Eliminating Leaking Containers

A PROCESS TO ESTABLISH SATISFACTORY APPLICATION TORQUE

AdeptGroup

ENGINEERING EXCELLENCE

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Establish Satisfactory Application Torque

Eliminating Leaking Containers

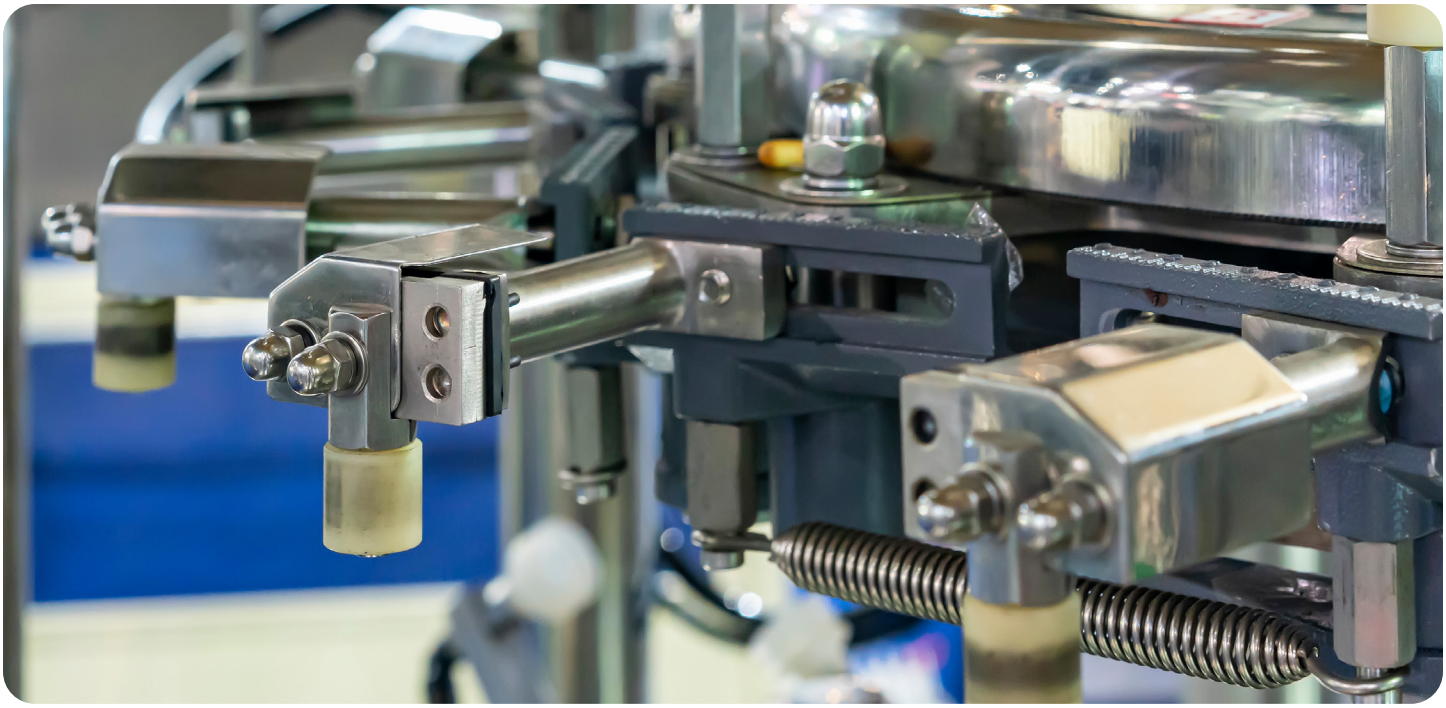
A leaking package detracts from the consumer experience and occasionally also results in personal property damage.

The companies that are manufacturing and marketing liquid products in container closure packaging systems have a vested interest in preventing leaks throughout the supply chain, aiming to providing consumers with leak-free, easy-to-open packages.

This white paper addresses the role of application torque in eliminating leaking issues through:

I. Defining application torque
II. Evaluating the factors that affect application torque
III. Establishing and incorporating a defined and repeatable process to determine the correct application torque

Eliminating leak issues in the distribution, retail and e-commerce environments is a frequent but critical challenge. A common cause of leaking packages and closures is the failure to apply the appropriate tightness during the application of the cap onto the bottle. This is known as application torque.



