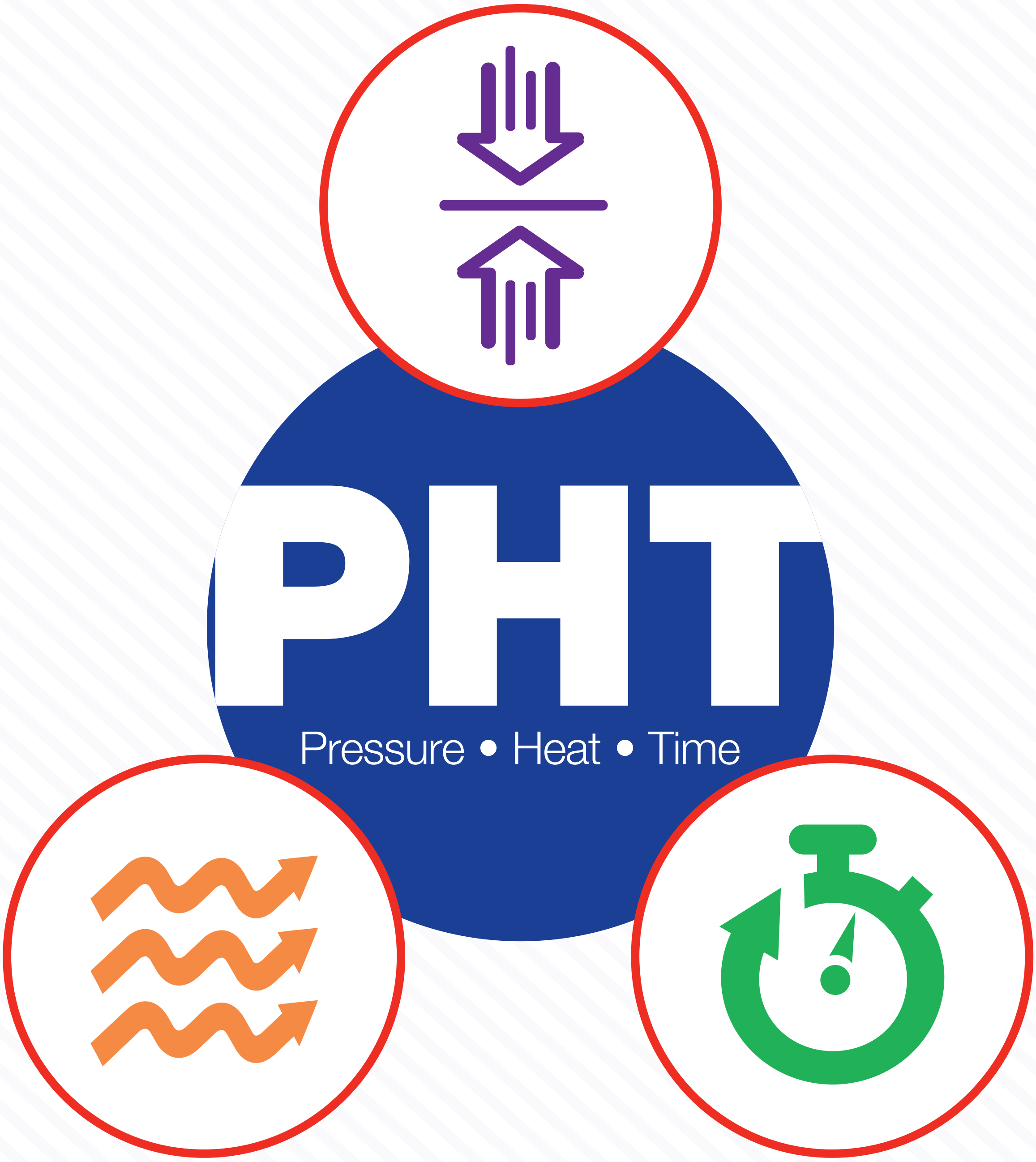
Selig group

www.seligsealing.com



Your Technical Guide to Induction Sealing

Edition III

About Selig Group

Selig Group is the world's leading manufacturer of closure liners and induction seals and the premier European manufacturer of printed flexible packaging materials. Selig has been meeting the needs of the packaging industry for over 120 years, with the largest range of products to address the needs of the Food & Beverage, Pharmaceutical, Nutraceutical, Agricultural, Personal Care and Chemical industries.

Our Lift 'n' Peel™ liner is the consumer preferred container seal allowing easy removal of the induction liner. Our industry-leading Safe-Gard™, FoilSeal™, Uni-Gard™, DUOSEAL™, DELTASEAL™, and QUADRASEAL™ brand product families are trusted by market-leading companies on billions of products a year to provide freshness, safety, leak prevention, and tamper evidence.

Our 4 global manufacturing locations (USA, Canada, UK, Switzerland) and our extensive broker network supply and service all areas of the world. Each Selig manufacturing location has ISO 9001:2008 certification, as well as certifications from the BRC (British Retail Consortium) for GMP (Good Manufacturing Practices) and US-FDA registration.

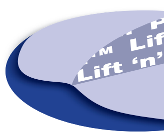
Quality Statement

As the global leader in closure induction seals and a premier manufacturer of printed flexible packaging in Europe, Selig is committed to world-class quality, peerless safety, superior customer support and outstanding value. We achieve this position through innovation, continuous improvement, customer satisfaction and operating under a registered quality management system that meets or exceeds regulatory requirements for our products.

CONTENTS

On-Line Resources

Selig's website (www.SeligSealing.com) is home to the world's leading manufacturer of innerseal solutions and innovation. There is a wealth of information for both potential and existing customers, from choosing the optimal liner for your application, to troubleshooting, including a FAQ section. For more in-depth information, we invite you to create your *FREE* personal account which allows unlimited access to the latest product and application information, including product data sheets, access to webinars and information on upcoming industry events.



NOTES

1 Introduction to Induction Liners

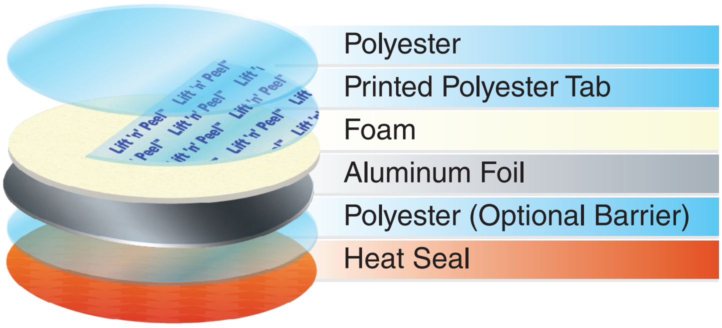
INDUCTION LINERS

ONE PIECE LINERS

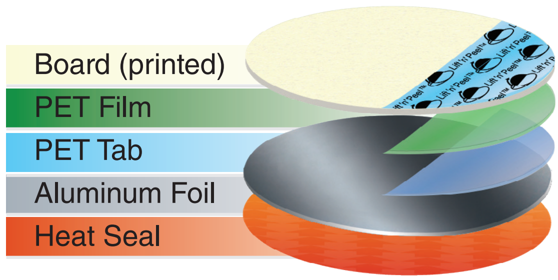
Seal to a container where a reseal is not required, or is provided adequately by the closure. Both peelable and tamper indicating options are available with custom, random, or registered print to enhance the product's brand and market perception.

Lift 'n' Peel™

The Lift 'n' Peel™ range of induction seals incorporates an easy open half moon tab that has been designed to be ergonomically easy to grip, flexible and extremely strong. Lift 'n' Peel™ MAX offers further brand differentiation by expanding graphics to the entire top surface of the liner. Lift 'n' Peel™ Wide Mouth is designed for applications of 53 - 120mm diameter openings.



Lift 'n' Peel™ (Standard)



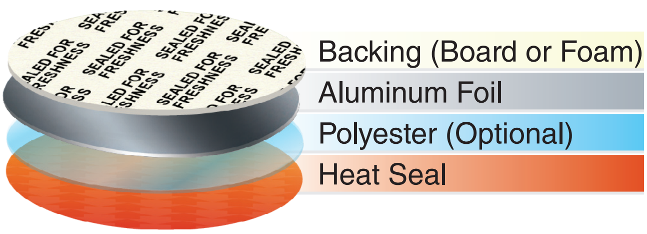
Lift 'n' Peel™ Wide Mouth

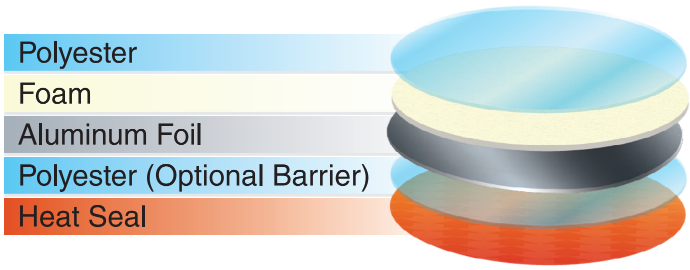
FoilSeal™

FoilSeal™ is a range of heat induction foil innerseals for sealing to a variety of resin types, including PE, PP, PET, PVC and treated glass. Additional options allow for venting of dry products. Adhesion will vary by container material type.

Uni-Gard™

Uni-Gard™ is a one piece induction foil. Uni-Gard™ provides benefits ranging from higher operating speeds and the flexibility to run at wider induction operating parameters, while still ensuring package confidence.





**Uni-Gard™ & FoilSeal™: A side-pull tab is commonly provided when the liner is punched and inserted to aid removal of the liner, as well as help the liner be retained in the closure.*

For additional information on induction liners, contact your Selig Sales Representative.

TWO PIECE LINERS

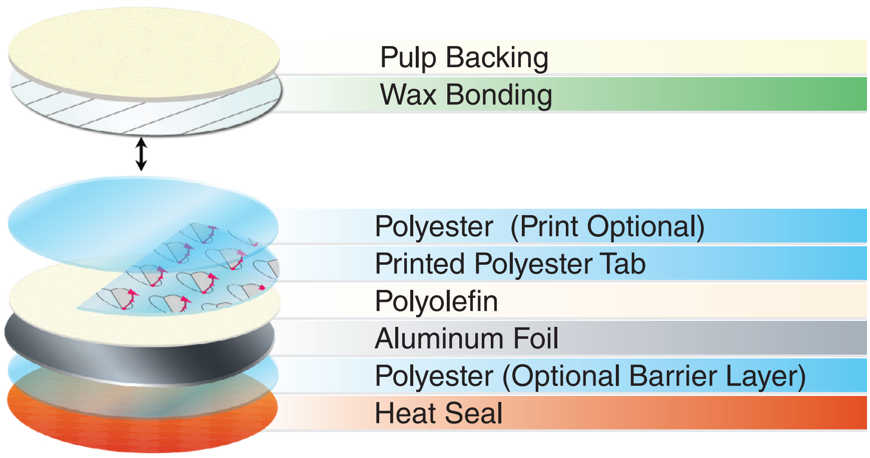
Seal to a container and has a secondary backing board or foam structure which ensures once opened, the container can be resealed. Two piece liners can be printed with a customer specific logo or design to provide brand differentiation.

Temporary Wax Bond

These liners are retained in the cap behind a retention feature or with adhesive. Two piece wax liners have a temporary wax bond to a secondary reseal liner.

Top Tab™

Top Tab™ induction foil is a two piece temporary wax bonded induction liner with a built-in half-moon tab for easy removal of the innerseal. The pulp based backing provides a reseal feature.

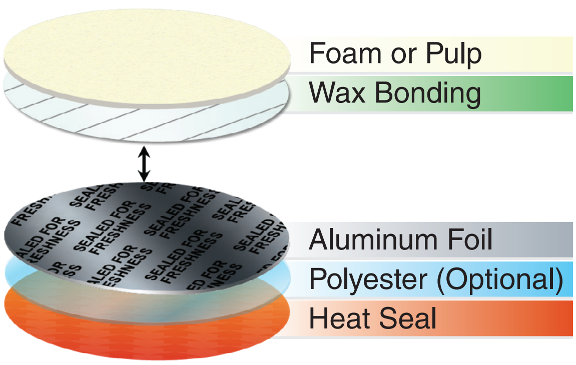


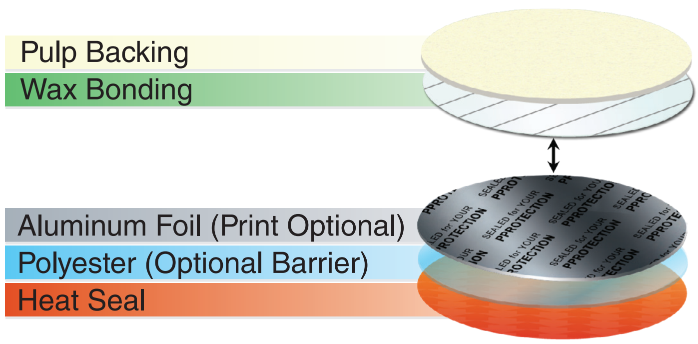
FoilSeal™

FoilSeal™ two piece is a range of heat induction foil innerseals with various combinations of foam, pulp, film, foil and heat seal layers designed and evolved over the last 70 years to create a perfect seal for almost any package.

Safe-Gard™

Safe-Gard™ liners are the world's leading brand of two piece temporary wax bonded, pulp backed liners.





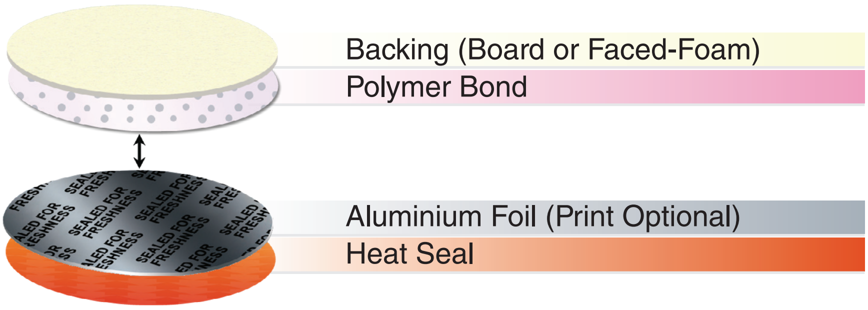
For additional information on induction liners, contact your Selig Sales Representative.

INDUCTION LINERS

Temporary Polymer Bond

DELTASEAL™

The DELTASEAL™ range of two piece induction liners have a temporary polymer bond to a board or foam reseal liner. The temporary polymer bond eliminates the use of wax as a temporary bond, offering a clean polymer-faced reseal. These liners are retained in the closure by a special retention feature in the closure (Chapter 11).



Upon removal of the closure, DELTASEAL™ gives an audible 'crack' during separation. The materials separate to leave a clean foil on the container and a polymer-faced reseal liner in the cap.

For additional information on induction liners, contact your Selig Sales Representative.

2 Introduction to Induction Sealing

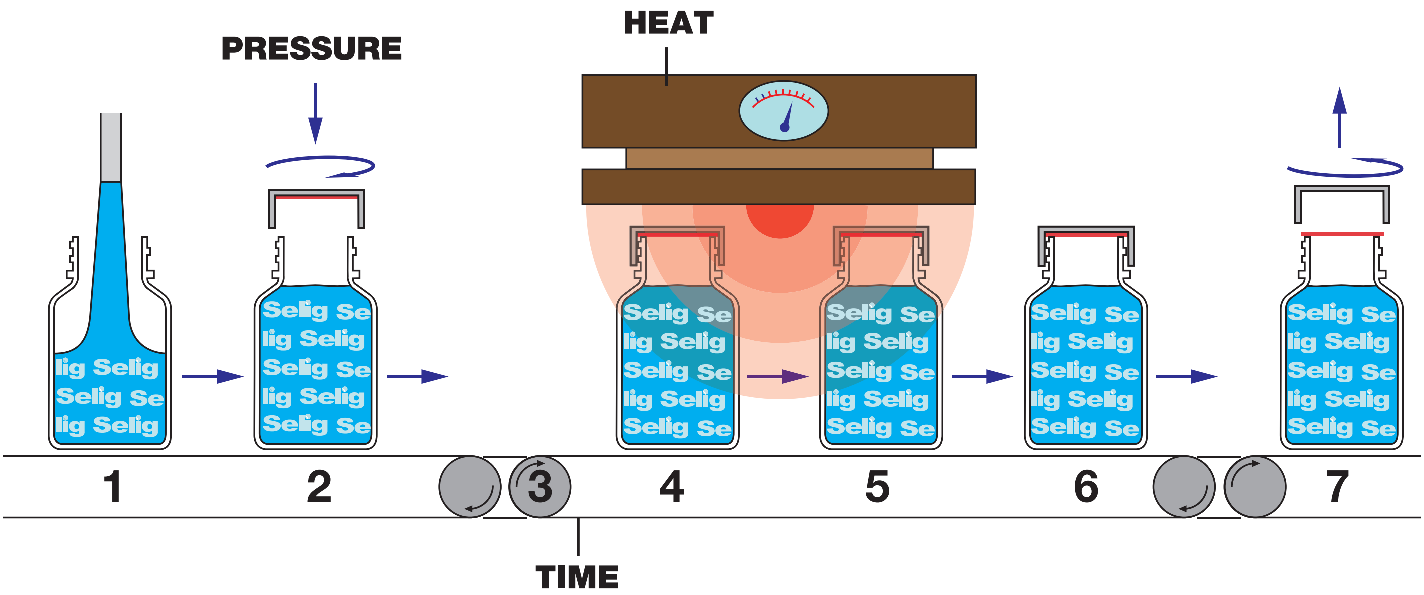
INDUCTION SEALING

What is Induction Sealing and how does it work?

Induction Sealing, otherwise known as cap sealing, is a non contact method of hermetically sealing a highly technical engineered laminated structure to the top of plastic and glass containers. The sealing process takes place after the container has been filled and capped. Induction sealing provides tamper evidence, leak prevention, freshness preservation, pilferage protection and enhances the brand of the sealed product.

This advanced technical manual will help you understand what the induction process is and what happens when an induction liner is sealed to the land area of the container. By understanding how to address and control induction sealing variables, you can achieve a perfect seal every time.

The process of developing a perfect seal depends upon several key operating factors to ensure that the maximum performance (operating window) is achieved. These factors include matching the closure to the container's neck profile to maintain PRESSURE; setting up the induction sealer to the correct performance HEAT levels; a correctly specified induction process places no limitation on your filling line speed TIME.



The Induction Process Stages

1. Filling
2. Capping with correct on-torque (pressure)
3. Product transported on conveyor (time)
4. } Induction period (heat)
5.
6. Cooling
7. Sealed Container

3 About Pressure, Heat & Time (PHT™)

PRESSURE, HEAT & TIME.

