 Security

- Security is a quality check on helix lug finishes only. Security is a measure of the lug tension of an applied closure and is a measurement of how tight a closure is applied.
- Low security values may suggest potential underapplication or dimensional deviations in the bottle or closure. Security values below 0 suggests the closure does not have a proper seal and should be corrected immediately.

6.8 Removal Torque

- Removal torque is a quality check for all steel closures. Removal torque is the torque required to initially move the closure on the glass finish, or the torque required to break the container hermetic seal.
- Removal torques vary significantly with glass lubricant or treatment, filling conditions, sealing conditions, vacuum level, and by operator. For this reason, Silgan doesn't specify specific torque ranges.

6.9 Closure Tilt

- Quality check for PT closures only. Tilt is the height difference between minimum and maximum post sealing applied closure height measurements. For PT closures, the lean must be less than 3/32" preprocessing. Greater tilt than this can suggest a level of misapplication is happening and may lead to loss of seal.

6.10 Common Lug Closure Application Issues and Causes

- Deviations from ideal capper or filling settings can lead to misapplications. Some examples of lug closure misapplications and potential causes are listed below:
  - Cocked caps: Product protrusion over the top of the neck finish, cap pickup issues due to improper capper height, cap chute that is not parallel to the bottle conveyor, first or second duck bill unevenness/tilt or improper height, side belts slipping during pickup allowing the jar to tilt, improper drag rubber pressure, jar conveyor is unlevel in the pickup area, or improper jar centering at capper entrance. Further issues can arise when capper components are worn, leading to seized capper components.
  - Crushed Lug: Duck bill spring tension is too high, improper drag rubber pressure, worn capper components like the drag rubber.
  - High/Loose caps: Low cap chute steam flow, low entrance or discharge sealing shoe pressure, low side belt tension.
  - Stripped caps: Excessive bump or pressure on the entrance or discharge sealing shoe posts.
- Closure or finish dimensional deviations can lead to misapplications:
  - Out of specification closure lug height, lug width, or compound thickness, and damaged or crushed lugs.

- Bottle tilt, bottle height variation, out of spec bottle L, K, E, or T dimensions.

6.11 Common PT Closure Application Issues and Causes

- Deviations from ideal capper or filling settings can lead to misapplications. Some examples of lug closure misapplications and potential causes are listed below:
  - Excessive closure tilt: Low cap chute preheat steam temperatures, improper jar centering at capper entrance, cap pickup issues due to improper capper height, cap chute that is not parallel to the bottle conveyor, first or second duck bill unevenness/tilt or improper height, side belts slipping during pickup allowing the jar to tilt, jar conveyor is unlevel in the pickup area, improper sealing pressure. Further issues can arise when capper components are worn, leading to seized capper components.
  - Closure pumping: Packages that develop less than 5”hg vacuum at the capper will not allow closures to properly seat during application. This can be caused by low capper vacuum efficiency, excessively high fill temperatures, or low headspace.

7. Thermal Processing Overview

7.1 Introduction

- Packages are passed through a heat treatment process to preserve the product and increase shelf life. The type of thermal treatment process is dependent on product pH:
  - Hot fill or open pasteurization products (180F – 212F) have a pH ≤ 4.6
  - Sterilized closed retort products (212F-256F) have a pH ≥ 4.6

7.2 Closure Compounds

- Closure compounds are designed for a specific thermal process in mind. For this reason, a closed retort compound closure can only be used for retort applications. Pasteurization or Hot Fill compound closures cannot be used in retort applications.

8. Pasteurization

8.1 Introduction

- Pasteurization processes typically involve fill temperatures below processing temperatures (less than 180F), followed by pasteurization in an open tunnel system. Unlike a closed retort, the pasteurizer doesn’t apply overpressure to the packages. This means thermal processing pressures are at atmospheric pressures. Therefore, the pasteurization temperature limit is the boiling point of water.

8.2 Pressure Differential

- During pasteurization, it’s important to ensure the delta pressure on the cap is always positive:
  - External pressure – package internal pressure = + pressure value.
  - If internal pressures rise above external, the cap can vent or back-off. Filling/capping parameters discussed earlier (headspace, temperature, capper vacuum efficiency) need to be controlled to ensure capper exit vacuums are high enough to withstand the internal pressure increase during processing.

- Products can vary in expansion properties, entrapped air, fill temperature, processing temperature. For this reason, Silgan recommends validating the package process to ensure filling/capping parameters allow the package to maintain a lower pressure during processing.

8.3 Post Pasteurization Checks

- Packages should be inspected post processing to ensure a proper seal is maintained and that containers are not experiencing back-off during processing. Securities, Pull-ups, and visual closure inspections should be performed.

9. Closed Retort

9.1 Introduction

- Closed retort processes involve fill temperatures much lower than processing temperatures, and processing temperatures are above the boiling point of water. For this reason, closed retort processes incorporate the use of overpressure to ensure water does not boil during processing, and to maintain the container's hermetic seal as internal package pressures will be high.
- Closed retort processes typically have 3 phases:
    - Heating, or come up phase: During this phase, temperature increases to cook temperature.
    - Holding or cook phase: During this phase, the product is held at cook temperature for the specified process time.
    - Cooling or come down phase: During this phase, temperature drops until package temperatures reach a cooled temperature.

