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Risk Mitigation in Medical Packagaing

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Risk Mitigation in Medical Packaging

Medical device packaging risk mitigation involves evaluating the medical device packaging process, determining where there are gaps or potential opportunities for critical issues to be missed or overlooked, and then identifying the most economical and effective way to ensure that those opportunities are eliminated or minimized.

The most vital areas of the medical device packaging process that must be evaluated include the packaging itself, creation of a seal/sterile barrier, insuring that the correct item(s) are in the pouch, labeling, and the inspection process—all of which are essential for ensuring that the end-user receives the correct product, sterile and intact, with the correct labeling and information. When medical professionals are working in the clinical setting, they need to identify medical devices quickly.

These packages must be sealed in a way that maintains sterility, and they must be visibly, legibly, and correctly labeled. In addition, the packages must be able to be easily opened so that the product can be removed in a controlled manner.

What are the key issues medical device manufacturers need to consider with regard to risk mitigation for medical device packaging?

One of the key issues to consider is validation. The packaging process for medical devices must be validated as robust and repeatable, so that operators can complete the executable actions in the correct order, accurately, over and over again. Because the packaging process typically involves manual steps, however, unforeseen or unexpected interruptions in the flow can occur.

For instance, when an operator packages a medical product into a pouch, they typically pick up the product, and then pick up then pouch. Next, they place the product into the pouch, and then take the pouch to a heat sealer where they apply a seal. Lastly, after the pouch is sealed, they visually inspect the package before putting it into the good disposition bin or placing it onto a take-away conveyor. If the operator is distracted during any one of these steps, errors can occur.

The incorrect product could be put into the pouch, the product could be put into the pouch in the wrong orientation or the wrong pouch could be used. In addition, the seal could be imperfect or missing entirely and/or the packaged could be labeled incorrectly. Engineers need to think through all of these possibilities and determine the best ways to prevent these kinds of mistakes. They need to understand where there are gaps in the packaging process and what the risks of these gaps are, and then work to mitigate those risks.

Why is risk mitigation important?

Risk mitigation is important because if medical devices are not properly packaged, patients can be injured or even die. According to an FDA study, there were more than 1.7 million preventable injuries and nearly 83,000 deaths associated with medical devices over a 10-year period.

Risk mitigation in medical device packaging diminishes significant business risks. If an issue with the packaging process is documented as a recurring issue, the device manufacturer could have to recall the product(s) in question. Recalls are typically costly to conduct, and there are additional costs associated with remediation steps and ensuring that the problem doesn't happen again. Medical device manufacturers can also suffer loss of sales revenue during remediation and considerable reputational damage.

What aspects of packaging should a medical device manufacturer review to mitigate risk?

Medical device manufacturers need to review several different aspects of packaging in order to mitigate risk. For instance, one of the most critical aspects to review is the seal on the package. Medical devices requiring sterility must be packaged with a hermetic seal. This type of seal creates a barrier that prevents microbes from infiltrating the package during the shelf life of the product. To maintain sterility, the seal cannot be weak or incomplete.

Creating a hermetic seal on pouches involves properly aligning the packaging materials in the sealer and then correctly applying the seal. Likewise, for medical devices sealed in tray, the tray must be properly presented to the sealer and the seal must be correctly applied.

Other aspects that need to be reviewed to mitigate packaging risk include ensuring that the correct product and the correct quantity of product is packaged as well as that the product is identified and labeled accurately. Many companies mitigate packaging risks by conducting a "line clearance" between lot runs. That means they completely clear the line of all products, packages, labels, and IFUs between runs.

What process should engineers follow when designing risk mitigation for medical device packaging?

In some cases, engineers begin the process of mitigating risk by taking a historical approach, comparing a new or proposed packaging process to one that the company already is using successfully.