Pressure is needed for the liner to have an even seal to the container. This is achieved by the torque heads of the capper when placing the closure onto the filled container. There are a number of factors that contribute to pressure:

Figure 3a: The pressure is measured in Inch pounds or Newton Metres on a torque meter

1. The profile (shape) of the threads on both the closure and container.
2. The number of threads per inch/mm.
3. The design of the neck and threads of the container must be matched to the closure so that the closure will give even pressure to the land area and the skirt of the closure will not bottom out on the shoulder of the container. This is known as the 'H' dimension *(see figure 3b)* of the container and closure. If the land area of the container has any defects, such as high spots (at seams) or possible low areas (saddle), you will have uneven pressure.

   When you induction seal a liner to the container with insufficient pressure on the liner and land area, the following could happen:

   a. Leakers
   b. Melt down of land area
   c. The induction seal liner may be overheated, melted or destroyed. It could burn and produce an odor and/or contaminate the product.
   d. There could be melting of the secondary liner (2 piece only).

   Note: One or all of the factors could happen at once. It is very important that the torque heads are checked at least once a shift to ensure that each closure receives its proper "on-torque": It is possible to over-torque a closure and when this happens it could strip the threads, resulting in uneven pressure. It is important that the closure is rigid enough so that it does not distort when torqued onto a container.

4. The closure/container combination require adequate thread engagement/rotation, ie 360° for a single start thread and 120° for a 3 start thread to help ensure a uniform pressure is generated when fully tightened.

Heat is also a very important factor required to produce a correct seal of the liner to the container. The distance (air gap) of the induction sealing head to the foil in the liner is very important as is having the right profile of the induction coil for the job, ie a flat or tunnel coil.

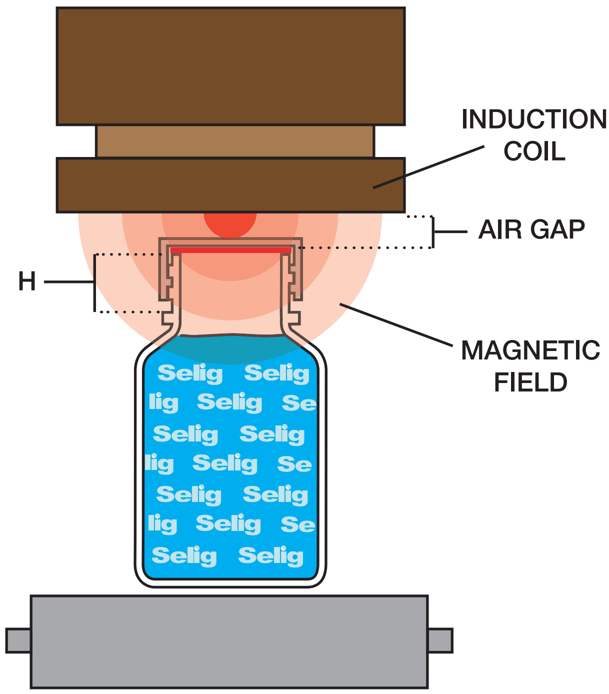


Figure 3b: Electromagnetic field generating heat

It is common practice to have one of the suppliers or manufacturers of the induction seal equipment run trials at their facility. They will recommend what equipment is required. The size of the induction seal equipment is very important; as it must have the capacity and power to efficiently produce the electromagnetic field around the induction liner to seal under the conditions of the conveyor line speed.

Time is needed when the closure is passing under the induction coil. This is called the dwell time. The induction seal liner needs sufficient time under the coil to be heated to the correct temperature for the sealing surface to melt and bond to the land area of the container. Also, a wax laminated "2 piece" liner may require more time for the wax to be absorbed into the pulp. The time that the closure/container spends under the induction coil is determined by the conveyor speed.

Containers that are hot filled require special attention to the length of time under the sealing head. If the container is hot filled at 200°F/ 93.3°C the additional energy from the induction coil can heat the liner and the land area of the container to approximately 400°F/ 200.4°C. The induction seal liner starts bonding to land area after it cools down to approximately 270°F/132.2°C. This is why time is needed after sealing to allow cool down, during which, the container MUST NOT be bumped, banged, roughly handled or opened, if it is, the seal can be broken as a result of the air hammer effect (caused by movement of the container contents).

Figure 3c: Timing is crucial for a successful seal

Remember: Hot filling a plastic bottle changes its shape and increases its volume. Also, the hotter the fill the easier it is to change the shape of the container.

NOTES

4 The Induction Process and Heat Sink

THE INDUCTION PROCESS

Step 1 - Liner Insertion

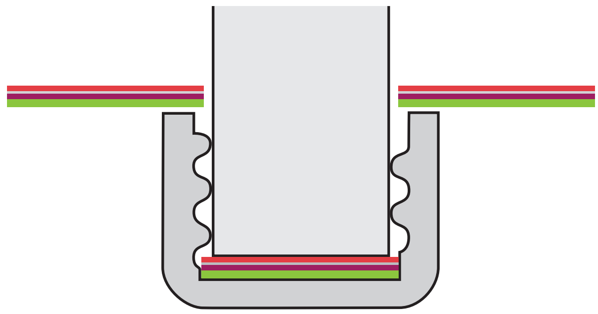


Figure 4a: Step 1 of the Induction Process

The liner is punched to a specific diameter and inserted centrally into the closure. This can be achieved either from a slit tape or by insertion of a pre-punched liner.

Step 2 - Closure Applied to Bottle

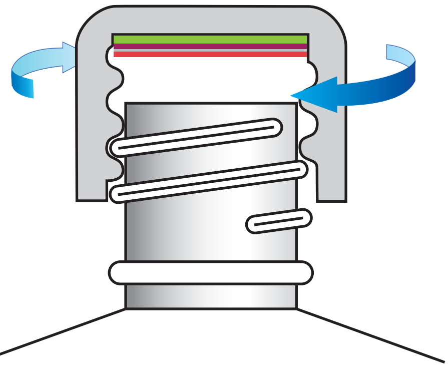


Figure 4b: Step 2 of the Induction Process

With the liner inserted, the closure is applied to the filled container and is tightened to a suitable on-torque value for the specific application.

Step 3 - Induction Heating

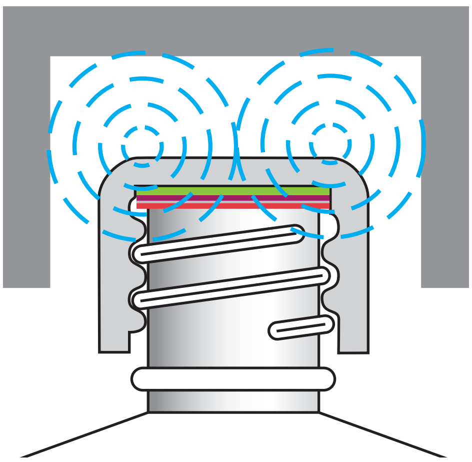


Figure 4c: Step 3 of the Induction Process

Container passes under the induction coil, which produces a high frequency electromagnetic field that generates heat in the foil layer. The heat causes the heat-seal layer to melt around the container land area. With two piece liners, the wax layer also melts *(figure 4d)*.

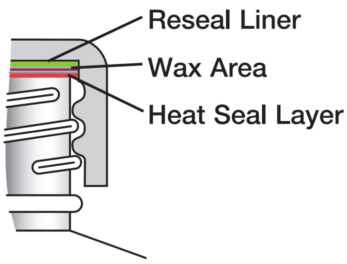


Figure 4d: 2 piece liner composition

Step 4 - Cooling

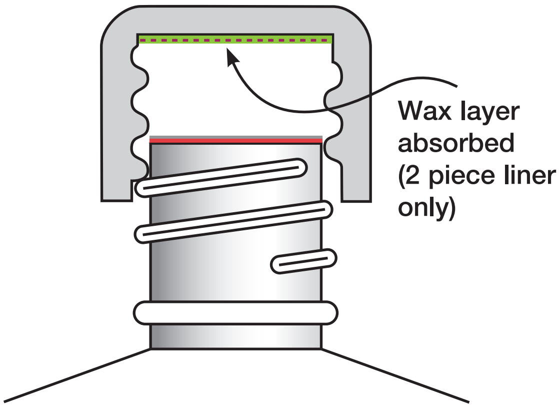


Figure 4e: Step 4 of the Induction Process

After the container has passed under the induction head, the heat-seal layer bonds to the land area during the cool down period. With two piece liners, the wax is absorbed by the pulp/board layer.

When the closure is removed after the cool down period, the liner remains bonded to the land area until removed. With a polyolefin laminated 2 piece liner, when the closure is removed the foil and secondary liner gives an audible 'crack' upon separation, providing an additional tamper evidence feature.

HEAT SINK

The container acts as a heat sink. This means that when you induction seal the liner with sufficient pressure to the land area, the container ABSORBS heat from the induction seal liner.

Insufficient liner pressure and/or uneven pressure on the land area will result in poor seals. If the liner is not held evenly around the entire circumference of the container, the area that is not firmly in contact will overheat. Due to the overheating of the liner, the land area could suffer excessive meltdown, which in turn causes more uneven pressure. For example, if the induction seal liner, by itself, has been passed through the induction coil, it could reach a temperature of 600°F/ 315°C or more thus causing the liner to melt or possibly burn. This heat sink phenomenon is also influenced by the fill level and fill temperature. Normally a higher power setting is required for a cold fill than a hot fill. The same is true if the container is full rather than empty. If you have overhang of the liner or tabs are folded down the side of the container, this may cause problems with induction sealing. The induction field does not react to aluminum foil that is in a vertical position when passing under the induction head. In some cases with the tabs folded down, the induction field gets deflected so the liner in that area sees less heat. Round corners on the tab tend to deflect the induction field less than square corners on tabs.

If you have a large portion of the liner folded over the edge of the container, this can have a cooling effect on the part of the liner that is on the land area and may produce weak seals or leakers.

There are many factors to take into account and the following chapters will help you to address them.

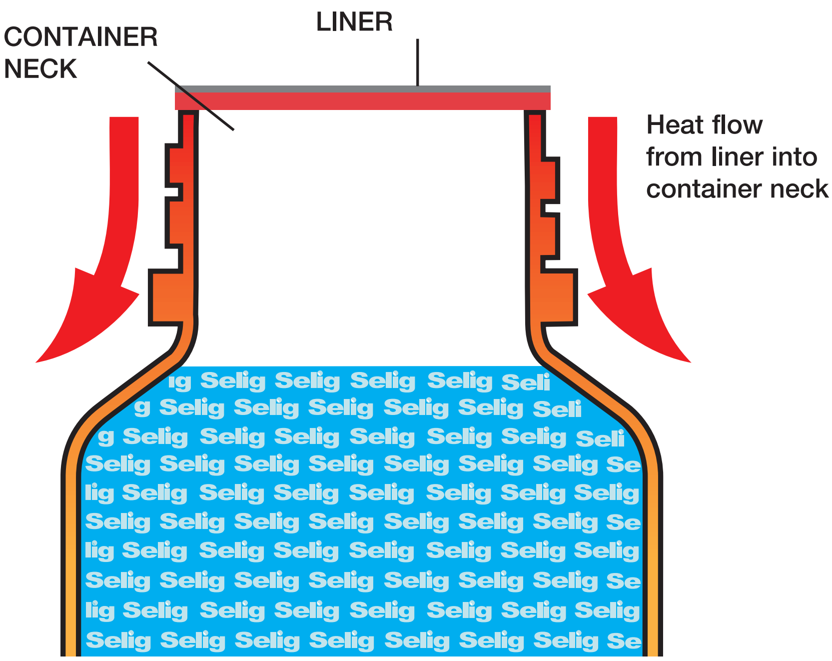


Figure 4f: Heating of the container during the induction process

NOTES

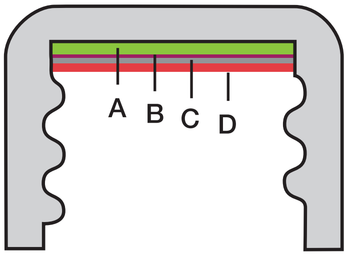
5 The Myths of Induction Sealing

UNRAVELING THE MYTHS AND MYSTERIES OF INDUCTION SEALING

- **High frequency**
- **Low frequency**
- **Ferrites**
- **Air cooled**
- **Water cooled**
- **Solid state**
- **Vacuum tubes**
- **Microwave**

Just what is induction sealing and what can it do for you?

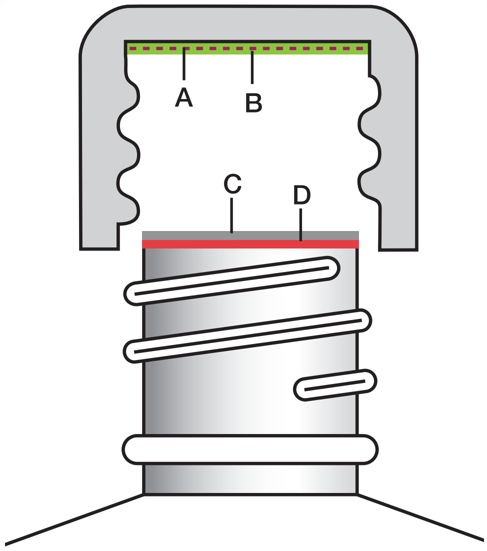
Induction sealing is a non-contact heating process that accomplishes the hermetic sealing of a container with a closure that includes a heat-sealable foil laminate.



A. PULPBOARD
B. WAX holding pulpboard to foil
C. FOIL
D. POLYMER

Figure 5a: ***Closure with foil innerseal (2 piece shown)***

This typical two piece induction innerseal begins as a multi-laminate liner inside a closure. It consists of a layer of pulpboard, a layer of wax, aluminum foil and a layer of polymer that is compatible with the bottle material and capable of heat sealing to the lip of the container *(Figure 5a)*. When the closure is placed onto the container and is passed through an electromagnetic field produced by the induction heater, several things occur. An electromagnetic current, called an eddy current, is induced into the foil portion, resulting in a resistance-type heating effect. The heated foil melts the wax layer, which is absorbed into the pulpboard, releasing the foil from the pulpboard, and the polymer coating melts, hermetically sealing the foil to the lip of the container. *(Figure 5b)*.



A. PULPBOARD
B. WAX absorbed into pulpboard releasing foil
C. FOIL
D. POLYMER sealing foil to container lip

Figure 5b: ***Closure and innerseal after sealing operation***

Notice the reference to the induction system as a heater and not a sealer. This clarifies the first misconception. Everyone who manufactures induction equipment for affixing a foil innerseal on a container refers to their generators as induction sealers. The truth of the matter is that they do not seal anything. The only function of the induction system is to heat the foil. You can heat foil as much as you want, but if it is not in intimate contact with the lip of the container, you will not achieve a seal. Occasionally, there will be calls from customers who say something is wrong with their induction sealer. They may go on to say 100 containers were run under the induction sealing head and only 97 of them sealed. In explanation if 97 containers were sealed, technically there is nothing wrong with the induction system and the problem could be elsewhere. Further examination usually uncovers the fact that there was insufficient torque on the three containers that did not seal. Either the foil was not in intimate contact with the lips of the containers, the lips of the containers were deformed or the caps were cocked. If a series of identical containers are put through an induction field and one of them seals, then all of them should seal. You must realize that when you are dealing with hundreds or thousands, if not millions, of containers and caps, you will experience an occasional bad lip, insufficient torque or cocked cap. When this occurs, poor sealing cannot be blamed on the induction equipment.

WHAT ABOUT FREQUENCIES?

The high-frequency/low-frequency confusion was initiated by the manufacturer of vacuum tube equipment.

The very first induction systems for heating foil were vacuum tube units, state-of-the-art at that time, which operated at approximately 450 kHz. As more modem devices were developed, many suppliers introduced solid-state generators that operated in the 26 to 100 kHz range. The makers of equipment who resisted change and continued to build vacuum tube systems began referring to the two systems as high-frequency and low-frequency, rather than vacuum tube and solid state, which would insinuate their equipment may be old fashioned and not state-of-the-art. There has been much written about the advantages of low-versus high-frequency induction equipment. It's almost a moot point at this time, since there are very few, if any, vacuum tube units manufactured now. The vacuum tube units are probably no longer supported by the original manufacturers, as critical components are no longer available. As the older vacuum tube systems fail and become high-maintenance items, they are being replaced with solid-state systems.

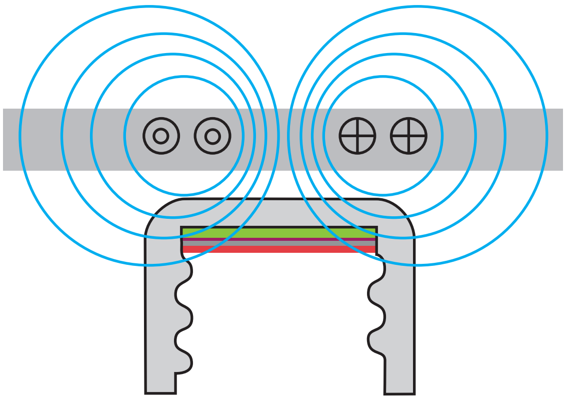


Figure 5c: ***Coil flux without ferrites***

Some manufacturers of induction heating systems tout their use of ferrites in the sealing head, as if this is something new and radically different. Ferrites are nothing more than dense homogeneous ceramic structures made by mixing iron oxide with other oxides or carbonates of one or more metals such as manganese, zinc, nickel or magnesium. They are pressed, then fired in a kiln at 2000°F / 1093°C and machined as needed. How and why are they used in induction sealing? If you examine the cross section of an induction sealing coil without ferrites *(Figure 5c)* the electromagnetic field radiates equally in all directions.

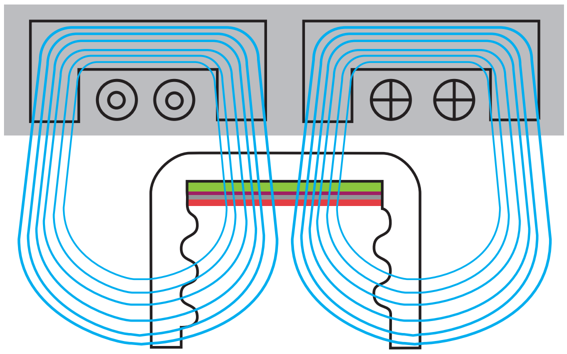


Figure 5d: ***Coil flux with ferrites***

By surrounding the coil with a ferrite material *(Figure 5d)*, the dense ferrites prevent the electromagnetic ferrite material field from radiating and actually concentrates and directs the field, making it more efficient.

Ferrites have been in use as flux concentrates for over twenty years and are certainly nothing new. Ferrites cannot be used with vacuum tube systems because the high frequency (450 kHz) causes excessive heat in the ferrites. This phenomena does not occur in the solid-state power systems which normally operate in the 26 to 100 kHz range.

Finally, let's look at the bottom line. The vast majority of induction sealing systems sold today use solid-state devices that operate at low frequency, below 100kHz. Some suppliers offer both air-cooled and water cooled power supplies. Major differences between suppliers do exist in terms of pre- and post-sale service and in some areas of warranty. The rules haven't changed. To be a smart buyer, read the proposals carefully, investigate the vendor's reputation for product quality and service and ask a lot of questions.