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A Critical Challenge

I. Defining Application Torque

Application Torque is a rotational force, often measured in inch pounds (in-lbs.), that is used to apply or assemble a threaded closure to a mating bottle by machine or hand.

If the application torque is too tight, it results in packages being too difficult to open, and if too loose, results in a leaking package. Determining the appropriate application torque for each package is critical to preventing leaks.

II. Application Torque Evaluative Factors

There are a variety of circumstances, rules and factors that manufacturers must consider when determining required application torque, such as:

- The general torque rule
- Stress relaxation
- Closure design
- Method of sealing
- The distribution chain

GENERAL RULE OF CLOSURE APPLICATION TORQUE

The first factor to consider when determining required application torque is the guideline for closure application torque for plastic closures on plastic bottles. Though this is a general principle which needs to be tested, it is common for the application of plastic closures to follow a rule that the torque requirement is approximately half of the closure diameter.

This means that a 38mm closure would expect to require an application torque of 17 – 21 in-lbs. This is not something that can be written into a specification without verification. It requires testing to determine what application torque will be required in each package system.

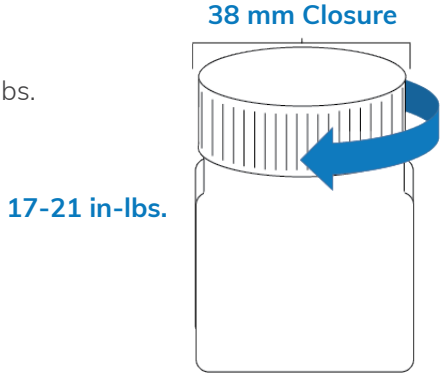
STRESS RELAXATION

In addition to following the general rule, plastic closures and bottles relax over time and the sealing effectiveness decreases. This is called stress relaxation. This principle describes the way thermo-plastics relieve stress while under a constant strain. Stress relaxation is a major contributor to torque decay in a package. It is essential for manufacturers to develop a method to evaluate the amount of torque needed to provide a secure seal that accommodates the decay in torque.

GENERAL APPLICATION TORQUE EXAMPLE:

Torque = ½ closure diameter

A 38 mm closure can be assumed to require an application torque of 17-21 in- lbs.



The Closure Design

Another factor that impacts application torque is the closure design.

Understanding the different types of closures and the effect that torque has on them will help manufacturers adjust application torque for each specific closure.

Injection or compression molded plastic closures are designed with threads that are unscrewed out of the mold or pushed off the threaded core of the mold. The latter is usually described as a jump thread.

The closure that is manufactured using an unscrewing action will usually have deeper threads and can use a thread profile that more closely matches the profile of the bottle thread. In addition to the thread profile, an unscrewed thread closure can have a side wall that is thicker and more rigid than a jump thread closure.

Because the jump thread closure is pushed off a threaded core, the threads are shallow and have a profile designed to allow part ejection. As a result, the closure thread will have a reduced amount of contact with the bottle threads. Compared to an unscrewed thread closure, the side wall of a jump thread closure must be more flexible to allow the cap side wall to distort, allowing the threads to be ejected without damage.

The method of design and molding action will determine the amount of thread contact and strength of the threads that ultimately provide the force to secure the closure to the bottle.

The Sealing Method

Once manufacturers choose a closure design and evaluate it for proper application torque, they must then evaluate the sealing method they will use.

A plastic closure can be combined with sealing features like: a pre-cut liner, molded liner, an induction-welded foil liner, a lineless plug seal on the inside diameter of the bottle or a crabs claw sealing feature. Each of these design features require a different application torque for the same diameter closure.

The importance of maintaining satisfactory removal torque results is greater if the closure is a torque-dependent, child-resistant (CR) closure. The CR push-and-turn closures maintain their functionality by retaining enough torque to prevent entry by children while being easy for seniors to open.

The example below exemplifies the impact sealing methods can have on required application torque.

SEALING METHOD EXAMPLE: INDUCTION-WELDED FOIL LINER

A closure with an induction-welded foil liner will immediately lose a material amount of torque from the induction-welding process. The process of heating the induction foil liner up to 500° F will melt the land of the bottle and relieve the pressure between the bottle land and the inside top surface of the closure. Loss of this force will also relieve the contact pressure between the closure and bottle threads. With that pressure relieved, the torque will be reduced immediately and continue to decline as the materials return to room temperatures. It is common to lose 50% of the application torque immediately from this process and additional torque within 24 hours.