For instance, if the medical device manufacturer is currently packaging a similar product of similar weight, similar barrier requirements, with similar packaging material, or using the same sterilization methods, it can be beneficial to leverage this history. In other cases, it may be more advantageous to disregard history and instead, evaluate the new or proposed project on its own, without any prior assumptions.

Often, it's a combination of the two approaches that is most effective. For example, if two different products use the same pouch, it may be helpful to look at historical data regarding how the pouch materials perform under specified sealing conditions. However, if the products differ in weight, the seal performance characteristics are likely to be quite different with each requiring its own unique process.

What processes are effective for identifying and closing gaps in the medical device packaging process?

One of the most effective methodologies for identifying gaps is the Failure Mode and Effects Analysis (FMEA). Engineers use this method to identify were there may be failures in the package itself or in the assembly.

Another popular method for identifying gaps is the Process Failure Mode and Effects Analysis (PFMEA). This method focuses more on the actual packaging process. Engineers use a PFMEA to confirm the specific actions that operators should take to properly package the medical device.

What is the difference between multi-piece and single-piece flow?

Operators using multi-piece flow process multiple pieces together, at the same time. This is similar to multi-tasking and although it may sound efficient, it usually is not because of the number of potential errors that are introduced.

Operators using single-piece flow handle and package one product at a time and are disallowed from starting the next one until the first package is completely finished. Much of the medical device industry is shifting from multi-piece flow to single-piece flow as a way to reduce packaging risk.

A PFMEA can determine whether multi-piece flow or single-piece flow is optimal for any given packaging process.

Are there other examples where PFMEA is used?

A PFMEA can also help determine the best way for operators to orient a pouch for the most effective seal.

If a pouch is comprised of dissimilar materials, the operator must know which side needs to be placed in the machine facing the operator and which side needs to be placed in the machine facing away from the operator. They also need to orient the pouch correctly so the seal is made in the right place.

Historically, operators have been asked to check their work by simply holding the pouch upside down to confirm the seal (if the product drops out, the seal is not good).

However, newer machines have sensors that can alert the operators if they did not place the package into the sealer correctly. Orienting the lid correctly on a tray is just as critical.

What are the areas to focus on to mitigate sealing risk and ensure a good hermetic seal?

To mitigate sealing risk and ensure a good hermetic seal, the heat sealer used must be maintained to factory specifications, validatable and have alarm capabilities for all process parameters associated with the validated window.

A validatable heat sealer with alarm capability can alert the operator and terminate the seal cycle when there is a detectable variance beyond the validated window.

What is validation and what parameters are reviewed for a validatable window?

For any kind of heat-sealing process, the validated parameters are time (or speed when using a rotary band pouch sealer), temperature, and pressure. To create a hermetic seal for a pouch or tray, the heat sealer needs to be able to deliver a repeatable and even temperature over repeatable time (or speed), and at a repeatable pressure.

Validation provides information about how stable the sealer performs at the required times/speeds, temperatures, and pressures. The validatable window allows for a small amount of deviation from these defined parameters. Then, if the sealer performs outside of that window, the machine alerts the operator to the deviation.

This is a fundamental part of risk mitigation for the seal process. If the validated window is not protected, the operator could unknowingly process the pouch or tray resulting in a poor seal. That, in turn, would allow the improperly sealed package to go out into the field. By the time that medical device is needed, the seal could be broken or have voids in it that allowed microbes into package, creating an infection risk for the end user.

How is a validatable window established with the three variables of time, temperature, and pressure?

A validatable window is established using a process called a design of experiment (DOE). The engineers input different times, temperatures, and pressures and then test the packaging at these various combinations.

They create a 3D mathematical/testing model of the results, which helps them determine the most repeatable recipe for creating the barrier seal for that package. For lightweight medical devices, the goal might be a minimum of a one-pound peel strength.

Heavier products require a stronger peel strength. Ultimately, the goal is to achieve a hermetic seal that can: 1) maintain sterility throughout the shelf life of the medical device and 2) be easily opened in a controlled manner by medical professionals in a sterile setting.