Understanding of your application and comparing efficiency of induction cap sealers. Does frequency matter?

Since its inception, the relationship between induction sealing and the frequency of power supply has been a subject of debate and misunderstanding. Many make claims about the relative efficiency of one type of power supply over another.

Initially, the only equipment available were 450 kHz vacuum tube devices. Later, solid state-power supplies were introduced, operating at a relatively low 26 to 100 kHz.

It must be understood that when a foil disc is intersected by electromagnetic lines of force *(Figure 5e)*, current is caused to flow in the aluminum disc. It is the friction caused by the current flow that causes the disc to heat up. These currents are known as eddy currents. At very high frequencies, such as those generated by vacuum tube power supplies, a phenomenon known as "skin effect" occurs.

The higher the frequency, the more the current tends to flow to the outside edge *(Figure 5f)*. In a foil disc, this can scorch the outside edge of the pulp disc (two piece products only). At the same time, any heat reaching the center of the disc must do so by conduction, that is, by thermal transfer through the aluminum foil. The conduction of heat through the aluminium foil is considerably slower than the direct induction of heat into a specific area. Therefore, by the time the conducted heat reaches the middle of the foil, the edges of the pulp disc are scorched or burned. This is particularly evident in closures larger than 38mm in diameter.

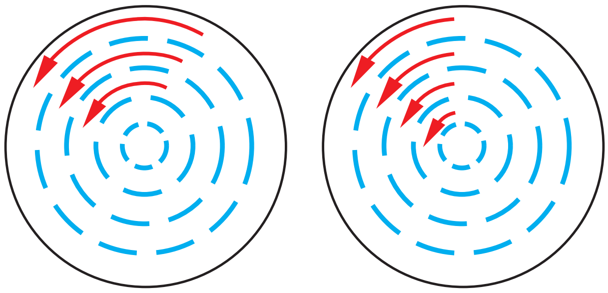
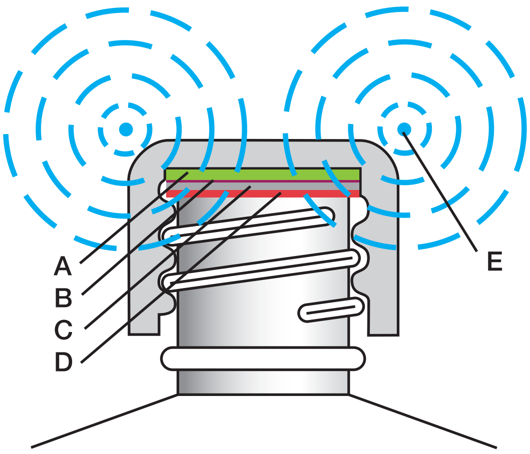


*Figure 5f: Left - **High frequency currents tend to flow to disc's outside edges, leaving center to be heated by conduction. Right - Low frequency can provide more even heat pattern***



A. PULPBOARD
B. WAX
C. FOIL
D. POLYMER COATING
E. COIL

*Figure 5e: **Expanding and collapsing lines of magnetic force induce current flow in the aluminium foil disc***

If the edge is heated just enough to achieve a seal, the center of the disc will not have been heated sufficiently to melt the wax holding the foil to the pulpboard. This results in a closure that is welded to the bottle, because the foil is sealed to the lip of the container, the innerseal is still wax-bonded to the pulpboard, and the pulpboard is glued into the closure. This causes the cap to be nearly impossible to remove. Solid-state devices operating at relatively lower frequencies (26 to 100 kHz, depending on the manufacturer), can provide a more even heat pattern, heating the entire disc by induction. Due to the absence of the skin effect, lower frequencies will allow deeper penetration. This results in more uniform wax melt, which separates the foil liner from the pulpboard and permits easy removal of the innerseal. The uniform application of heat to the foil disc and the control of magnetic flux density depends on the proper placement of ferromagnetic materials in the sealing head.

With the introduction of induction innerseals with retention or folded pull-tab features, the operating frequency of the power supply becomes even more critical. Because of the shape of the tabbed liner, the high-frequency eddy currents tend to be attracted to the edge of the liner. When the liner is inserted into the closure and the tabs are folded down or back, the high frequency tends to continue to follow the edge of the liner *(Figure 5g)*.

With high-frequency sealing currents, this can result in a weak seal under the retention tabs or folded super tab. In addition, early testing revealed that the folded super tab, when heated, may stick to either the inside of the closure or to the pulpboard liner.

Tests indicate that this phenomenon does not occur when using a lower frequency, solid-state generator and a sealing coil using ferrites to direct the induction field into the appropriate areas of the liner material, when used at the correct settings.

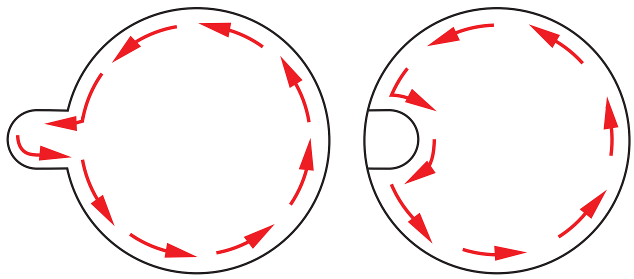


Figure 5g: ***Currents tend to follow the outside edge of a pull-tab (left), which can result in a weak seal where tab is folded back (right). Typical only for high frequency systems.***

MATCHING THE POWER SUPPLY

Coil design - the key to improving induction cap sealing efficiency

Common perception holds that an effective induction cap sealer is built from the power supply up. For more effective cap sealers, however, it is important to start elsewhere. The proper sizing of an induction sealer starts with a close examination of the application followed by the sizing of the sealing coil. Only then should a matching power supply be chosen.

Improper coil sizing or design can result in wasted power output, as well as poor seals. By contrast, with a properly sized sealing head, it is conceivable that the same power supply can be used to seal 110mm liners and 22mm liners. To understand the pivotal role played by sealing head coil design, a closer look at the dynamics of induction cap sealing is necessary.

Induction sealing, very simply, requires the creation of an electromagnetic, or flux, field near foil liners incorporated into caps. Once an electromagnetic field is established near the liner by the sealing-head coils, the heat produced in the foil melts a polymer coating that bonds the foil liner to the container mouth, forming a hermetic seal. The downward force on the liner appled by the torqued on cap ensures a bond between liner and container.

For the process to be effective, certain conditions relating to the sealing head coils must be met. Conductors have to be arranged to provide the proper induction coupling into the foil liner. For improved efficiency, dense ferrite material can be placed around the heating coils to direct the electromagnetic field into the foil liner.

The distance between the coils and the foil liner, which determines the coupling, also affects the performance of the sealing head. While the container need not touch the sealing head to produce an effective seal, it has to be close enough for the electromagnetic field to penetrate the foil liner. Conveyor speed is important to ensure that for an individual set up, the dwell time of the liner passing under the induction coil and in the magneticflux is constant, thus allowing a consistant amount of energy to be induced into each liner and achieving the same sealing condition. Some modern induction units can operate at varying conveyor speeds by using a line speed signal to match the required induction output power to the varying conveyor speed. On older induction units the number of containers/liners passing under an induction coil at any one time could influence the effectiveness of the induction unit. However on most modern induction units this is no longer an issue.

Finally, cap style and liner diameter must be closely considered when determining proper sealing head coil design. For example, child-resistant caps, pull tabs, hinged tops, squeeze spouts of geometric tops are thicker and the liner may not be near the surface of the cap. Special sealing heads or coil designs may be required to produce a stronger electromagnetic field, or to direct the electromagnetic field to the position of the liner.

Induction sealing heads come in many sizes and shapes with coils arranged to fit most applications. But typically there are three types of sealing heads: designed for **conveyor**, **hand held units** and **direct application**.

Conveyor systems are most common in high volume applications. The typical conveyor system has either a flat or tunnel sealing head coil mounted above the conveyor with the product traveling beneath at a determined line speed. Tunnel coils are capable of sealing mouths up to 69mm in diameter. Flat coils can be used for sealing smaller mouths diameters but are typically used for 50mm and above. Some flat coils are designed to be angled across the conveyor. Typically this allows such coils to be used with a wider range of diameters than is possible with a standard flat coil. This 'universal' design is particularly useful where a filling line is used to fill several different diameters.

Tunnel coils solve the problems associated with child-proof, flip top, or other unique shaped caps. Their special design directs the electromagnetic field into the foil liner, resulting in an effective seal without having to boost power (Figure 5h).

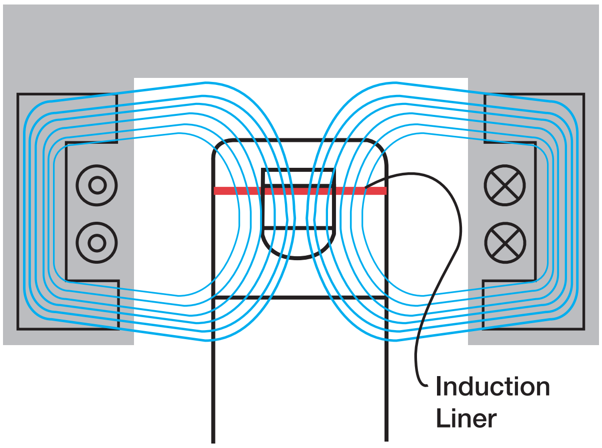


Figure 5h: Tunnel Coils overcome induction sealing problems associated with childproof, flip top or other unique caps.

Large liner diameters may also require a unique sealing head design or increased power supply rating. Large diameter two piece wax laminated foil liners with a pulp-board backing requiring wax to melt present a special problem. If wax is not completely melted, separating the foil liner from pulpboard, the cap is almost impossible to remove.

Line speed, or dwell time, may have to be adjusted to accommodate a larger liner. These adjustments are even more critical if a two piece liner requires a wax melt. The increased dwell time in the electromagnetic field helps to ensure complete wax melt. However, more exposure in the electromagnetic field is not always the answer. Prolonged time under the sealing head can result in a scorched container liner.

As a result of these induction cap sealing dynamics, power supplies need to closely match the application. Current solid-state switching devices allow engineers to custom-design electronic generators that can supply the high-frequency currents required for induction cap sealing.

Usually power levels of 1 to 3 kilowatts are adequate, depending on the seal and line speed desired. However, attention must still be paid to the frequency for the power supply. Scorching is more evident with higher frequencies, as high frequencies cause more current flow and heat generation towards the outer edge of the foil liner.

Any heat reaching the center of the liner must do so by conduction. If the wax has not melted and been fully absorbed into the board or paper layer the pulp board and the foil may not separate on removal of the closure. In such a situation, a more effective sealing head coil or power supply with lower frequency should be considered and/or the dwell time increased.

Direct application is a process for capless sealing where the induction coil applies pressure directly to the liner positioned in place over the container aperture. The coil is then energized for a set period of time. The pressure applied by the coil is maintained for a further period of time whilst the seal bond sets/hardens. The sealed container is then capped or left capless depending on the requirement of the application.

Hand-held sealing heads allow operators to manually place the sealing head over each container's cap. Operators energize the sealing head from a momentary switch electrically tied to a timer, which starts sealing the application and stops the generator at the end of the required heat cycle. Manual operation limits the usefulness of hand-held cap sealers to-low volume applications, or testing of prototype development under laboratory conditions.

Hand-held sealing heads can also be designed to accommodate caps to unique size or shape. But it is imperative to determine where the foil liner sits in the cap so a sealing head can be designed to match the application. When parameters are consistent, reliable results can be obtained.

Hand-held sealing heads are offered in various sizes to match any sealing application. Operators energize the sealing head from a switch electrically tied to the generator.

For more effective cap sealer sizing, packagers should ensure that their vendor reviews the application, determines output demands, sizes the sealing head and then calculates the power supply requirements.

6 Fault Finding - Troubleshooting

COMMON INDUCTION PROBLEMS & SOLUTIONS

Troubleshooting: Common Problems & Solutions

The most common result of improper induction sealing is leaking from the container seal area. These leaks are usually the result of improper setting of the Pressure, Heat, or Time (PHT™) variables. Other problems that can sometimes result from improper induction sealing are excessive removal torques or high peel force, low removal torque/loose closure or low peel force, visual defects (corroded foil, scorched backing of the liner), or the liner 'back' bonding to the closure. In the following section we'll address these issues, their root causes, and solutions. This section does not replace the responsibility of checking all packaging components (container, closure, etc...) and equipment (capping, filling, induction, conveyance, etc...) against their specifications and operating procedures. This includes checking compatibility of components when there is a supplier, material or design change for any of the sealing components (bottle, liner, closure). It will be assumed that those basic checks have been completed.

Category	Observation	Root	Solution
Seal	Containers leaking or leaking upon slight pressure	Not enough heat applied to the seal area	Increase power setting (H) Increase time in induction field (T) (slower conveyor speed) Decrease air gap
	Containers leaking or leaking upon slight pressure	Too much heat applied to seal area - land area of bottle or closure melted down.	Decrease power (H) Increase conveyor speed (T)
	Containers leaking or leaking upon slight pressure	Liner and container not in intimate contact	Increase application torque (P) Make sure closure skirt not bottoming out on container neck (H dimension) Confirm cap not stripping and jumping threads and relieving contact pressure
	Containers leaking or leaking upon slight pressure	Uneven pressure on liner - surface defects	Repair closure and/or bottle mold land area to provide flat area (eliminate flash, mismatch, sink marks)
	Containers leaking or leaking upon slight pressure	Induction heating not consistent around seal area	Position induction head so it is aligned properly with the center of the bottle finish/seal area. Check conveyor rail guides to make sure not too wide allowing movement of bottle from side to side
	Containers leaking or leaking upon slight pressure	Land area of bottle too thin or not flat	Increase bottle wall thickness and make flat to accept more surface area to seal

Category	Observation	Root	Solution
Seal	Containers leaking or leaking upon slight pressure	Uneven pressure on liner - distortion of closure/container	Lower application torque if distorting cap or bottle (P) Provide full 360° thread contact (<360° may result in uneven pressure) Confirm closure and bottle finishes are round, not ovalized
	Inconsistent sealing	Capping heads have inconsistent static torques	Adjust all capping heads to same static torques (P)
	Inconsistent sealing	Inconsistent line speed (not enough heat)	Fixed conveyor speed through the induction unit (T)
	Inconsistent sealing	Inconsistent fill height (head space vs flood fill)	Control fill height to avoid container contents acting as heat sink with varying fill heights
	Inconsistent sealing	Land area contamination	Control container fill to avoid seal area contamination - use blowers or mechanical means to clean finish
	Inconsistent sealing	Liner not centered on bottle finish	Prohibit container from being squeezed or agressively handled before, during and after induction process to ensure intimate and static contact of liner to bottle
	Inconsistent sealing	Cocked caps	Adjust capper, cap pick off, etc…to assure square application of closure to container
	Inconsistent sealing	EVOH barrier on land area of bottle	Eliminate EVOH from the land area of the bottle.
	Inconsistent sealing	Seal interrupted during cooling	Prohibit aggressive handling of or impact to the package during the bond cooling process, post induction heating.
Peel Force/ Removal Torque	'Peelable liner' hard to remove and/or excessive cap removal torque	Too much heat and/or pressure applied to seal area - land area of bottle or closure melted down.	Lower application torque (P) and/or lower power setting (H) and/or increase conveyor speed (T).

Category	Observation	Root	Solution
Peel Force/ Removal Torque	'Liner too easy to remove, and/or removal torque too low	Not enough heat applied to the seal area. Liner and container not in intimate contact Inconsistent fill height (head space vs flood fill) EVOH barrier on land area of bottle	Increase power setting (H), increase application torque (P) and/or decrease conveyor speed (T) If 'H' dimension prevents contact, revise closure/bottle design. Set fill level; don't vary Eliminate EVOH exposure
	Inconsistent peel force or removal torque	Uneven pressure on liner - surface defects Induction heating not consistent around seal area Uneven pressure on liner - distortion of closure/container Land area contamination EVOH barrier on land area of bottle	Repair molds to provide flat contact area Center the closure under induction head Lower pressure (P) to point where container and closure not deformed Clean land area of EVOH or product contamination
Visual Defects	Scorched/burned liner	Power setting too high, or time under induction head too long	Lower power setting (H), or increase conveyor speed (T)
	Delaminated liner	Power setting too high, or time under induction head too long	Lower power setting (H), or increase conveyor speed (T)
	Wrinkled liner	Non-flat land area of container or closure	Check for high spots on bottle land area and closure flat area - repair mold or resolve by process
	Liner adhered to the closure or container side walls	Back bonding due to too much heat or pressure causing heat seal material to flow to closure or bottle side wall	Decrease application torque (P) Reduce power setting (H) Increase conveyor speed (T)

Induction Considerations

1. INDUCTION SEALING HEAD SET-UP & CLEARANCE

   Closure must be centered in the induction tunnel. If there is a center line, then center of the closure must follow it. The induction sealing head must be parallel to the top of the closure and conveyor in all directions. Some sealing heads have been developed to be positioned diagonally to the conveyor and the products, it is also important to ensure that this style of induction equipment is set equally at the correct position.

   Always securely fasten the induction equipment to the floor so that the sealing head cannot be bumped or even vibrate out of alignment.

   The gap between the top of the closure and induction head must be uniform and not vary after set-up. Typically a 1/8" (3mm) clearance is ideal, on a simple flat cap under a flat coil, although it may be necessary to vary the clearance to suit a particular application. With sports or flip top closures running in tunnel coils, the clearance is dependent on the internal design of the coil. On hot fill containers sometimes the overall package height changes and then you need to use a wider gap 3/16".

   By having the induction head securely fastened to the floor, you must still check the alignment of the induction head. It's a good practice that when you check on-torque, seal integrity, you should also check the induction head alignment.

2. LINE SPEED

   Check conveyor speed when line is empty of product and full of product. Once line is set-up and checked, do not change conveyor speed. If line speed slows down or speeds up, then power on the induction equipment must also change. Whilst some machines offer proportional control (where a change in line speed automatically changes the sealer's output power), the most consistent results will be obtained at a fixed speed.

3. CONTAINER QUALITY

   Land area must be flat and smooth. Ridges or saddles on the land area will contribute to weak seals and leakers. The liner will have hot spots because of inconsistent pressure.

   To help ensure proper seals, the land area should be a minimum of 1mm wide. The neck area and the land area must not be flame treated or chemically treated in any way, since the induction liner does not seal properly to the treated areas, giving weak to no seal at all. The height of the container neck should be consistently at the correct height to prevent the closure from fouling with the shoulder and thus restricting the amount of pressure applied to the liner by the closure.

4. CLOSURE QUALITY

   Closure should have 360° or more of thread engagement between the closure and container when tightened to give uniform pressure on the liner and land area. Closure threads to be compatible with threads on the container; both having the same pitch. The closure I.D. should be properly sized to fit the container.