A 38mm closure with an induction-welded liner, applied at 19 in-lbs. could see a removal torque of 9–10 in-lbs. immediately instead of taking 24 hours to reach this torque with other sealing methods. Torque would continue to decay over 24 to 72 hours to approximately 5–7 in-lbs. with this type of liner. The package would be sealed because the liner is successfully bonded to the bottle, but the torque retaining the closure will have reduced significantly by the time the package is shipped.

The issue with this application is when a foil-induction liner is used in a CR closure. Failure to maintain the required torque with these closures can place the entire package out of compliance and risk the safety of the consumer. This condition can also result in a potential product recall for the manufacturer. For this reason, some push-and-turn CR applications require re-torque machines after the induction-welder to maintain the proper amount of torque.

The Distribution Chain

Once the closure design and sealing method are evaluated to ensure proper application torque, the next factor to consider is the distribution chain.

The distribution chain must account for the multitude of variables a package may encounter from the distribution center to the final destination. Packages are susceptible to leakage from a wide variety of factors during all steps of the distribution cycle.

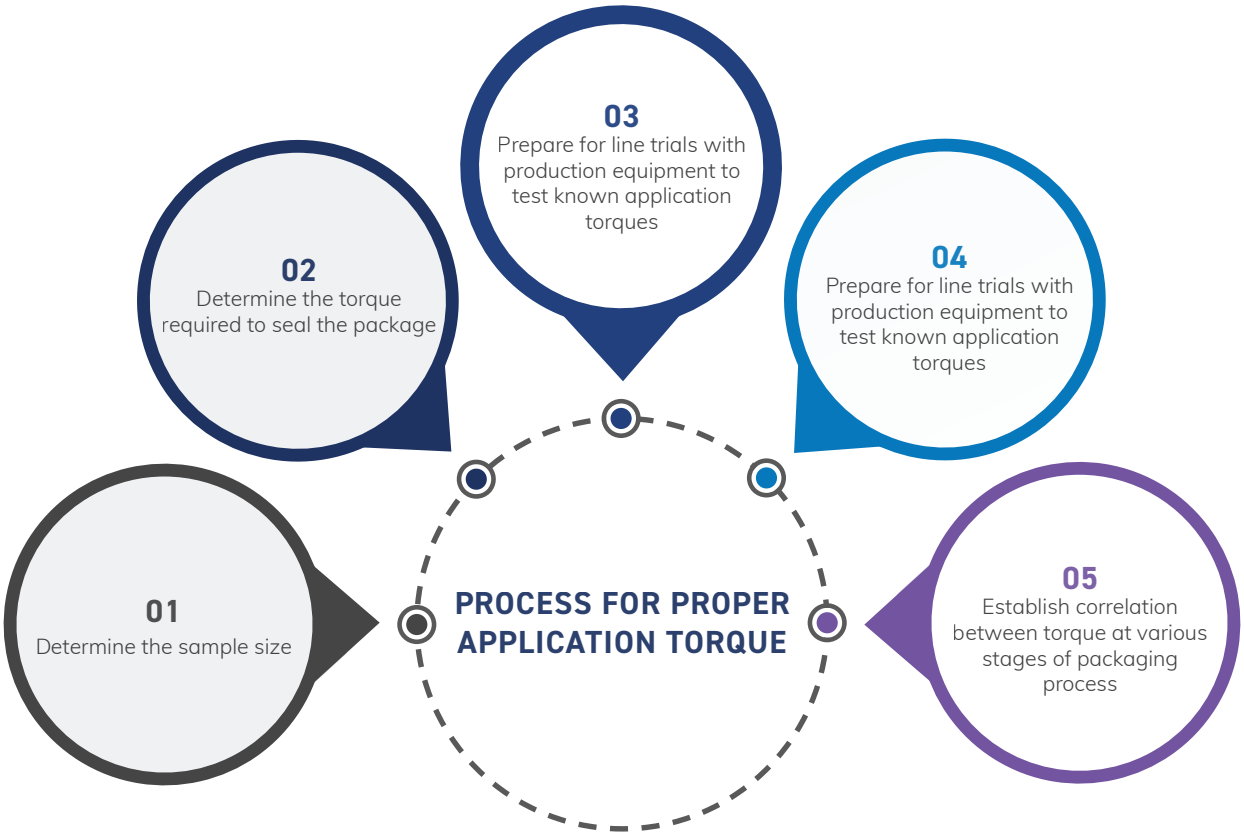
Stress and vibration testing is essential to evaluate the sustainability of the package throughout the distribution chain. The stresses of shock and vibration during shipment can further reduce the available closure torque in the package. There are testing standards that can be used to simulate the stresses that packaging can experience between the plant and the end user. ASTM D4169 and D7386 offer options for testing products on a pallet or in individual case packaging configurations. Organizations that don't test properly can find their package is not capable of successfully reaching its destination.