Beyond validation, what other areas are important for seal risk mitigation review?

In addition to establishing a validatable processing window, it is also important to ensure that the medical device being packaged does not interfere with the seal area. If there is product in the seal area, it is not possible to create a hermetic seal.

Ensuring that the product is away from the seal area might involve reducing the opening height of the guarding, ensuring that the product can't migrate into the seal area, or using height indicators that produce an alarm to notify the operator that the product is too close to the seal area.

Risk mitigation review should also include the labeling process. All labels must be applied correctly so that they do not encroach upon the seal area and interfere with the creation of a hermetic seal.

What Features Are Important to Review When Evaluating Heat Sealers?

One of the main features to review when evaluating heat sealers is process control capability for temperature, seal dwell time/speed and pressure as well as the ability to interface with the heat sealer for data acquisition, operator identification and recipe control.

Capabilities for controlling process parameters such as temperature, pressure and time

When evaluating heat sealers, it is critical to review each machine's capabilities for controlling process parameters such as temperature, pressure and dwell time.

For packaging medical devices, temperature is one of the most critical process parameters to control, but it can also be the most challenging.

Constant heat sealers heat to a specific setpoint, which then must be maintained within the validated window. Impulse heat sealers heat up and cool down for each seal, and the entire cycle must occur within the validated window.

The amount of pressure applied to the seal must also be carefully controlled. If too little pressure is applied, there is not intimate contact of materials in the interface layer and the seal will be spotty or too narrow or weak. If too much pressure is applied, the adhesive in the interface layer may squeeze out or the packaging materials could be thinned.

One of the best ways to ensure a repeatable pressure process is to use seal bars that apply direct force versus a cantilever design. It is also beneficial to have a protected air reservoir such as an air accumulator tank within the regulated side of the pneumatic system of the heat sealer. This ensures that the sealing process is not subject to other equipment that might be cycling in the plant between the machine and the

air compressor. Having a protected air reservoir inside the heat sealer helps guarantee that the sealing process is protected and the risk of other equipment cycling at the same time is mitigated.

Capabilities for HMI, the interface with the heat sealer, and data storage

It is also essential to review each heat sealer's capabilities for communicating with operators when functions fall outside of the validation window. Alarms help operators ensure that they are not putting incorrectly or improperly sealed product into the good disposition area. CeraTek tray sealers have a light tower, and the HMI is mounted on the swing arm. That way, regardless of where the operator is standing, they can always see the messaging that is on the HMI.

The light tower also includes a green light that, if illuminated, notifies the operator that at least from a time, temperature, and pressure process standpoint, the seal cycle was completed without encountering any alarms. Of course, that doesn't necessarily mean that there is a good seal. The lid could have been put on upside down, the product may not be fully seated into the tray, etc. Errors like these can be mitigated with cameras and sensors that can detect that a lid is oriented correctly, that the tray is fully seated into the tool, and that the product is fully inserted into the tray.

What other features are important to review when evaluating a tray sealer?

It is critical that the tray sealer deliver consistent heat across the entire usable seal area. CeraTek uses a blanket style heater that is wired in series so that one line comes into the heater, makes a closed-circuit pattern throughout the entire heater, and then exits out of the heater.

The custom heater pattern ensures a very even temperature profile across the entire usable seal area. Other tray sealer manufacturers use cartridge style heaters. These heaters use rods that run parallel through the heated dye so that, theoretically, the heat will migrate from the rod to the areas in between the rods.

However, what actually happens is that there are hotter areas underneath the rods and cooler areas between them. That means there could be one tray flange underneath the rods that could be getting good heat exposure and another tray flange that is in-between the rods that could be at a lower temperature exposure and so not able to create a good hermetic seal.