   On hot fill applications, the neck of the container will expand and the closure must be sized properly to tighten fully and not give false on-torque readings.

   The design of the closure must be able to handle the on-torque application and not strip when properly tightened. When a closure is screwed onto a container, the design of the closure should be that the liner is completely flat. There should also be a space within the closure to allow for a minimum of 0.5mm overhang of the liner around the container neck that should remain flat/horizontal when fully tightened. If the liner is forced to crimp down by the closure, wrinkles in the liner can form which may lead to leakers.

5. PRODUCT

   The contents in the container should not touch the liner at the time of induction sealing. When the contents are touching the liner, it acts as a heat sink and cools the liner causing weak to no seals, liner may not seal to the contaminated land area.

6. CAPPING & ON TORQUE APPLICATION (AN APPROXIMATE GUIDE)

   Use one-half the diameter in (mm) of the closure for In-lbs of on-torque. Eg. 33mm = 13 to 20 In-lbs. on-torque. Off-torque before induction sealing will be lower (9 to 15 In-lbs. typical).

   Normally after induction sealing the off-torques are much lower (6 to 14 In-lbs. typical).

The closure is the main tool for applying uniform pressure on the liner to achieve the proper seal. This is why it is so important to have the proper on-torque, remember P.H.T. (Pressure, Heat, Time).

7. INDUCTION LINER

   Make sure the liner material is the correct type for your chosen container material, and the liner is suitable for the intended application and has the correct barrier properties for the contents to be sealed. The liner should be punched to the O.D. to accommodate the closure and container. The liner should be centered in the closure, and free of wrinkles and impurities.

8. CONFIRMATION OF SEAL

   At the start of each shift all containers should be checked for proper on-torques.

   Depending on line speeds and the type of package, check on-torque every two hours or less. The seal integrity should also be checked at the same time as on-torque.

LINER SELECTION CONSIDERATIONS

Well before any induction sealing trials, these questions need to be considered.

Check List

Will the container be hot or cold filled?

Will the 'H' dimension of the container and closure be sufficient to handle the thickness of the induction seal liner?

Do you want or need a peelable liner?
Does the application call for an easy open liner, such as a Lift 'n' Peel™?

Do you need a secondary liner?

What material is the closure?

What material is the container?

What product is the container filled with?

What conveyor speed is the line operating at to determine the time needed for sealing?

True Weld vs. Peelable Liners

An induction seal liner that gives a 'true weld' seal to the container has the sealing surface made of a material that is compatible with the land area of the container. This gives a very strong seal. True weld means that when the liner is broken, the foil structure cannot be completely cleared from the land area. Peelable means that the liner will peel cleanly from the land area of the container. It is important that it does not leave any film deposits or foil on the land area. You should never expect a peelable liner to seal as aggressively to the land area as a true weld liner. The reason is the heat sealable layer on the peelable liner is made with a modified resin that is not especially compatible with the material on the land area of the container. When induction sealed, this liner does NOT seal as aggressively to the land area as the true weld. Yet, this peelable liner will still give you a strong seal and still be clean peelable.

Seal to Glass

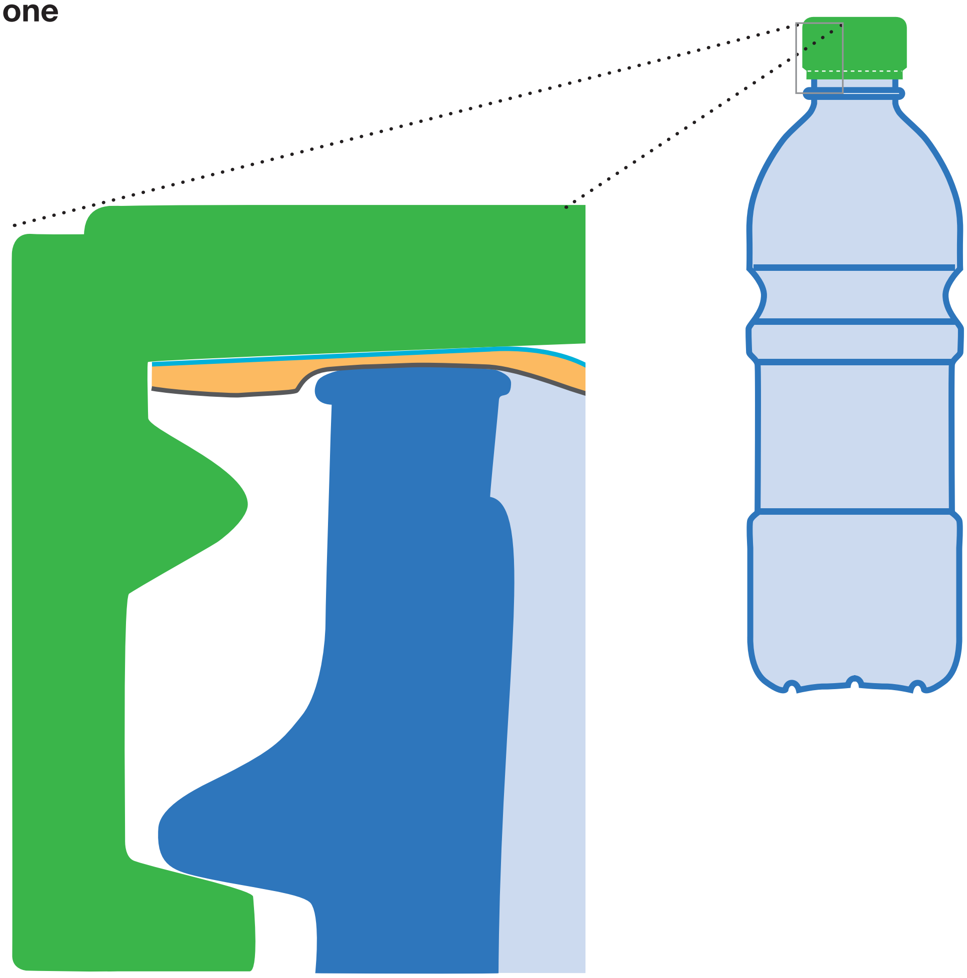
Sealing a membrane to a glass container by the induction method provides at the very best, a peelable seal. Unlike sealing to plastic containers, the glass does not melt on the land area under the induction system. Other characteristics must be understood and taken into account. The glass is colder and in most cases has a greater mass than plastic. This creates "heat sink" therefore, dwell time or power should be increased to allow the foil to maintain the temperature for a longer period of time. Torque of the closure to the container should be set and maintained so as to obtain the very best of contact between the seal and the land area. Aqueous based products are difficult to seal. Dry or viscous products normally do not present any difficulty with seal to glass applications. In any event, we advise all fillers to carry out their own tests. There are various surface treatments of glass available on the market. These can have a significant impact in achieving a good seal to glass.

Take note of each step and when a satisfactory seal has been established, be sure that all set conditions are maintained for future fills pertaining to that container, that closure and that content.

7 Fault Finding - Troubleshooting Examples

GOOD EXAMPLE OF SEALING

Problem: None



Positive Observations

- Good pressure on liner
- Good thread contact
- Liner fits evenly in closure
- Meltdown on land area
- Liner is compressed
- Good seal

Negative Observations

- None

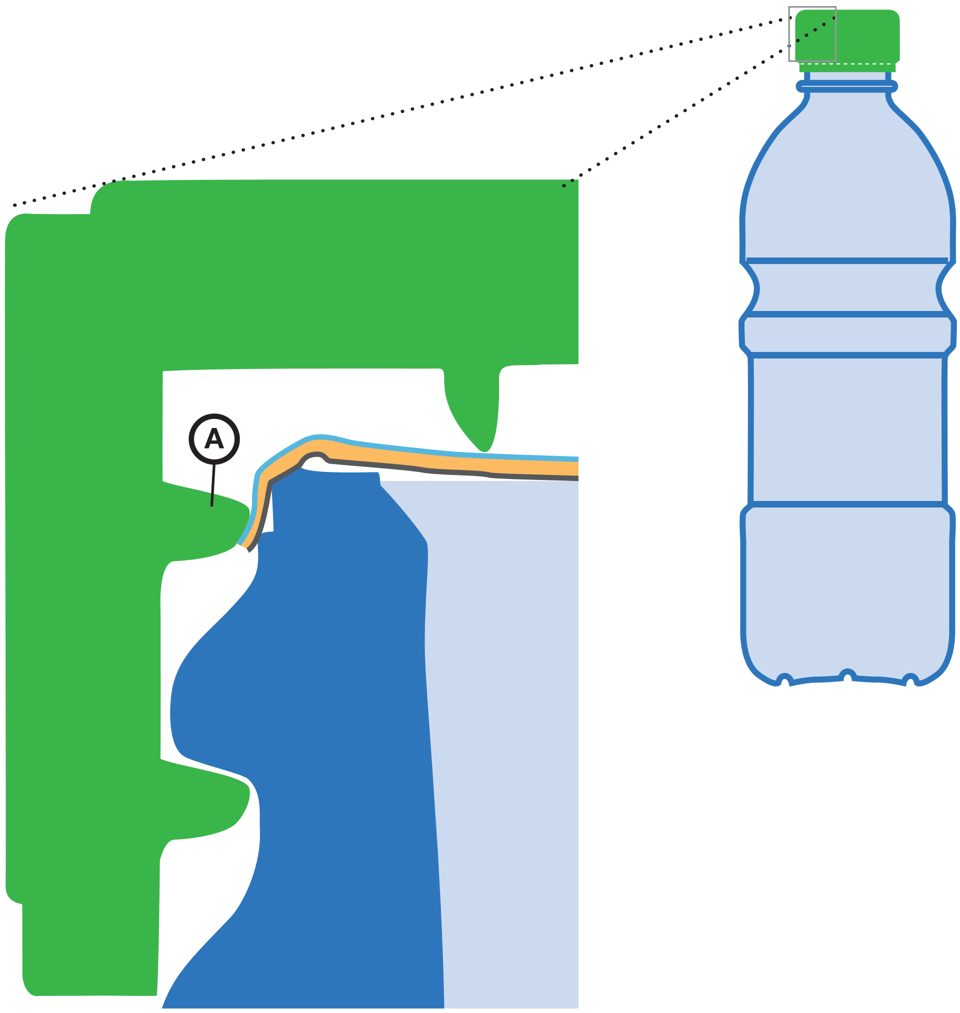
Solutions/Recommendations

- None needed, quality seal

FAULT FINDING - TROUBLE SHOOTING

Problems

- **Leaker**



Positive Observations

- None

Negative Observations

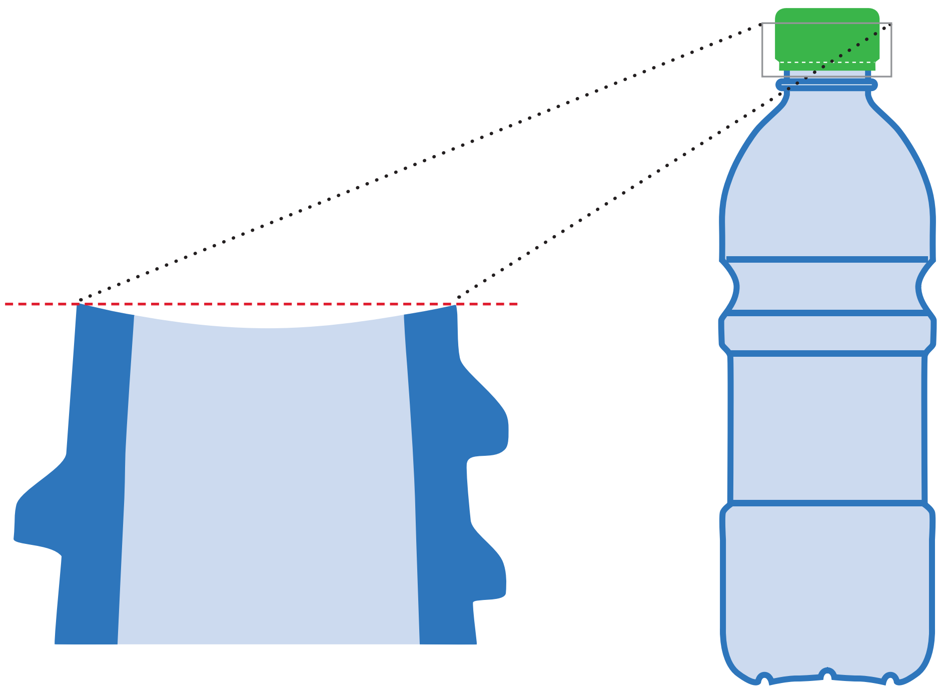
- Closure designed with plug seal

Solutions/Recommendations

- Redesign closure without plug seal

Problems

- **Leaker**



Positive Observations

- None

Negative Observations

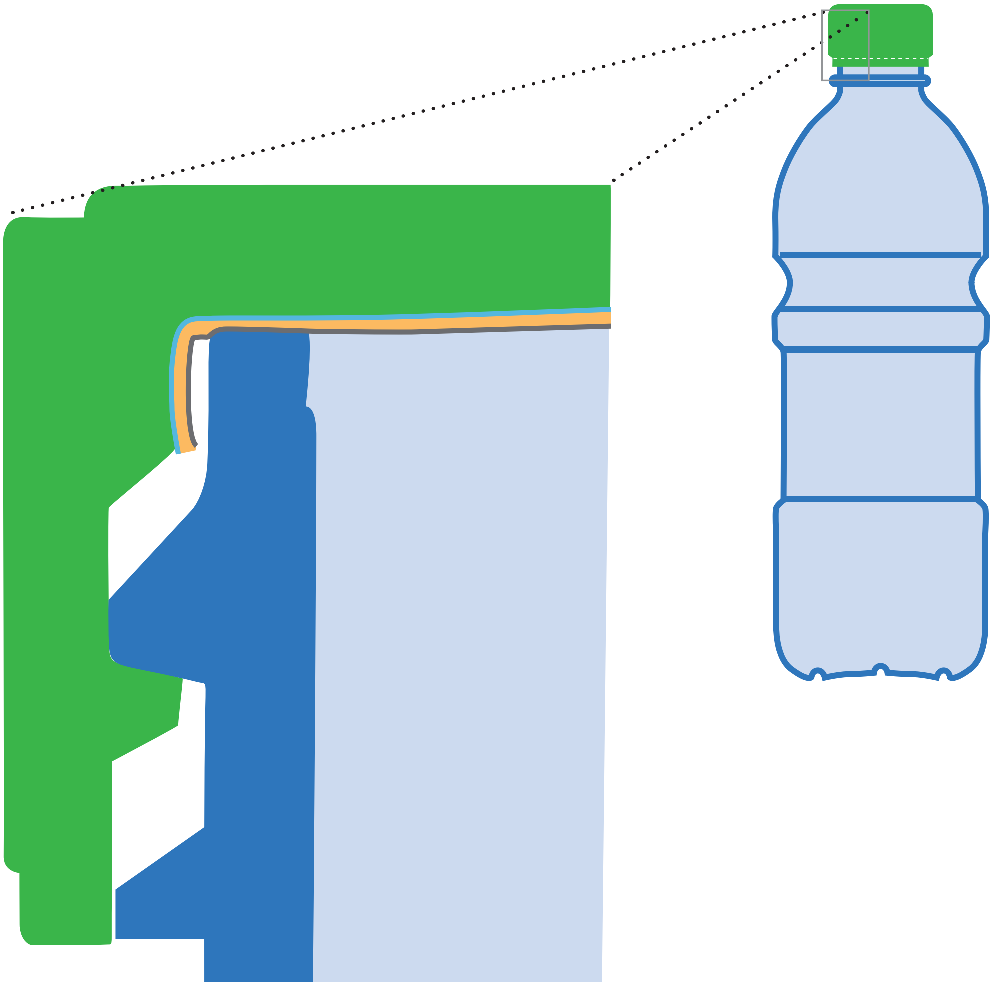
- Uneven land area
- Land area has saddle which creates high and low spots
- Possible uneven wear in molds
- Incorrect spin trimming of neck
- Uneven pressure on liner
- Overheating of induction seal at high spots
- Excessive meltdown of land area at high spots

Solutions/Recommendations

- Ensure land area is flat by trimming or grinding
- Refurbish molds

Problems

- **Restricted liner**



Positive Observations

- Sealed
- Good pressure
- Wide land area
- Good thread contact

Negative Observations

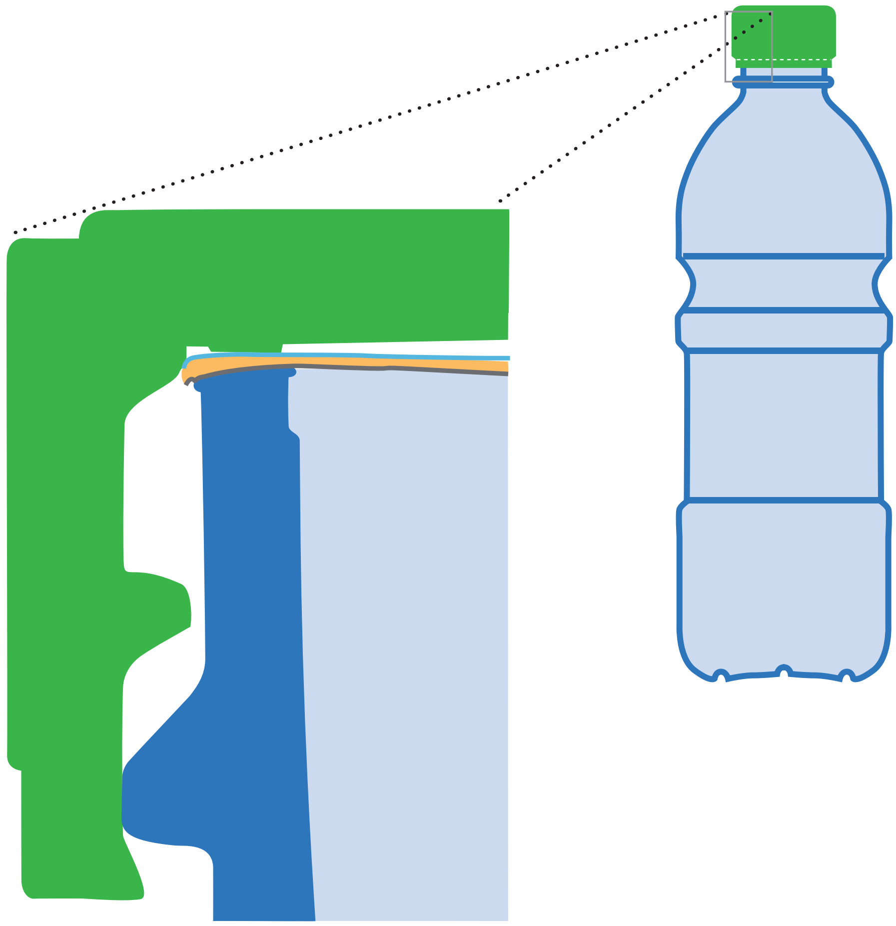
- Overhang of liner is restricted, or liner diameter too large
- Closure was not designed for overized liner
- Wrinkles on land area from restriction can cause leakers
- Liner overhang can bond to container side wall