The level of torque decay in the closures during shipment depends on the closure design, sealing method and distribution chain required for the product. This varying combination of factors requires a reproducible process that allows manufacturers to evaluate each package to ensure the product will perform properly.

III. Solution Process for Proper Application Torque

In order to seal or retain the intended function of the package, the removal torque deemed satisfactory by the end user must be identified.

Testing is required with prepared lab samples and from samples obtained from production trials. This process require multiple steps to address all of the applicable factors including:



Determine the Sample Size

In order to prepare, manufacturers need to determine the sample size needed to be used in all phases of the testing process.

The rule of 3s can be used to determine the number of samples required to match the intended defect performance rate. The basic formula p=3/n can be used for this purpose. The sample size “n” is used to determine the upper risk limit “p” defect rate. The lower risk limit is always zero. The formula would then be rearranged to n=3/p in order to determine how many packages to test. Once the defect rate percentage is chosen, the percentage of likelihood of finding one or more defects within that same size is able to be determined.

EXAMPLE OF RULE OF 3S

p = 3/n

Below is an example for a package with a 2% leak defect requirement.
The number of packages would be determined by n=3/.02. By this rule, “n” would equal 150 packages.

p = 3/.02

p = 150 packages

This would mean using the defect rate of 2%, there would be a 95% likelihood of finding one or more defects within that sample size.

DETERMINE THE TORQUE

Once the sample size has been established, the next step is to determine the torque required to seal the package and maintain proper functionality. This can be done by leak testing the product at various known torques in significant quantities to generate the performance desired.

This requires manually applying closures in a lab setting using 1-2 in-lbs. increments and immediately testing to determine the limit of the package sealing performance. It may be advisable to test a smaller number of samples initially to help narrow the range and increments to be used in larger test samples. The lowest removal torque that produces an acceptable leak performance will be used as the minimum acceptable torque target for the production samples to be tested in the following distribution conditioning. Once the final torque that meets requirements is defined, it is time to begin to set up trials and testing protocols to define an acceptable process.

Determine Line Trial Protocol

Once the sample size is determined and the torque requirement of the package is established, the next step is to prepare for line trials with production equipment to test known application torques.

