White Paper

Package Integrity in the Food Industry

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1. Introduction

The impact of weak sealed seams on package integrity—ensuring product protection and safety by using 100% on line systems.

Protecting the product is the main purpose of a package. Package leaks are very critical especially in the food sector, with possible impacts ranging from a loss of nutrients and aroma to premature spoilage loss of perceived quality and brand. In addition, other products may be contaminated by leaking package contents.

This whitepaper explains the significance of contaminated sealed seams and presents the packaging technologies available to prevent them.
2. The packaging industry: facts and figures

Most food packages are made of plastic (44.7 %), followed by paper and cardboard (30 %), metal (13 %), and glass (7 %).
The industry as a whole grows. The worldwide market value of packaging materials for food exhibits an annual growth rate of 4.5% between 2012 and 2017, while the global flexible packaging volume of food products is projected to grow by 5% between 2010 and 2020. A similar growth rate of 4.87% is expected for the global market value of FFS devices (form-fill-seal) between 2015 and 2020. Therefore, heat-seal packaging and modified-atmosphere packaging (MAP) are growing since a couple of years.

2.1. The package of tomorrow

New technologies, higher standards and growing consumer expectations result in challenges for future packaging technologies. The package of tomorrow should:

- be environmentally friendly and recyclable,
- increase the food’s shelf life,
- be made of material leading to lower production and shipping costs,
- ensure food safety and traceability,
- be compatible with high production rates, ultra-high filling speeds and fast changeovers,
- be user-friendly (easy to open and close),
- improve the freshness protection of the food,
- enable quick product changeovers for individualization by the development of new bag designs and digital printing.

Only few packages meet these criteria, including top-sealed trays or FFS bowls, vacuum packages and flowpacks. Last but not least, they ensure optimum presentation of the product.

Reasons for seal failure

- Seal parameters: 70%
- Mechanical failure: 60%
- Contamination by food: 50%
- Other: 40%
3. Heat-sealing for quality and safety

The main purpose of a package is to contain, protect and preserve the food and to inform the consumer. Modified-atmosphere packaging (MAP) can increase the shelf life of food and improve the attractiveness of a product for the retail business by offering a pleasant package.
The primary purpose of the package is to ensure the protection and integrity of the product. Therefore, the package must be safely sealed. For plastic packages, this can be done on the packaging line using heat sealing, by application of a cap (e.g. a screw cap) or by using glue. Highly error-prone packaging sectors include heat-sealed seams and screw caps because any damages can lead to leaks, letting the package lose its preservative effect.

Product protection and effective shelf life depend on the quality of the package sealing. The thickness of the film affects the stability of the sealing. Seal integrity can be evaluated as part of the in-line quality function by checking the package using standard devices by applying pressure or vacuum. Thus, it can be checked how fast air or oxygen can escape through the seals and even pack resistance to pressure.

MAP and retort packaging are made of thermoformed or preformed base either in a flexible pouch or bag. Concept rely on closing the pack and ensuring whole air-tightness by heat sealing once the product has been filled onto. Packaging machine seals the container after filling operation. Many criteria influence proper tightness of the container: temperature during the sealing process, storage and distribution, exposure to light, gas composition inside the container, handling operations during life of the pack.

3.1. Heat-sealing for protection and increased shelf life

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Seal protects the product and must resist to the product life cycle

<table>
<thead>
<tr>
<th>Put in boxes</th>
<th>Transport to the retailer’s</th>
<th>Unpacked</th>
<th>Filled in the shelves at the retailer</th>
<th>Taken away by the end consumer</th>
<th>Stored at consumer’s home</th>
</tr>
</thead>
</table>

From 8 days to 24 months

3.2. Compliance criteria for heat-sealed packaging

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Product packages can influence many of these factors. Developments in packaging materials aim to mitigate the impact of these environmental factors, thereby increasing the shelf life of the food. In specific cases, the package itself can increase shelf life, for instance by completely blocking light and oxygen. Quite often, however, the package will only be one of many factors that would have no impact alone but can increase the product’s shelf life when they are combined.
The quality and safety of heat-sealed packed food is degraded if the integrity of the seal is lost during the required shelf life of the package. Any break or leak in the heat-sealed seam results in a rapid loss of the modified atmosphere within the package. Therefore, the sealing process is a critical inspection point that must be monitored by the quality-control procedures during production.