Solutions/Recommendations

- Redesign closure for proper retention of liner
- Reduce diameter of liner

Problems

- **Weak seal**



Positive Observations

- None

Negative Observations

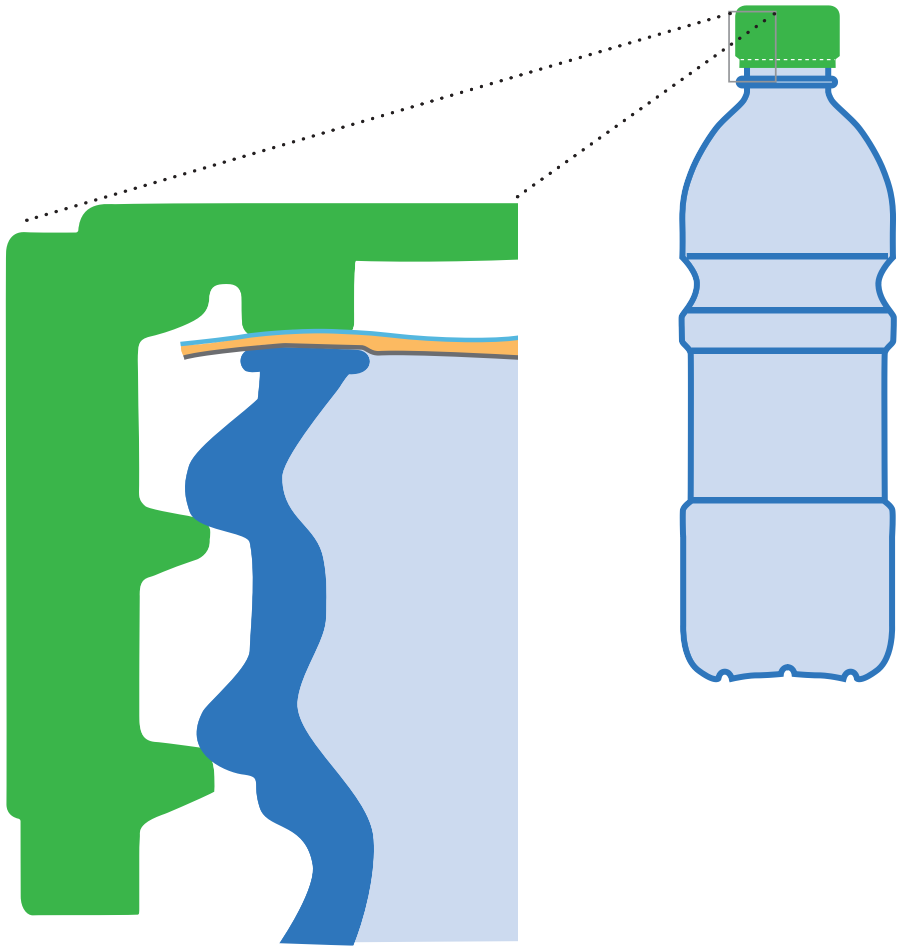
- Closure threads do not match containers' thread
- Uneven pressure on liner resulting in uneven seal strength
- Cannot achieve proper on-torque
- Insufficient thread engagement
- LIner retention in closure very weak

Solutions/Recommendations

- Design closure threads to match container threads
- Design a closure with cavity or retaining ring for the overhang of liner to fit under

Problems

- **Poor match between container and closure**



Positive Observations

- Good pressure on liner from closure
- Pressure bead is directly on land area
- Melt down on land area
- Strong seal but is not a leaker

Negative Observations

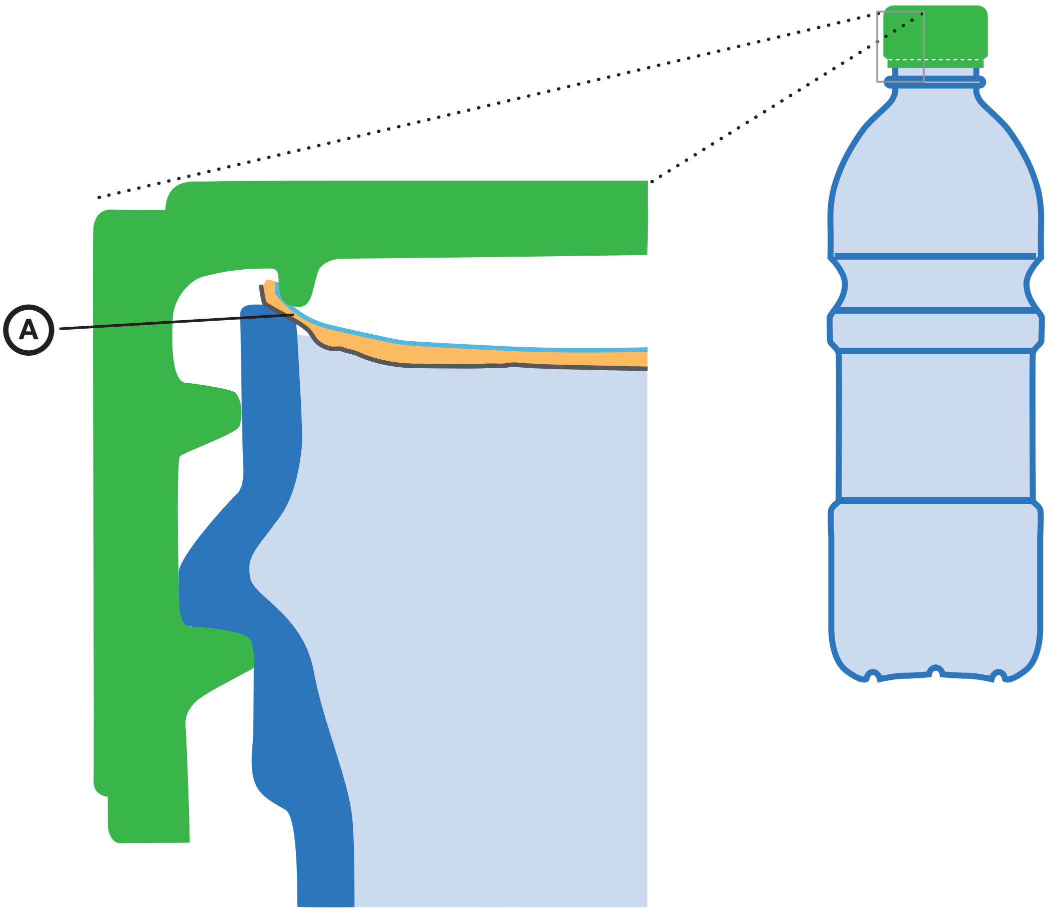
- Closure is larger than container
- Threads will strip when closure is torqued on causing weak pressure on liner
- Side walls of container distorted when closure is sealed with proper on-torque

Solutions/Recommendations

- A redesigned closure or bottle will provide more consistent results

Problems

- **Weak seals**



Positive Observations

- Good thread contact

Negative Observations

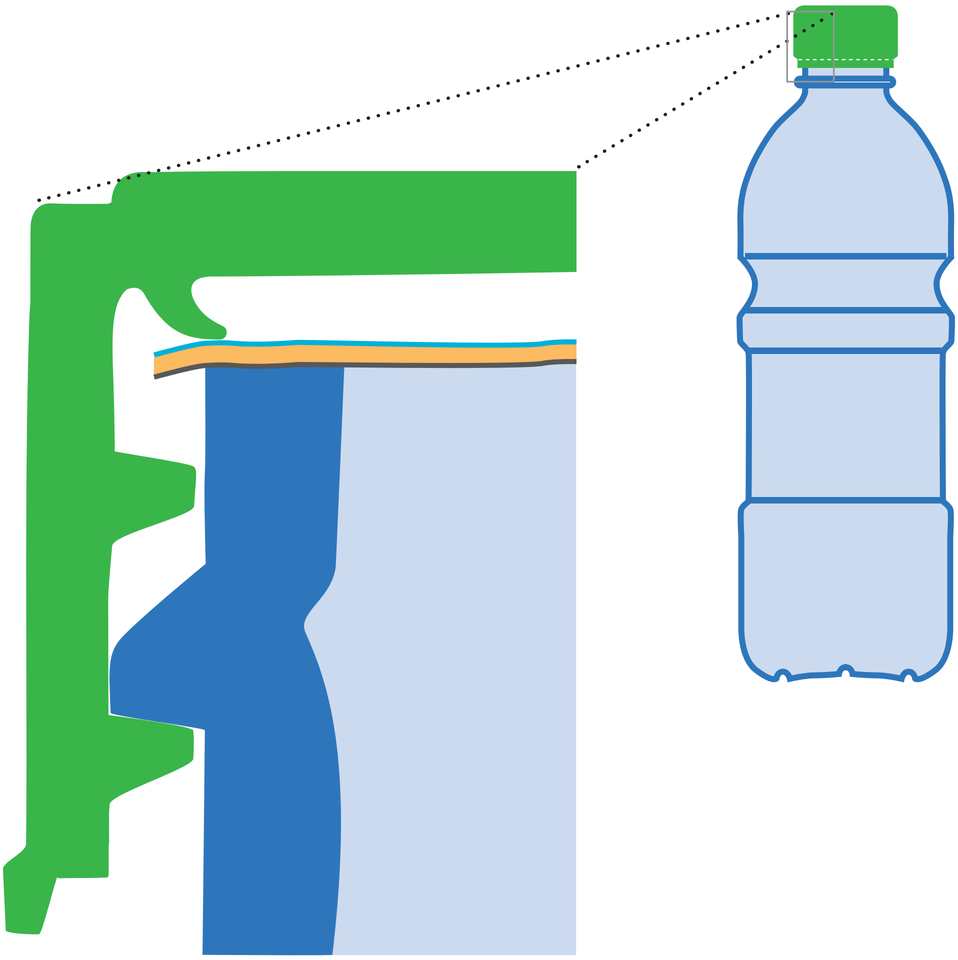
- Pressure bead of closure does not line up with land area of container **(A)**
- Closure was not designed to properly fit container or container is out of specification
- Narrow land area

Solutions/Recommendations

- Redesign closure or bottle for proper match

Problems

- **Weak seals**



Positive Observations

- Excellent thread engagement and match
- Closure designed with a “crab claw” to apply pressure

Negative Observations

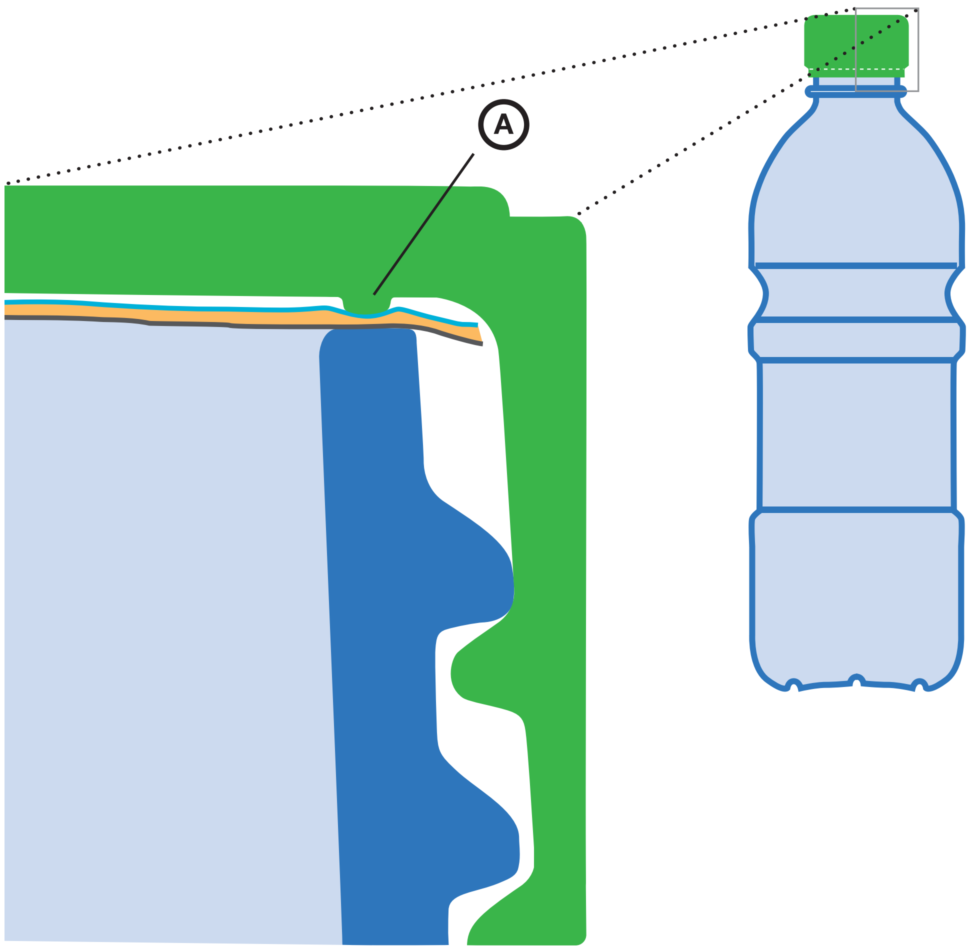
- Small contact area of ‘crab claw’ may melt and put less pressure on land area thus creating a leaker.

Solutions/Recommendations

- Design pressure bead or crab claw to give a more uniform, wide and consistent pressure area.
- Move ‘crab claw’ so that it sits centrally over the land area when fully on-torqued.

Problems

- Closure and container have different style threads



Positive Observations

- Very little melt down of pressure bead **(A)**
- Pressure bead is nicely centered on land area
- Good contact area and pressure

Negative Observations

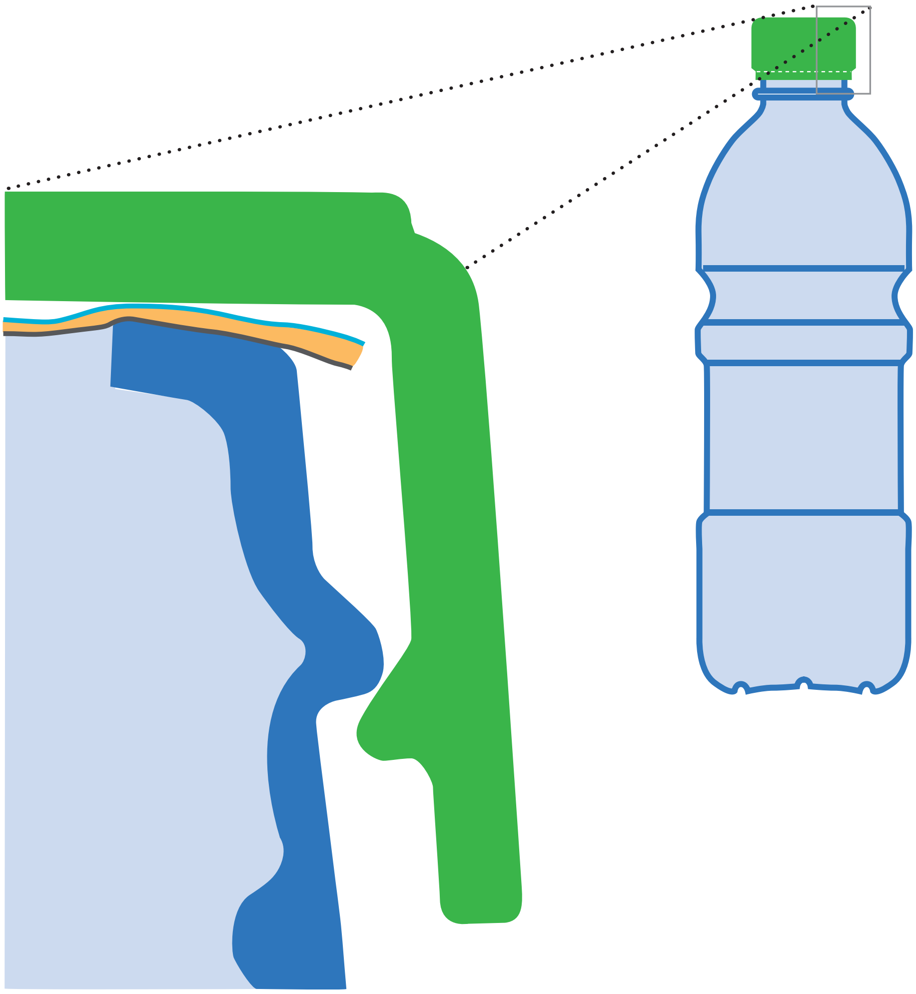
- Poor engagement of threads
- Thread design could encourage stripping and contribute to uneven pressure

Solutions/Recommendations

- Ensure thread design of both container and closure are compatible

Problems

- **Side wall of closure and container are distorted**



Positive Observations

- None

Negative Observations

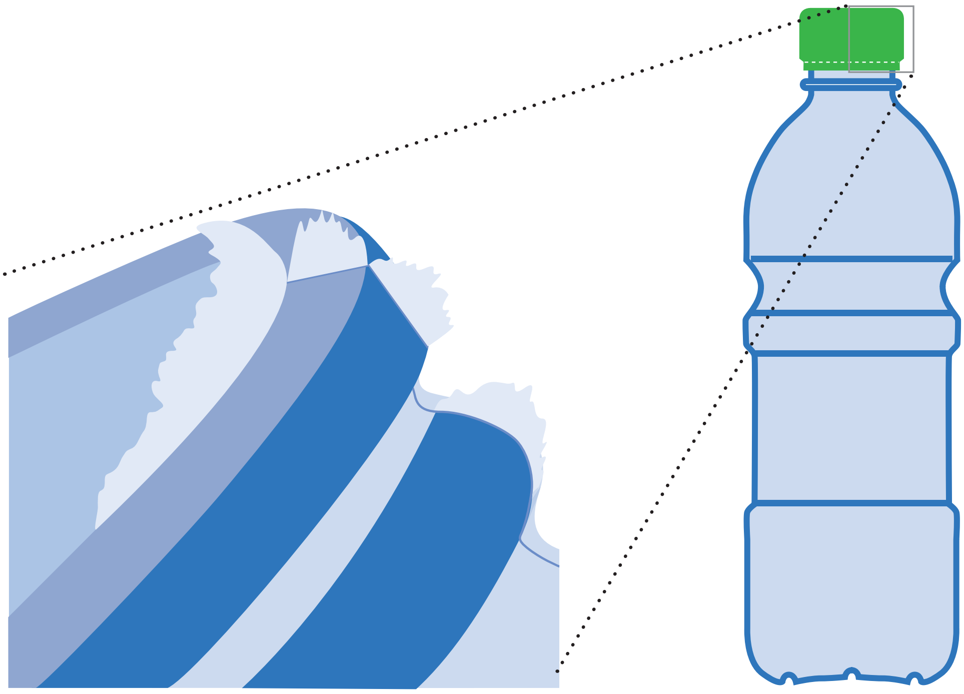
- Uneven pressure on land area
- Threads stripping
- Land area is at an angle
- Side wall of container neck is thin and weak