9.2 Overpressure and Pressure Differentials

- Overpressure, or positive pressure on the container, must be held during all three phases of the cook cycle. Silgan recommends holding an overpressure such that the pressure differential between external and internal is between 3-5 PSI. During the initial part of the come down phase, internal pressures and temperatures will be high. Therefore, it is important to hold or gradually reduce pressure during the come down phase.
    - If overpressure is too high (high pressure differential), the closure can experience low remaining gasket thickness, and in some cases, compound cut through. Silgan recommends a maximum overpressure of 32PSI to avoid this scenario.
    - If overpressure is too low (low pressure differential), the closure can experience venting or back off.
- As discussed in section 3, headspace and fill temperature play an important role in capper exit vacuums, and therefore internal pressure during the cook cycle:
    - Lower headspaces will increase package vacuum during cooking.
    - Lower fill temperatures will increase package vacuum during cooking.

9.3 Cook Temperature

- Cook temperature is an important factor in internal pressure buildup during the cook cycle:
    - Higher cook temperatures will increase internal pressure during cooking.
- Silgan recommends a maximum cook temperature of 252°F.

9.4 Rotary Retort Considerations

- The rotary retort process can be more abusive than a still retort process. More processing conditions need to be monitored to ensure packages maintain a hermetic seal.
- The rotation speed, or Rotations per Minute (RPM) applies additional pressure onto the closure compound through product inertia. Silgan recommends a maximum RPM of 16.
- Clamping pressure needs to be met such that containers are held tight and secure in each layer of the retort basket. During retort rotation, containers not held in place will move which can scuff closures, break glass, and potentially lead to loss of seal.
    - Clamping plates work off pneumatically controlled cylinders that pushes the top plate down into each basket. Each clamping device must be checked on a regular basis to ensure proper load is being provided.
- Rotary retort baskets should be properly sized such that there is minimal movement within layers to allow container movement. Rotary basket layers should be formed so that containers stack in orderly columns to avoid uneven clamp pressure loading.
    - All containers entering the basket need to be in good condition. Down containers, misapplied closures, or no closure containers can disrupt even stacking and lead to uneven load distribution during cooking.

9.5 Divider Mats

- Divider mats need to be used in any retort application. Divider mats separate layers and protect the face coat of the closures from scuffing or abuse.
- Silgan recommends the use of mats made of a Silicone material. Polypropylene style dividers are prone to cause damage to the face coat of the closure.
- Divider mats need to be in good condition. Deterioration or delamination of the silicone material can lead to uneven clamp pressure distribution, allow containers to move, or displace uneven load to containers within layers.

9.6 Initial Water Temperature

- The temperature of the water in the retort prior to immersion of the filled basket cannot be hotter than the product temperature. Likewise, product should be cooled in the retort to at least the initial immersion temperature.

9.7 Post Retort Checks

- Packages should be inspected post processing to ensure a proper seal is maintained and that containers are not experiencing back-off, scuffing, or cut through during processing. Securities, pull-up, compound impression/remaining gasket thickness, visual checks for scuffing should all be completed on a regular basis.

10. <u>Post Process and Cooling Moisture Removal</u>

- Care should be taken to adequately remove moisture from the annular space of the closure after cooling to avoid potential corrosion of the raw cut edge.
    - See TAB19 for additional recommendations for proper moisture removal.

11. Post Cooling Inspection System

- Silgan recommends having an additional closure inspection system on the back end of the line, typically immediately after bottle labeling. For button closures, down flip vacuums may not be reached until after processing, meaning the post capper inspection system wouldn't be able to distinguish between a good and bad package.
- For thermal processing applications, post cooling inspection is especially important to ensure the process is not negatively impacting the seal.

12. Tray Packing, Palletization, and Finished Product Shipment

- Tray or carton pallet overhang should be minimized for maximum pallet stability. Carton or tray corners should rest on the pallet deck corners for maximum pallet stability.
- Pallets of stacked product should be machine stretch wrapped to provide consistent wrap tension. Wrap tension should not be excessive to minimize carton or tray buckling/damage that could shift load and lead to a potential loss of seal integrity on individual packages.
- All stacked pallets should be as straight as possible. The use of corrugated dividers between each pallet is recommended for even load distribution and to avoid any potential abuse to the top of the closures when the cases are tray packed. A minimum of a B-fluted divider is recommended, and each divider should only be used one time.
- Finished products cannot be shipped frozen or in freezing conditions as glass can fracture and create a loss of seal condition.
- See TAB17 for additional guidelines for tray packing and palletization.

13. Closure Qualification

- There are various other parameters that need to be monitored and optimized during a new closure startup/qualification.
- Line setup (chutes, conveyors, capper, inspection systems, thermal processing parameters, closure drying systems, etc.) should be documented during startup and maintained for proper closure performance.