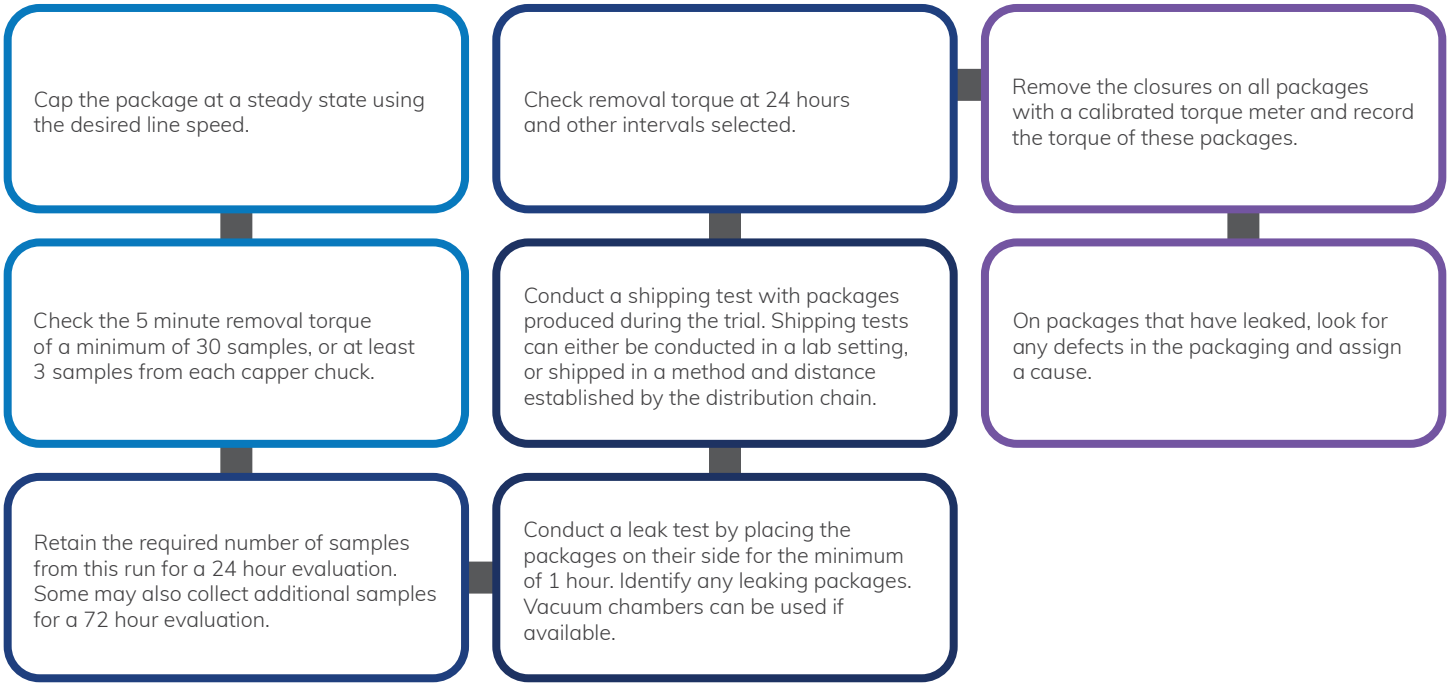
The elements that need to be verified before testing vary depending on the capper being used.

When using capping equipment, the chucks should be tested with a torque wrench to confirm that the clutch releases at the indicated setting. Spindle speeds on chuck cappers can also influence torque. Rotational inertia can add to the amount of torque applied to the closure and can be above where the capper chucks release.

Inline capper settings can only be determined by adjusting and testing individual packages until the target immediate removal torque values are reached. It is important to begin the testing with straight and true spindles. Gripper wheels that are not worn and are the correct Shore Hardness for the closure must be used.

RUN LINE TRIALS

Once the capper and line conditions have been confirmed, the product is then ready to run on the line. Most companies prefer to test various application torques during one trial to avoid repeating the trial several times. The method for each variable is as follows:



Establish Correlation

After completing these steps, a correlation between the 5-minute removal torque, 24-hour torque and the final torque after shipping can be established.

This will allow production operators to perform line audits during production to ensure the proper application torque for product integrity is being used.

Determining the proper torque to seal the package and testing at various points to ensure proper application is essential to improving leak performance. It is also critical to document the process to achieve the proper torque at the capper and that it is used in production.

ACHIEVING RESULTS

Each step in the process needs to be completed appropriately to correctly determine the proper application torque. Once the process is implemented, manufacturers will have a standardized way to ensure that plastic containers with plastic closures arrive at their final destination with minimum leakage. Establishing the process allows for repeatable results and consistently satisfied consumers.

Partner Selection for Process Development

One final consideration about process development is that understanding the factors that impact application torque, how to test them to ensure the correct application torque is determined and applied, and developing a process requires time, experience and expertise.

Manufacturers often seek Packaging Engineering services suppliers with experience in production lines to assist them with process development and testing. This approach allows for production to continue without burdening the internal team.

Companies like Adept Group can help clients develop a standardized repeatable process to establish proper package application torque. Adept Group has the capability and experience to assist clients with the establishment of standards and test protocols, management of new product launches, development of bottle and closure system, line trial execution and solving quality issues in the beverage industry and other fields. With over 100 clients, over seventy Packaging Engineers and multiple Packaging Engineering teams, Adept Group has the depth and breadth to manage client needs that may arise throughout any aspect of the packaging line.

Contact Us to establish an application torque.