Solutions/Recommendations

- Ensure the shape and pitch of the threads are properly matched between the closure and the container
- Design closure and bottle to prevent distortion when closure properly torqued on by increasing wall thickness and/or using a stronger type of resin
- Check container molds to ensure wall thickness of the containers are uniform

Problems

- **Weak seals**
- **Leakers**
- **Ripped liners**



Positive Observations

- None

Negative Observations

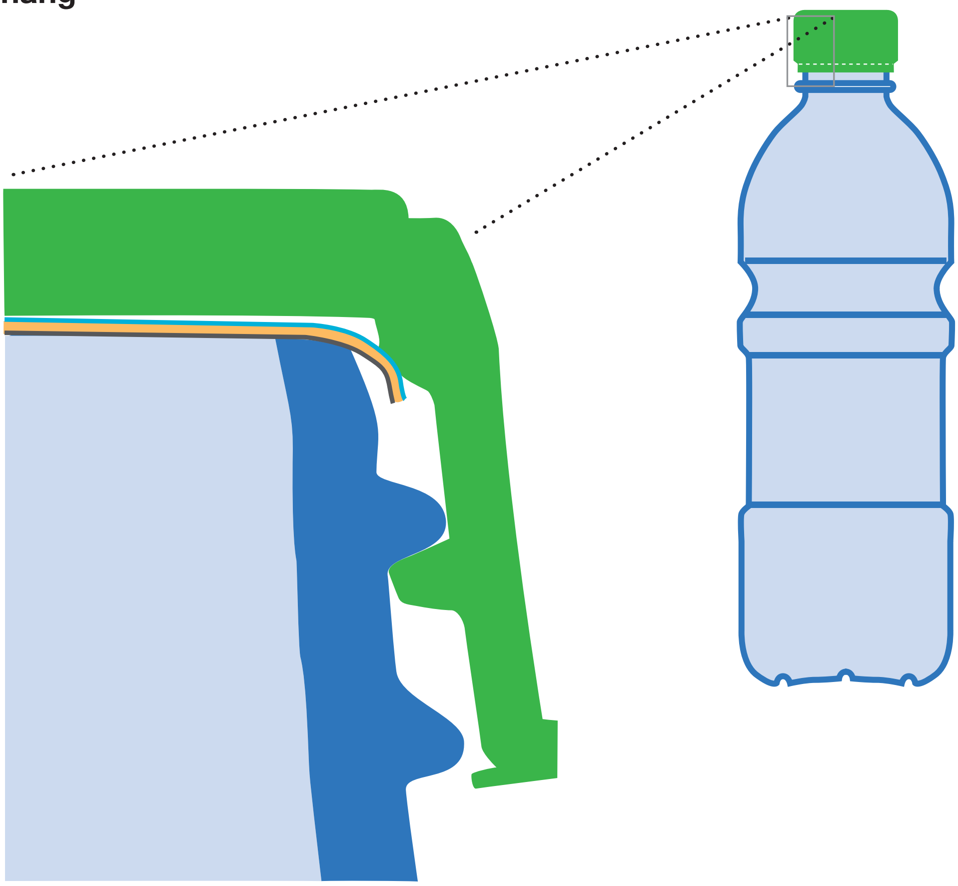
- Poor finish of land area - flashing or thread mold mismatch
- Uneven pressure - thread mismatch

Solutions/Recommendations

- Ensure land area is flat by trimming or grinding
- Refurbish molds and thread splits
- Clean and check molds for excessive material build-up

Problems

- **Too low on-torque**
- **Liner overhang**



Positive Observations

- Good thread engagement

Negative Observations

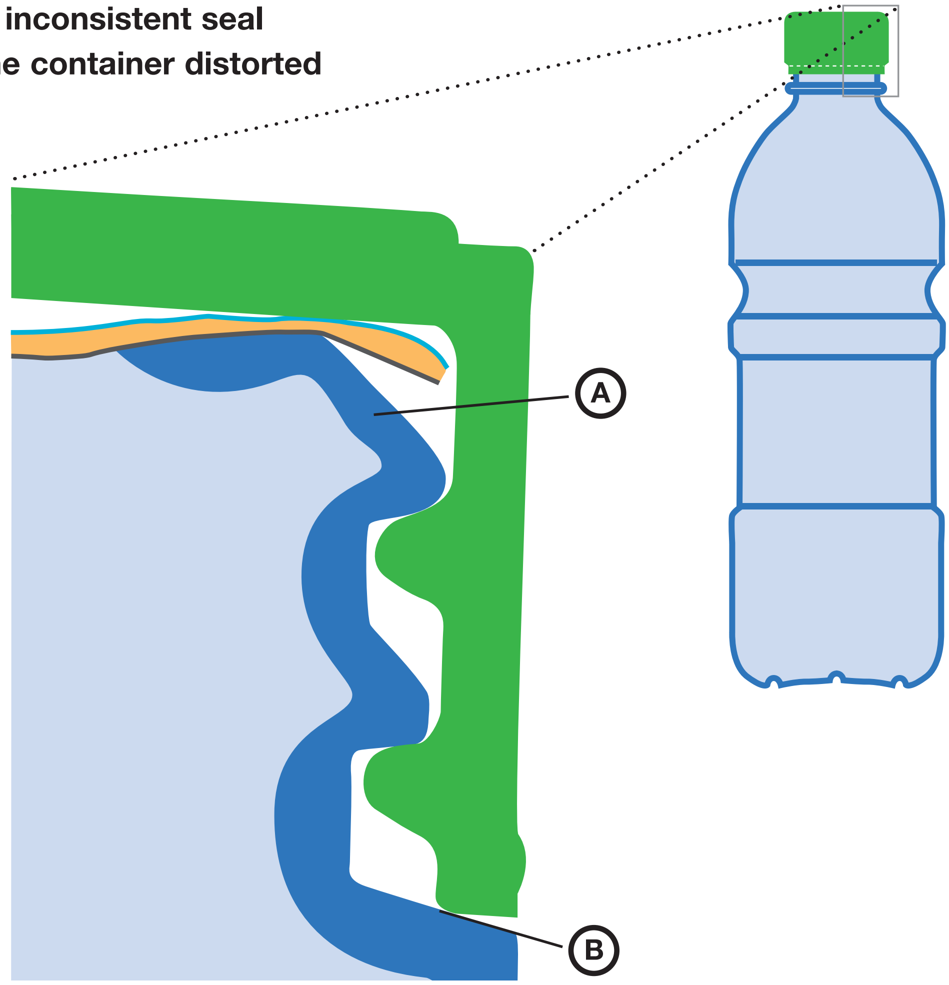
- Thread start of closure forces overhang of liner down the side of the container
- Overhang of liner is being wedged between threads of closure and container
- Closure is not designed to have a cavity or retaining ring for the overhang of liner to fit under
- Uneven pressure on liner due to low on-torques

Solutions/Recommendations

- Redesign closure to allow overhang of liner to fit into
- Higher on-torques

Problems

- **Too high on-torque**
- **Weak and inconsistent seal**
- **Neck of the container distorted**



Positive Observations

- Good thread engagement between closure and container

Negative Observations

- The neck of the container is being distorted due to high on-torques. This applies too much pressure for the container to withstand, causing the neck and land area to deform) **(A)**
- Uneven pressure on land area
- Land area not flat, possibly due to neck finish distorting or too much on-torque
- Bottom of closure touches shoulder of container **(B)**

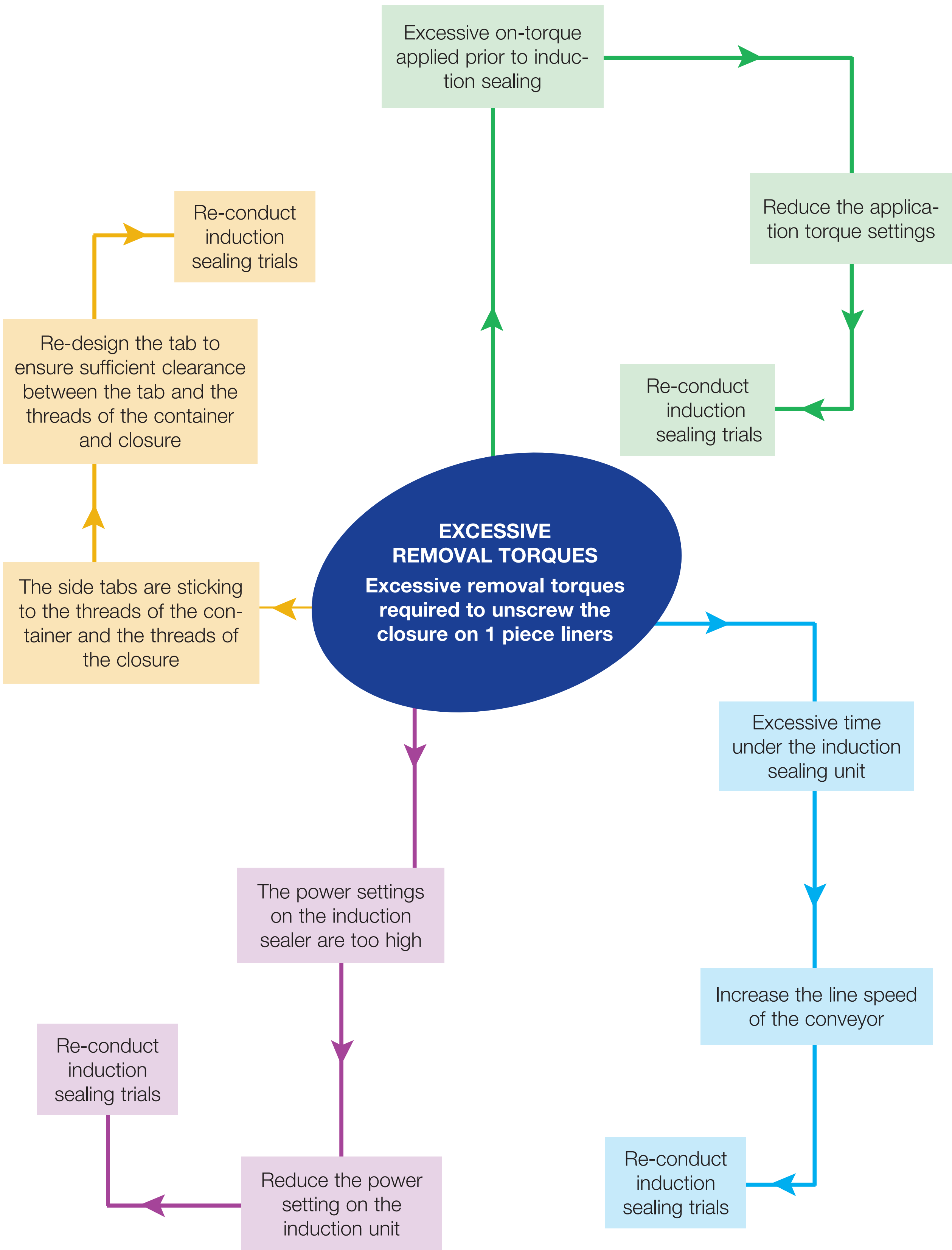
Solutions/Recommendations

- Lower on-torque
- Strengthen neck finish of the containers
- Possibly change the “H” dimension of the container to allow the closure to tighten properly without bottoming out