The presence of an organic particle in the sealing area is likely to develop and cause a leak during its shelf life. Thus, adding the following criteria for the seal quality; cleanliness with the absence of foreign material in the seal area.

A defective seal resulting from contamination or creasing allows the gas mixture to leak out with the following results:

- The product appears to be less fresh, e.g. in the case of beef, a red colour is better than dark brown.
- The growth of micro-organisms, especially aerobic but also anaerobic, with contamination of the food (mould, bacteria, etc.)

A faulty seal generated by contamination or creasing causes the gas mixture to leak and will produce:

- The development of microorganisms
- Decrease in the freshness index of the product.
- Soiled packaging during transport

3.3. Correct gas composition for increased shelf life

Microbial growth, color changes and oxidative rancidity are among the most significant factors degrading the shelf life of boiled, cured or processed meat products. In boiled meat products, the heating process should kill any vegetative bacterial cells, deactivate any decomposable enzymes and fix the color. Therefore, spoilage of boiled meat products can be primarily attributed to a contamination with microbes due to bad hygiene and inappropriate handling procedures. As the color of boiled meat is prone to oxidation, it is important to allow only small amounts of residual oxygen in the package.

3.4. Contaminated sealed seams are the most significant weakness of leak-tightness

Sealed seams are the most significant weakness regarding the leak-tightness of heat-sealed packages. In fact, most leaky packages can be attributed to contaminated seals.

According to the survey “Seal Integrity and the Impact on Food Waste” conducted by the Waste and Resources Action Programme (Wrap) and researchers at Lincoln University in 2009, product contamination around the sealed seam is the most frequent cause of seal failures. It was also determined that seal problems are more frequent if the products include liquid or crumbly ingredients.

Critical weaknesses of leak-tightness include air bubbles in the seal zone. Contaminations can also be a significant problem if a product includes sauce, oil or fat and is manually loaded on trays. For instance, if a protein with sauce is manually put or bailed into the tray, fat or sauce can contaminate the flange of the tray. This, in turn, can adversely impact the bond between the sealing zone of the film and the tray, leading to weak seals that can degrade over time. Seal contamination can also occur with meat and ready-to-eat fruit salads because juices and diaphragms can negatively impact the seal.
4. Seal-testing systems

Most seal-testing systems are unable to detect contaminations in the seal area. Although they can detect existing leaks resulting from holes in the film with diameters of 0.25 mm or greater or from unsealed creases in the sealing zone, organic contaminations or unsealed interior areas are not detected as standard.
On the other hand, solutions like vision inspection systems identify any weaknesses on the whole production and automatically eject any packages that do not meet the pre-defined criteria.

Big asset of vision is that it is contact-free, not destructive and 100% even at very high output. The integrity of seals and packages can be checked using destructive and non-destructive tests. Destructive testing methods immerse the package in water to check for any bubbles near the seal. Other testing methods subject the package to compressed air until the seal fails. Non-destructive tests, however, are based on measuring pressure changes originating from packages in closed vacuum chambers.

### 4.1. Criteria for quality control of pouch packages

The following criteria must be met by a successful quality-control system for pouch packages:
- Selection and continuous monitoring of laminate materials
- Regular checks of shaped pouches for seal strength, product stability and indications of perishableness and flawlessness
- Careful selection, maintenance and inspection of the filling, sealing, processing and handling devices
- Specifications of inspection measures for product recipe, processing (viscosity, ventilation, filling temperature, etc.) and filling (feed quantity and absence of contaminated sealed seams)
- Inspection and testing of cap seal for fusion, flawlessness and possible contamination following the sealing process
- Control of critical parameters that have an impact on processing (incl. maximum pouch thickness and residual air content)
- Standardized retort processes using only recommended process times and temperatures to ensure optimum processing
- Regular inspection and checking of retort equipment and inspections ensuring equal heat distribution
- Optical inspection of all pouches to control the seal after processing
- Processing and handling of only dry pouches and packing into single or collective packages that have been specifically tested to provide appropriate stability
- All inventories should routinely be on stock within 14 days before shipping and should be free of spoilage
- Careful recruitment and training of staff at all levels

Examples of leaky seals and contamination in the sealed seam or within the seal. For instance, in-line seal tests can detect unsealed seal areas with a width of less than 2mm. Sealed-seam inspection using SealSecure helps to detect contaminations, excessively narrow sealed seams and unsealed areas within the seam. A combination of SealSecure and in-line seal tests ensures that all contaminations and flaws within the seal seam are detected.
4.2. Visual inspection fills the gap

Although seal checks will detect any leaky packages, they are unable to detect potentially leaky packages beforehand. Causes of leaks include contaminations of the sealed seam or excessively narrow seals. Flaws like these can degrade the package’s lifetime, which in turn reduces the product’s shelf life.