Cartridge style heaters also introduce a risk that a failed heater rod could go undetected during a run. This cannot happen with CeraTek's blanket style heaters because they are wired in series, and if one zone fails, then the entire heater fails. CeraTek has been selling heat sealers since 1996 and has never sold a replacement heater due to a failure in the field. Our heat sealers are known for their reliability and durability, which are especially critical for medical device manufacturers.

For tray sealers, it is also important to review platen orientation and which platen moves in a tray sealer. CeraTek tray sealers have a stationary top platen. During the sealing process, this platen heats up and the tool is moved up to it. That enables extremely precise parallelism between the top heated die plate and the bottom tool area. In fact, CeraTek's four post guided press maintains parallelism within five thousandths of an inch for the life of the machine. This extremely precise parallelism makes it possible to deliver an even amount of pressure across the entire tool area.

What role does automation play in risk mitigation for medical device packaging?

Automation provides unique opportunities for the medical device industry. First and foremost, automating a packaging process removes the operator from the process, eliminating the risk of human error, which is the greatest risk. When a packaging process is automated, the machine is programmed to complete a particular set of steps in a particular order. That process can be validated, ensuring a repeatable and reliable process.

The downside of automation is it is significantly more challenging to validate. Validating a piece of automation takes repeated testing and trial and error, as engineers introduce variables to impact the process in different ways. By contrast, a human

operator is able to look at a package and decide that it doesn't look quite right (without knowing the reason why). In other words, they can assess variables that may have not been tested.

Risk mitigation is very frequently just trying to engineer out the distractions that we know operators experience and where there might be gaps in that process where a distracted operator might make a mistake. This makes automation a good fit for longer runs, longer lifecycle products, where there would be a return on the upfront investment needed to validate the process.

Likewise, automation may be optimal for a high value product that has a very complex packaging process with many risk factors. In this case, the validation process associated with automation may be worthwhile to ensure that the high value product does not have the opportunity for risks related to a human process.

Why is automation such a good fit for rotary band sealers, continuous sealers, and pouch filling devices?

Using automation with rotary band sealers, continuous sealers, and pouch filling devices is becoming increasingly commonplace because it can increase throughput and mitigate risks caused by human error.

Automation can be used for packaging, for inspection and counting of the finished packages, and for segregating of finished packages by whatever parameter is required. With automation, operators do not have to worry about making mistakes. The entire process is handled automatically.

If errors occur, they can be detected by sensors, and the incorrect packages are diverted to a reject bin. Alarms notify operators if any of the automated processes fail.

What are the future trends in medical device packaging risk mitigation?

CeraTek is committed to identifying areas for improvement and then

implementing these improvements to benefit our customers. To that end, we are currently working on integrating our heat sealers with load cells that measure the amount of force being delivered to the seal area.

This will ensure that the sealing die is closing fully and has delivered the correct amount of force. It could also offer an opportunity to start and end the dwell time off of a force window that is saved in the recipe.

These features will allow the heat sealer to maintain the desired seal pressure and risk mitigation features, while still controlling and alarming for the correct input pressure. We are also actively pursuing an automated seal inspection for our pouch sealer. This would be a system through which the sealed pouches automatically index for inline nondestructive seal inspection and it would satisfy the medical device industry requirement for Container Closure Integrity Testing (CCIT).

More and more medical device manufacturers are requiring CCIT systems in their sealing equipment to ensure that every package that comes out of the heat sealer is inspected according to a programmed set of inspection pass-fail requirements. In automated environments, it is not subject to manual inspection by an operator, who may or may not make the correct judgment call, or who may or may not get distracted.

What's important to look for in a heat sealer manufacturer?

When evaluating heat sealer manufacturers, it is essential to find one that fully understands your particular project and has experience solving similar challenges. CeraTek focuses on solving problems, not simply selling machines. We partner with our customers and work together for shared success. Our goal is to provide our customers with the packaging solutions they need to get their products safely, reliably, and efficiently to the people who need them.

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