8 Fault Diagnosis

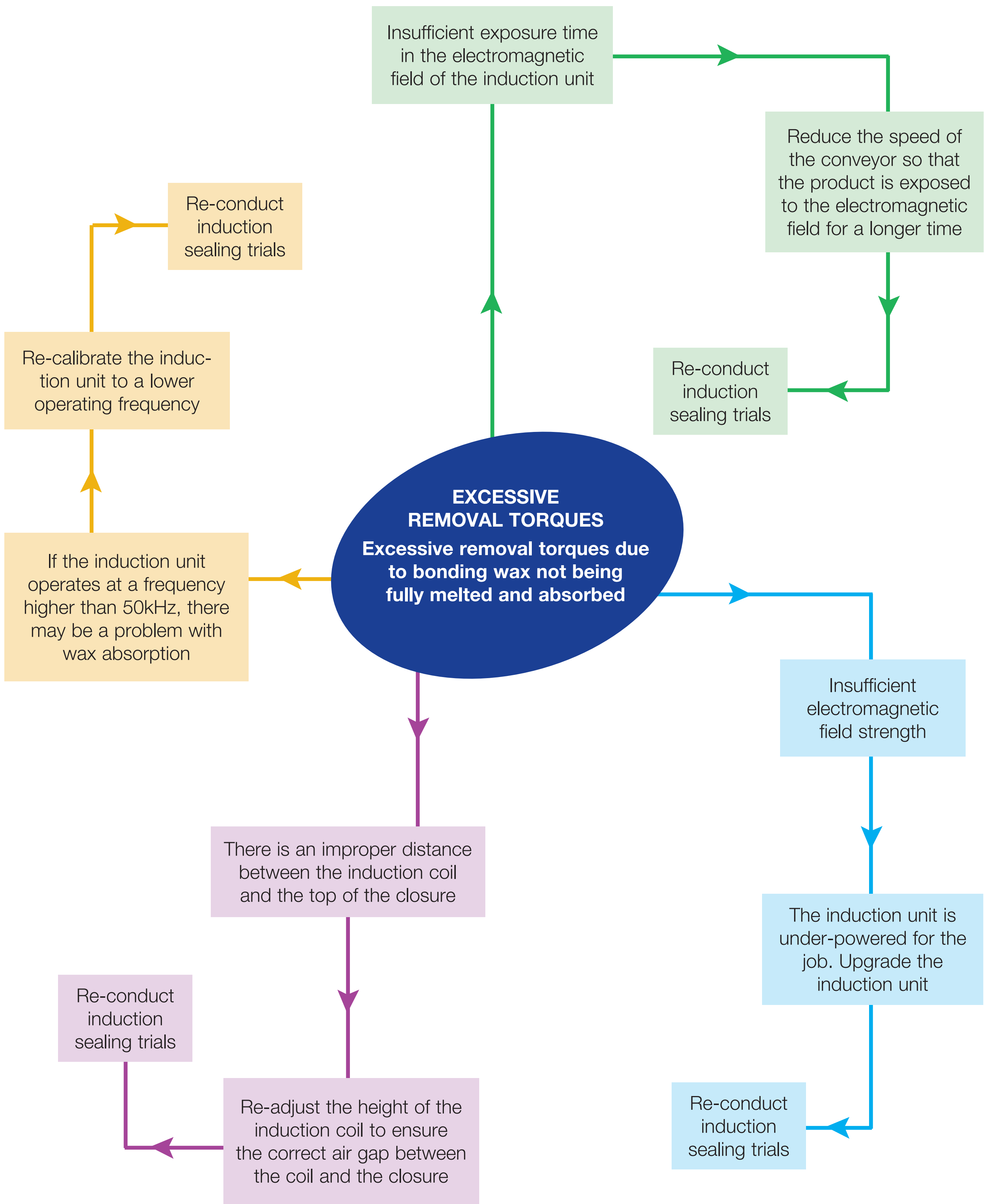
FAULT DIAGNOSIS

Excessive closure removal torques on 1 piece liners



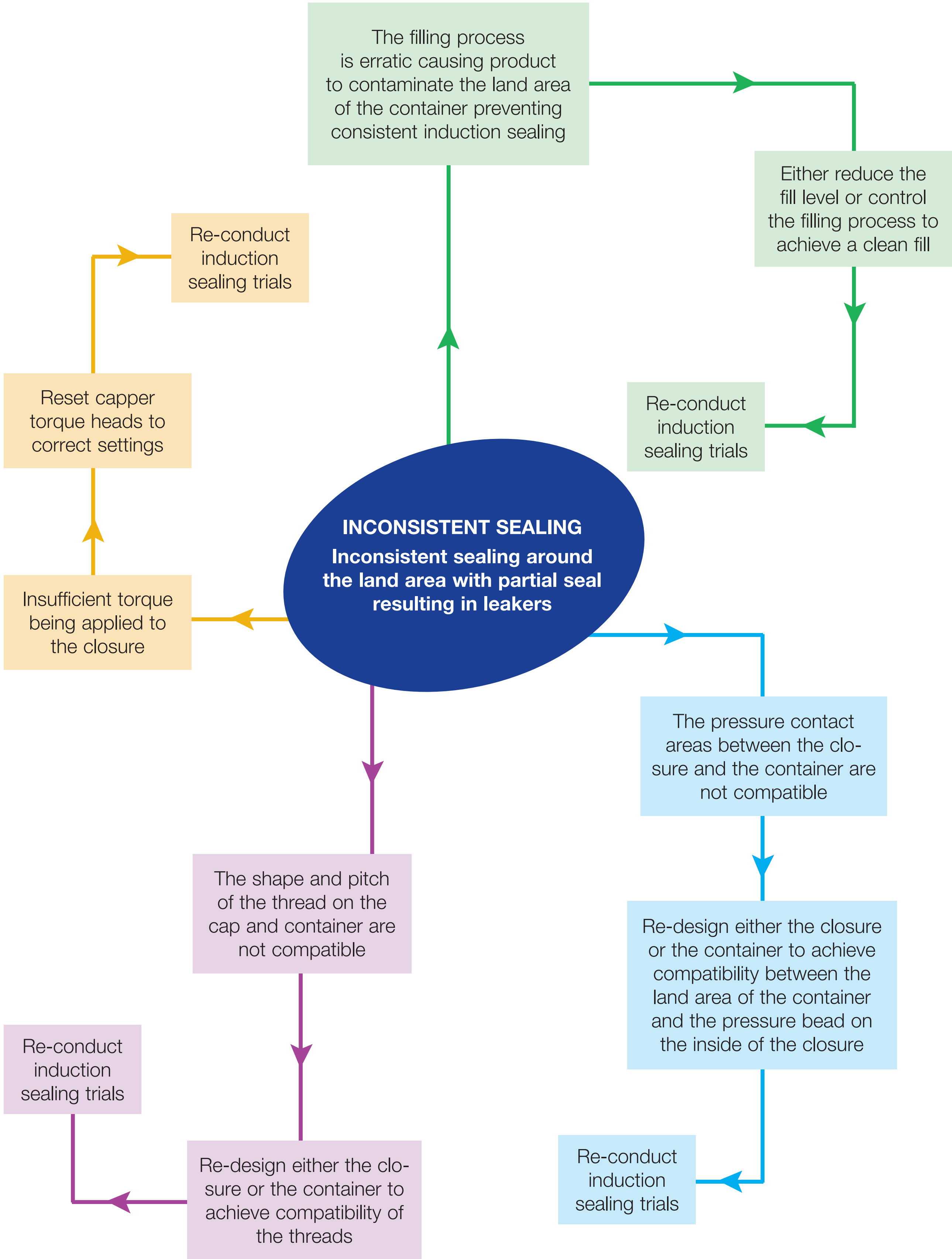
FAULT DIAGNOSIS

Excessive closure removal torque on 2 piece wax-laminated liners



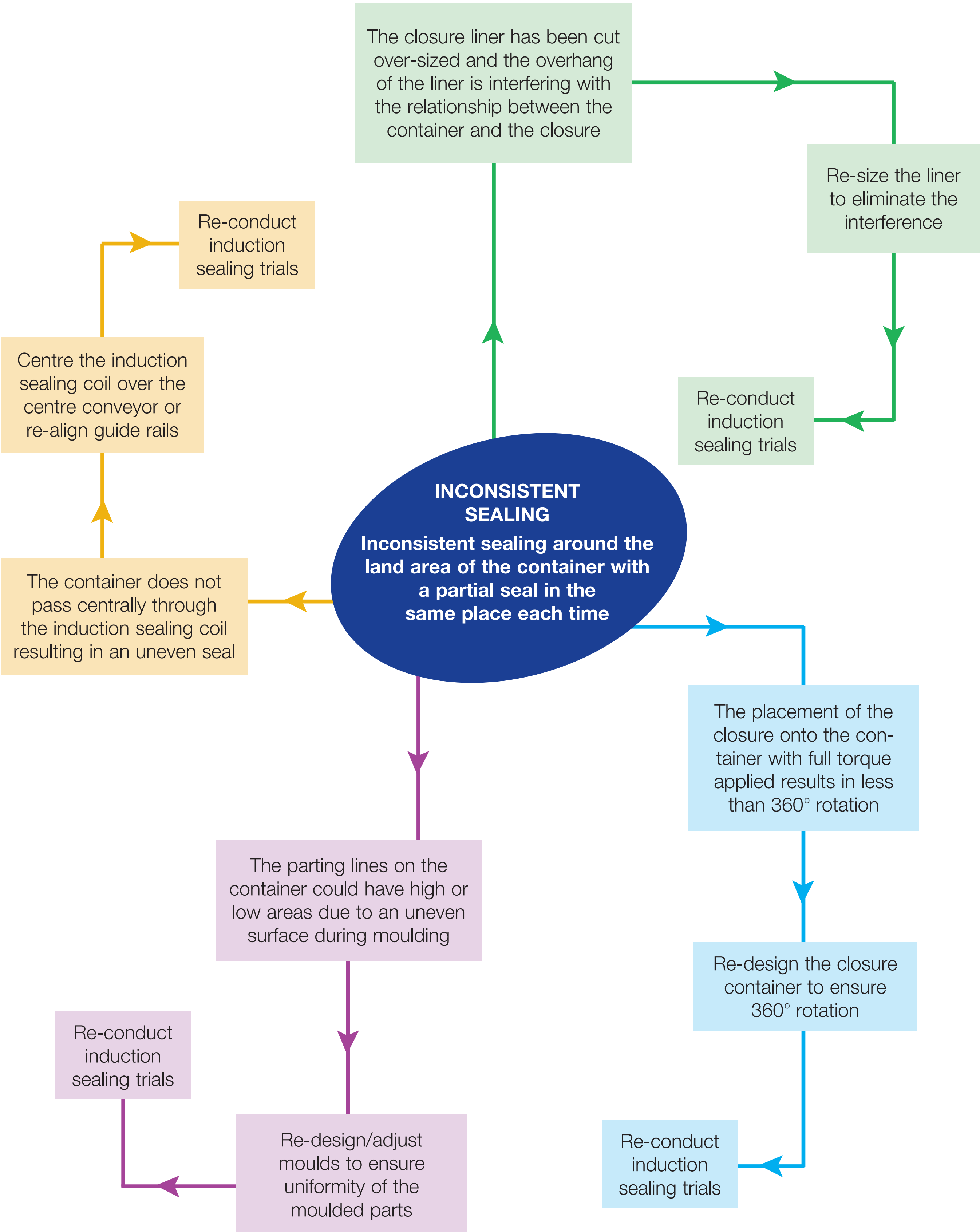
FAULT DIAGNOSIS

Inconsistent Sealing of Liner



FAULT DIAGNOSIS

Inconsistent Sealing of Liner in a Common Area



NOTES

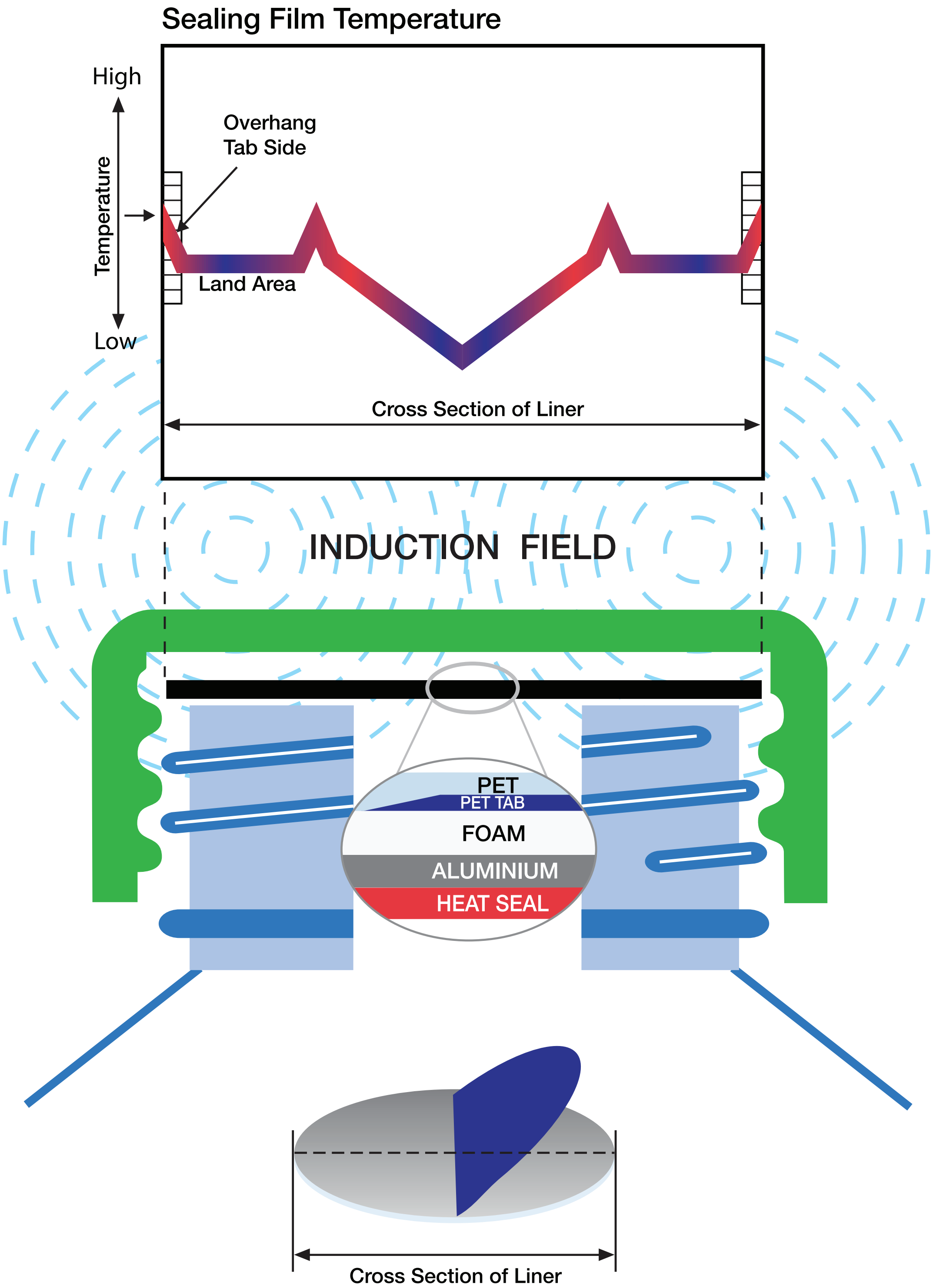
9 Heat Dissipation

HEAT DISSIPATION FLOW CHART

The chart below shows the differential of temperatures during the induction sealing process for round liners

Type of Liner: Round One Piece or Lift 'n' Peel™

(temperature profile the same for each)

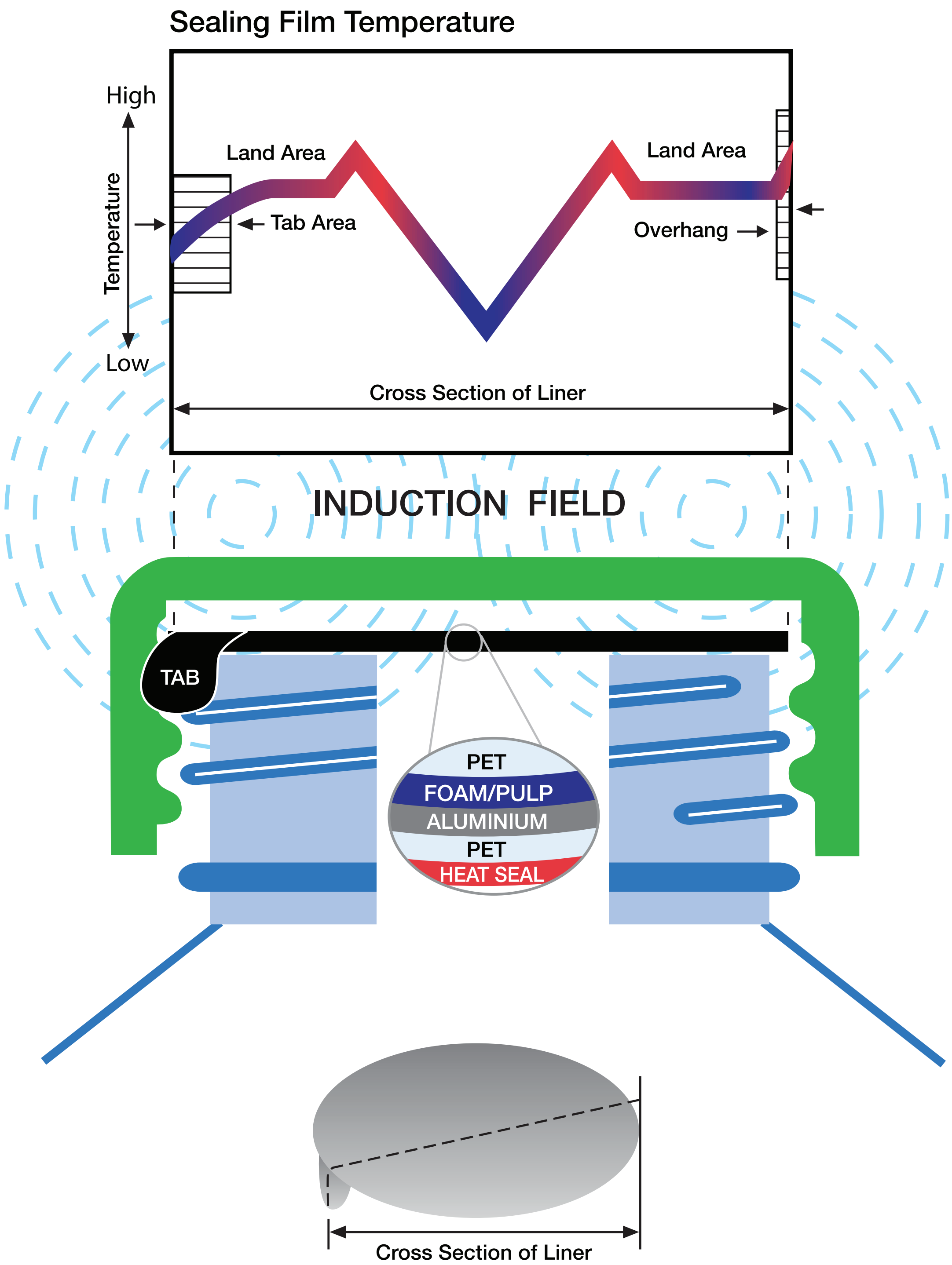


Lift 'n' Peel™

HEAT DISSIPATION FLOW CHART

The chart below shows the differential of temperatures during the induction sealing process for liners with a tab at its periphery

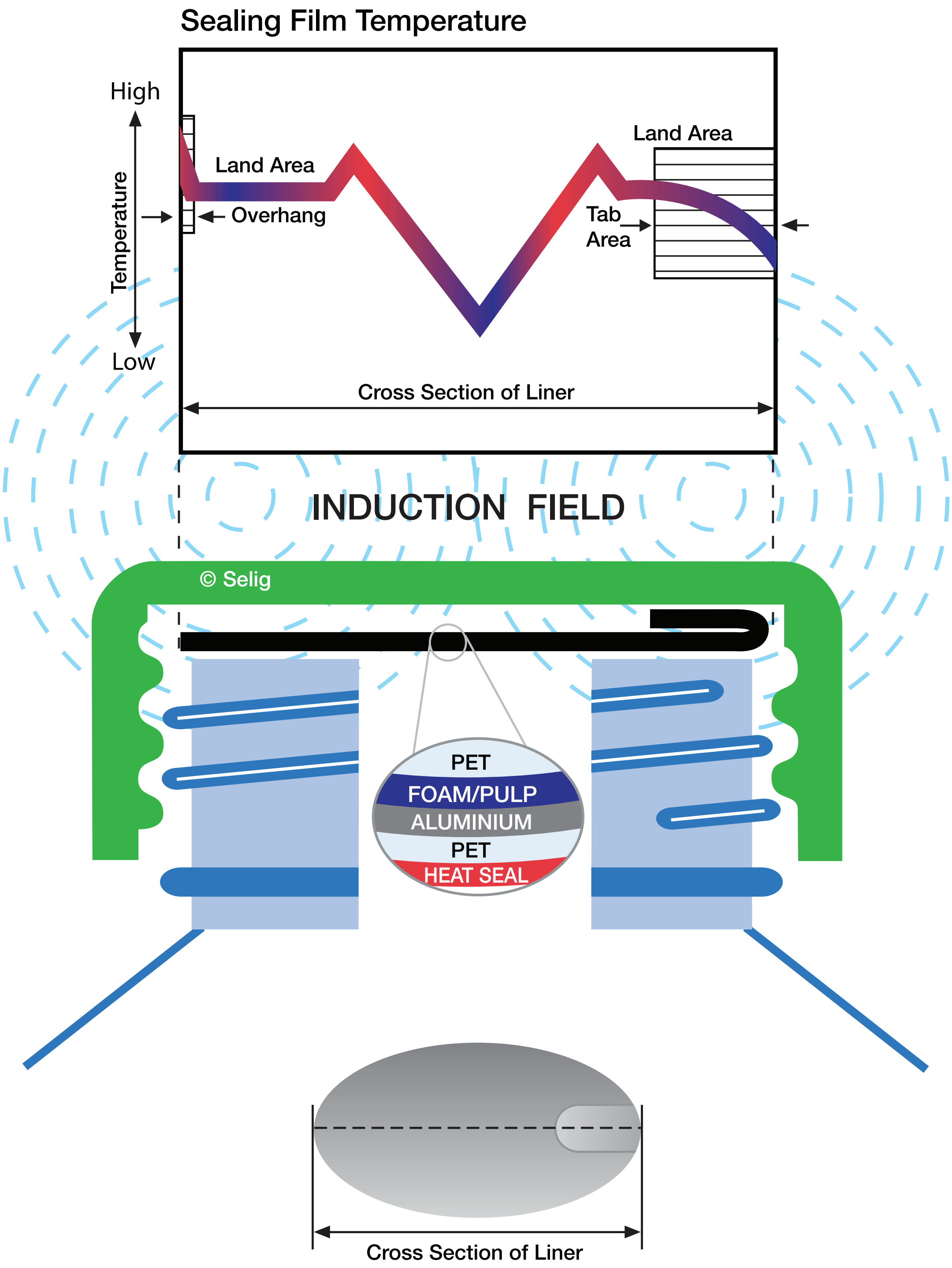
Type of Liner: FoilSeal™ / Uni-Gard™



HEAT DISSIPATION FLOW CHART

The chart below shows the differential of temperatures during the induction sealing process for liners with a folded back tab ('Super Tab')

Type of Liner: FoilSeal™ / Uni-Gard™



10 Setting up the Induction Window

THE OPERATING WINDOW

To achieve a good seal for an application it is necessary to run a trial on the actual production line under production conditions.

This is referred to as "Determining the Operating Window", which enables you to make the necessary variable adjustments to ensure the induction process is successful.

The operating window is the range of settings in which the performance of the seal is deemed to be acceptable i.e. it does not leak due to insufficient induction power at the bottom end of the settings, and the liner has not been over heated by the induction process at the top end of the settings. The ideal/optimum operating settings will be approximately at the mid point between the two.

Before running the trial to determine the operating window, please check the following:

1. The filling and capping process should be checked, and the desired on-torque is being applied by each and every torque head of the capper.

2. The induction unit and coil is the correct unit and size for the application/closure.
   a The coil is parallel to the conveyor and central over the closure.
   b. The coil is level
   c. The height of the induction coil is set to give the correct air gap as recommended by the manufacturer for that particular induction unit.

3. Ensure that the conveyor speed is constant and that the speed does not vary when passing under the induction unit.

4. That the guides on either side of the conveyor under the induction coil are correctly set so that they control the flow of the containers without causing them to slip on the conveyor.

Determining the operating window

Starting with the induction unit set at approximately 25% power output run a series of filled and capped containers on the conveyor under the induction coil at 5% incremental increases of output power. Ensure that you mark the power settings on the individual containers. Remove the containers from conveyor and allow it to cool down. When cooled, remove the closure and inspect the liners.

Starting with the sample inducted at the lowest power setting inspect the liner to see if it has sealed and then work your way up the range until you find the liner that is correctly sealing.

The containers can be subjected to a hand squeeze test or a vacuum test to determine the strength of the seal, depending on the criteria that needs to be met. If it is a peelable liner, then force required to peel the liner needs to be taken into account.

Next inspect the sealed liners on the containers one by one in order, inspecting to see at which power setting the liners are starting to show signs of distortion due to excessive induction power. For example you may determine that the operating window is from 60% - 80%. In which case you may choose to run the line with a power setting of 70%.

If you find that you need a power setting close to 100% or above, then it may be due to one of the following:

a. The conveyor speed is too fast
b. The air gap is incorrect
c. A larger/more powerful induction unit is required.

Determine the operating window on a 2 piece wax laminated liner:

When running a trial to determine the operating window with a 2 piece wax laminated liner, achieving a good seal is as important as ensuring wax melt and absorption by the board or paper layer. This is required for the two halves to separate.

If it is found that the sealing aspect of the liner is good but that there is still un-melted wax in the center of the liner, the operating parameters need to be changed. Success will normally be found by slowing down the conveyor speed as well as reducing the power, ie increasing the dwell time. This will allow more time for the heat generated within the liner to conduct to the center of the liner and fully melt all of the wax.