Visual inspection systems can help by detecting unsealed interior areas including air bubbles in the seal that weaken the seal during its long lifetime. Vision systems like Bizerba SealSecure system cover a wide range of packages. The inspection system generally detects sealed seams as well as labels and indications on the top and bottom of the package, ejecting faulty packages and defective products before entering the cartoning stage.

- Poor quality sealing examples

- Seal inspection with inline leak testing

- Seal inspection with SealSecure

- Combining SealSecure and in-line leak testing guarantees tightness for the life cycle time
5. Solutions provided by Bizerba

Vision inspection system SealSecure: end-to-end visual package inspection.
Vision inspection system SealSecure

Optical sealed-seam inspection: SealSecure meets all the key criteria for optimum product quality by ensuring a clean, flawless sealed seam. The system checks packages for faulty sealed seams, automatically ejecting any packages that do not meet pre-defined criteria. SealSecure checks sealed seams of packages for contamination and quality. The optical system prevents rework on defective packages not meeting the seal specification as well as complaints and product recalls. SealSecure notifies operators in case of any faults or production problems, enabling corrective measures to be taken immediately to ensure the quality of the sealing process.

SealSecure ensures the integrity of the seal and automatically contributes to complete traceability by archiving all product images during production and monitoring production lines with regular production reports. The system can be used with a wide range of packages and provides a wide variety of inspection options.

Application:
100-percent checks for contaminated seals

Highlights:
- Contactless, non-destructive seal-integrity inspection
- Prevention of leaky packages in retail
- Automatic rejection of packages not meeting the reference criteria
- Modular design to allow integration of a broad range of sensors according to inspection requirements
- Suitable for packaging lines with automatic product changeover
- Suitable for many packaging types: Thermoformed or top-sealed trays and flow packs with transparent, partly colored or printed seals
- Upgradeable for future requirements
- Hygienic design and time-saving cleaning
- Software for complete traceability of all products: Archiving of all images including date and time, counter, production and machine logbook

- Safe, straightforward operation:
  - Intuitive user interface with color touchscreen
  - Offline parameter-setting enables manual parameter adjustment based on stored images on the device itself or on a PC
  - Easy to integrate into existing production lines, max. 2 m incl. rejection stage

SealSecure can even be embedded in thermoforming (FFS Form, Fill and Seal) machine to an immediate detection of improper sealing and even more efficient for flexible pouches.

Seal check can be associated to label check with the PackSecure range.
New technologies, high standards and increasing customer expectations result in growing challenges for the food industry regarding product packaging.
Apart from protecting the product against spoilage, packaged goods should be kept fresh and non-perishable, combined with maximum user-friendliness and sustainability. Issues including production and transportation costs, traceability, consumer information and the potential for rapid product changeovers also play an increasingly important role.

Advanced packages include sealed trays or FFS bowls, vacuum packages and flowpacks. A high level of quality and product safety is ensured by effective hot sealing using MAP packaging machines because many factors influencing the product’s shelf life, including temperature, relative humidity, light and the gas composition, can be checked and controlled through the packaging process. However, the product will spoil prematurely if the integrity of the seal is lost during the lifetime of the package. Thus, the sealing process is a critical inspection point that must be monitored during production as part of the quality-control measures. Additional weaknesses include air bubbles in the seal zone and contaminations.

Most seal inspection systems are unable to detect contaminations. Only a combination of optical inspection systems and in-line seal tests will find all possible contaminations and faults within the seal. Optical inspection systems check packages for faulty seals, automatically ejecting all packages that do not meet the pre-defined criteria. Apart from checking contaminated seals, vision inspection systems also detect faulty or missing labels or product indications. Operators are immediately alerted so they can take corrective actions and sort out any faulty products.

Modern packaging and inspection systems effectively protect perishable goods from a loss of nutrients and aroma. Furthermore, consumers receive user-friendly packages, and complaints and product recalls can also be avoided.
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