NOTES

11 Closure Design & Punched Liner Geometry

The Right Fit

Guidelines on Closure, Container & Liner Relationship

All Liners - Seal Pressure

Figure 11a: *Seal rings on closure.*

For consistent and even pressure, which is required for good sealing, the closure should have at least 360° of thread engagement. This is especially important for induction seal liners during the induction process (consistent pressure/torque). Seal rings on the underside of the closure, opposite the container land area, are optional, but useful for concentrating seal pressure on the container land area, improving seal integrity (see Figure 11a).

One Piece Induction & Two Piece Induction Wax Bonded Liners

The design of the closure and the container neck finish should be such that when fully assembled and screwed together with a liner in place, that the liner is centered on the container, and that there is sufficient space for the liner periphery to remain flat and not fold down or touch the outside of the neck wall or neck threads. This is also true for one piece liners with retention tabs, if the tabs are bent down, they must not come in contact with the container neck wall or threads. Any contact between the liner and the side of the container finish can result in the edge of the liner adhering to the vertical side of the finish (side bonding) and negatively affecting the ease of seal removal. We recommend the liner overhang the flat land area of the container neck by a minimum of 0.5mm around the entire circumference. Excessive overhang should be avoided to prevent this 'side bonding.'

Two Piece Induction Polymer Bonded Liners (QUADRASEAL™ & DELTASEAL™)

Section 1: Liner Retention Features of Closures

When using two piece liners with a temporary polymer bond, the closure/liner system must have coordinated dimensions for the system to function correctly (see Figure 11b).

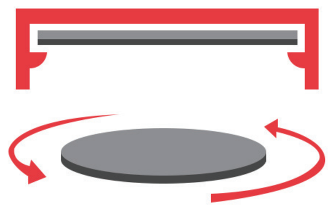


Figure 11b: *Closures must have sufficient means of retaining the lining material behind a retention bead while allowing the liner to rotate freely.*

Five parameters have to be considered when assessing the suitability of a closure's liner retention features for satisfactory performance with QUADRASEAL and DELTASEAL™ brand liners:

1. Liner Diameter Clearance - to allow rotation.

Liner Diameter Clearance (mm) = "B" (mm) – "A" (mm) (See Figure 11c)

In the use of QUADRASEAL™ and DELTASEAL™ two piece liners, it is important that the liner rotates freely within the closure to ensure satisfactory separation. The liner clearance i.e. Liner Recess Diameter "B" minus Liner Diameter "A" will provide this freedom of movement. This should typically be 0.30 - 0.40 mm total clearance for 50mm or smaller diameter closures and 0.50 mm for larger diameter closures.

2. Interference Fit - to ensure retention.

Interference Fit (mm) = "A" (mm) – "C" (mm) (See Figure 11c)

The second consideration is the Interference Fit between Liner and Liner Retention Bead i.e. Liner Diameter "A" minus Diameter of Liner Retention Bead "C". This parameter increases with increasing closure size (e.g. 1.10 - 1.20mm total interference for 50mm diameter closures, 1.20 - 1.40mm for 65mm closure diameters, and 1.60 - 1.80 mm for 80mm diameter closures).

Closure Design | The Right Fit

3. Retention Bead Profile - to minimize damage to liner upon insertion but ensure retention in closure. *(See Figure 11c)*

With regard to the Retention Bead Profile, ideally this should be quadrant shaped on top (insertion side) and flat underneath (retention side) to minimize insertion distortion and to resist liner pull-out. Avoid tapers or radii from the bead flat to the side wall to avoid the liner jamming on a taper or radius, causing the membrane to separate by shear rather than by a lifting action (tension). Refer to Figure 11c below describing bead profile.

4. Retention Bead Profile Length – to retain the liner but allow injection mold design simplicity.

The retention bead should exist symmetrically in at least 80% of the inside circumference of the closure.

5. Height of Retention Bead from Closure Base - allow for complete insertion and minimum edge distortion.

Retention Bead Height (D) - 2.50mm minimum

A - Liner Diameter

B - Recess Diameter
(or distance between tangential flats - see Section 2)

C - Diameter Between Retention Beads

D - Retention Bead Height

E - Thread ID

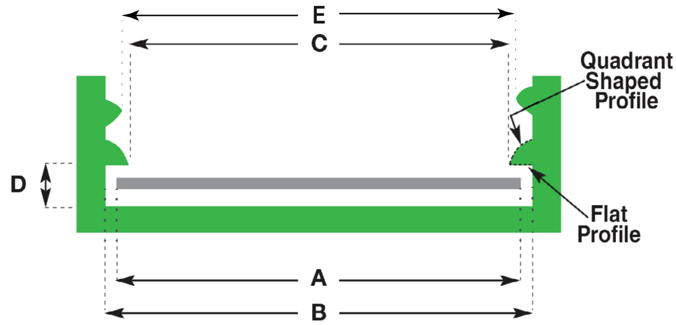


Figure 11c: *Dimensional relationships between closure & innerseal.*

Interference Fit and Liner Clearance*

	Closure Diameter		
Parameters	**50mm**	**65mm**	**80mm**
Interference Fit (A-C)	1.10 - 1.20mm	1.20 - 1.40mm	1.60 - 1.80mm
Liner Clearance (B-A)	0.30 - 0.40mm	0.50mm	0.50mm

**Guideline only - Selig suggests that customers determine suitability for their own application.*

Section 2: Liner Retention Feature & Closure Thread Relationship

Ideally the retention bead inner diameter (C in Figure 11c) is the same diameter or smaller than the closure thread internal diameter (E in Figure 11c). This will minimize any distortion to the outer edge of the liner when it is inserted past the closure threads. To achieve this while still maintaining the liner clearance (B-A) relationship, and minimizing the thickness of the closure side wall in the retention bead height area, equally-spaced tangential flats (6-8) can be added to the closure side wall beneath the retention bead. The preference for tangential flats as opposed to narrow ribs, is that not only do they avoid sharp rib corners that can dig in and damage the edge of the liner, but that a tangential flat helps to keep the liner centered and presents a smooth surface against which the liner can smoothly rotate and correctly function beneath the retention bead, thus reducing the risk of liner pull out or visual defects on the liner. The liner recess diameter `B' dimension would then be taken as the distance between two opposing flats.

Lift 'n' Peel™ & Top Tab™ Induction Liners

Selig's Lift 'n' Peel™ (1pc) and Top Tab™ (2pc) consumer convenient induction liners have been specially designed to provide a 1/2 moon shaped center tab to provide easy removal of the liner. The following section provides guidelines to help optimize the function and use of these consumer preferred liners.

Punched Liner Geometry Guidelines - Existing Closure and Bottle Design

Closure Mold Design Type → **Liner Feature** ↓	**Bump/Strip Molded Closure** (Preferred mold design - allows for liner retention features) *-See Figure 11D-*	**Unscrewing Core Molded Closure** (Not ideal design for liners - no designed liner retention features) *-See Figure 11E-*
Geometry	Round (side tabs not recommended)	Round with tabs for retention (tri-tab design recommended) *-See Figure 11F-*
Orientation - ½ Moon Tab 'hinge'	Side tabs not recommended (if tabs - 'hinge' not extended into side tabs) *-See Figure 11F-*	'Hinge' not extended into a side tab *-See Figure 11F-*
'Overhang' (extension of liner diameter beyond bottle 'E' dimension)	Min 0.020" (0.5mm) per side Max no larger than the closure side wall ID ('T' dia) *-See Figure 11G-*	Min: 0.020" (0.5mm) per side for the liner minor diameter Max: Major dia no larger than the dimension between thread start and closure side wall opposite the thread start ('Liner Retention Area') *-See Figure 11H-*
Tab Geometry	Side tabs not recommended *-See Figure 11F if used-*	*-See Figure 11F-*
Diameter	Lift 'n' Peel™ & Top Tab™: 20-63mm; Lift 'n' Peel™ Wide Mouth 63-120mm (<20mm not recommended - tooling/layout limitations) (>63mm recommend Lift 'n' Peel™ Wide Mouth - application dependent)	
Thickness	Thicker suggested as more resilient to deformation upon insertion, compensates for closure or bottle finish deficiencies	

Figures 11D - 11I

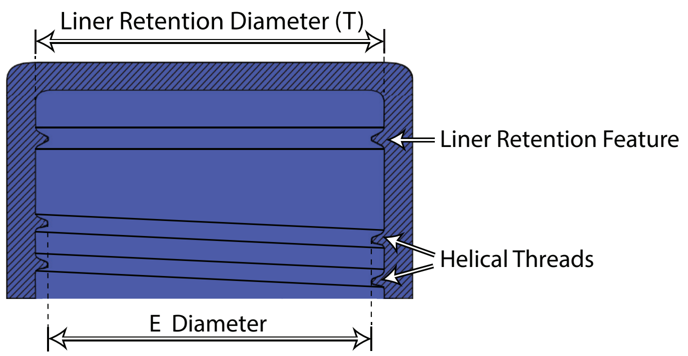


Figure 11D
Bump/Strip Molded Closure

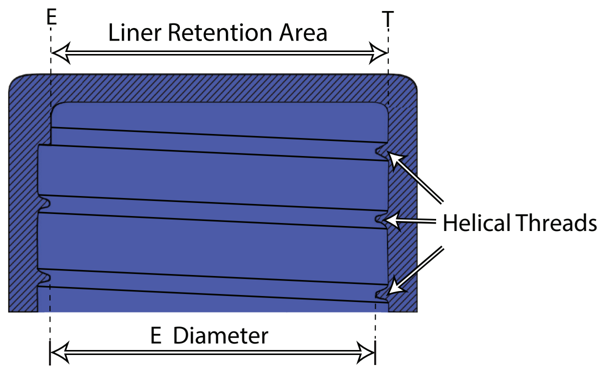


Figure11E
Unscrewing Core Molded Closure

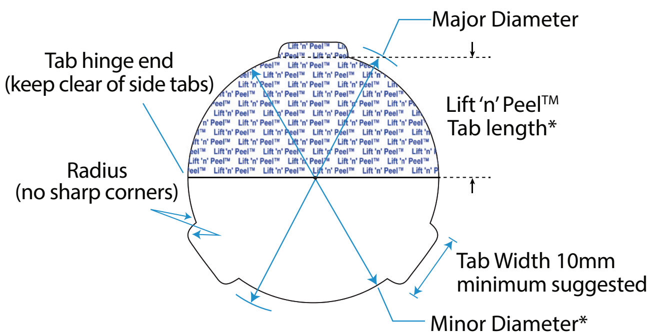


Figure 11F
Tri-Tab Geometry

**The length of the tab on minor diameters greater than 50mm should not exceed 25mm.*

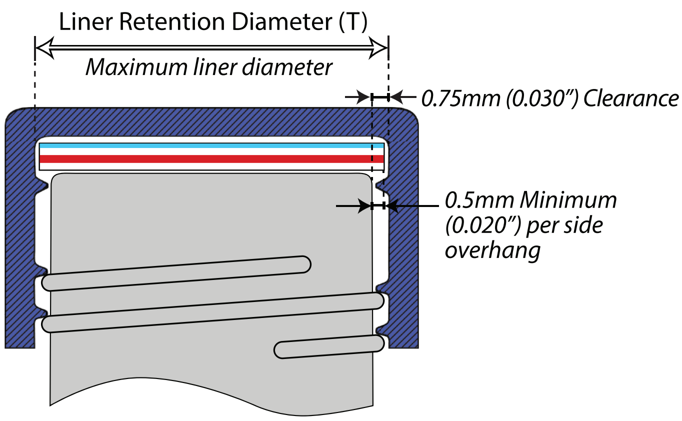


Figure 11G
Liner Overhang - Strip Mold

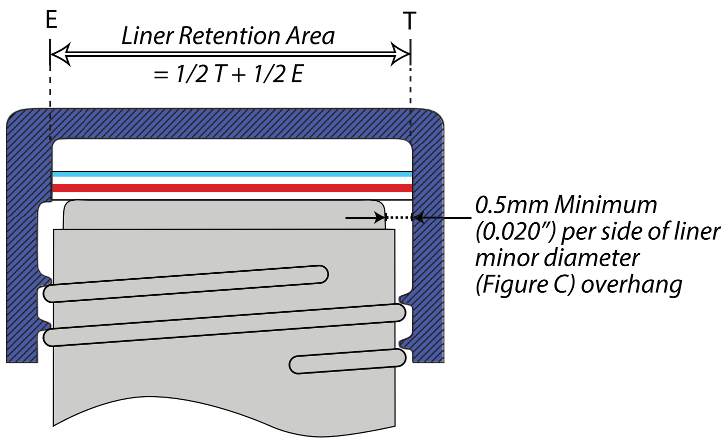


Figure 11H
Liner Overhang - Unscrewing Mold
Tri-Tab Style Liner

Note: Container O.D. at orifice may need to be stepped in

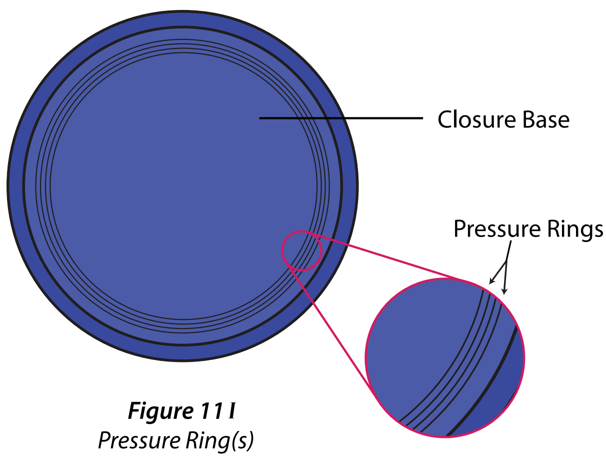


Figure 11I
Pressure Ring(s)

Punched Liner Geometry - New Application - Closure and/or Bottle Not Yet Designed

- Bump/Strip design preferred for the closure mold, with retention features for the liner. *(-See Figure 11D-)*

  °For a bump/strip mold with a 3 start or more thread design, the thread starts at the base of the closure may be large enough and close enough to the back of the closure to retain the liner, eliminating the need for retention features.

- Incorporate a pressure ring or multiple rings into the closure base opposite the bottle land area. *(-See Figure 11I-)*

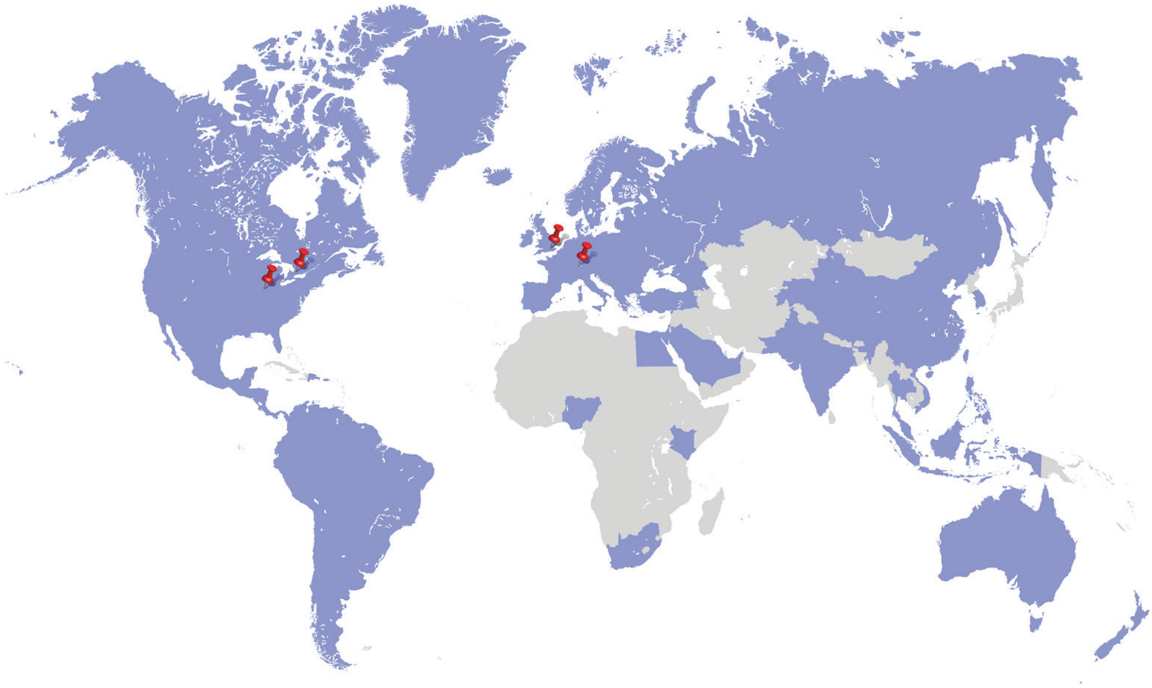
- Avoid embossed markings on the closure base (cavity, mold, manufacturer ID) that could interfere with the liner lying flat. If required, minimize height of the embossing and locate in the center of the closure base - far from the intended bottle land area contact location.

- Thread engagement is required to be at least 360 degrees to assure even pressure on the liner.

- Bottle/closure should have a clearance of at least 0.030” (0.75mm) per side on an imaginary plane extending beyond the bottle land area. This will insure the liner has sufficient overhang without being folded down by the closure side wall. *(-See Figure 11G-)*

Selig group

Protect, Seal and Deliver



Selig Sales

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Selig Liners | Markets Served

Selig Group has a reputation for reliability and a tradition of excellence in meeting the needs of the Food and Beverage, Pharmaceutical, Nutraceutical, Agricultural, Personal Care and Chemical Industries. Selig offers the largest range of closure liners, wet glue applied seals and induction seals in the global packaging industry.

Selig uses a wide range of materials (foils, films, board, papers, foams and resins), unique laminating processes (solvent based, water based, heat and extrusion), printing, slitting and punching capabilities to offer its industry leading range of liners for standard or custom applications.

USA Manufacturing
342 E. Wabash
Forrest, IL 61741
+1 (815) 785-2100
+1 (815) 657-7584 (fax)
sales@seligsealing.com

North American Sales
184 Shuman Blvd., Suite 310
Naperville, IL 60563
+1 (630) 922-3158
+1 (630) 922-8469 (fax)
sales@seligsealing.com

European Sales & UK Manufacturing
635 - 637 Ajax Avenue
Slough Trading Estate
Slough, Berkshire SL1 4BH, UK
+44 (0) 1753 773000
+44 (0) 1753 773111 (fax)
sales@seliggroup.com

Canada Manufacturing
145 Edward St, Aurora,
Ontario, Canada. L4G 1W3
+1 (905) 727-0114
+1 (905) 727-8544 (fax)
sales@seligsealing.com

Switzerland Manufacturing
Bahnhofstrasse 13
Niederglatt 8172
Switzerland
+41 (44) 851-5050
sales@seliggroup.com