The Vision Inspection Guide

Building an Effective Programme

METTLER TOLEDO

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Introduction

For any product, a strong brand reputation is an invaluable, yet potentially vulnerable asset, which must be protected at all costs. Brand reputation can easily be damaged by negative factors such as customer complaints, product safety concerns and product recalls; however, vision technology provides an inspection solution that examines all products on a production line with a high level of accuracy, making it an extremely effective means of protecting against risks.

Nevertheless, simply using appropriate vision inspection technology and hardware on their own is not enough to ensure truly effective product protection; vision inspection should be part of a turnkey production-line product inspection program – and if implemented correctly, it can help to protect, preserve and build a strong brand reputation, both now and in the future.

The primary purpose of this Guide is to help you decide which elements of a vision inspection program you need, and which types of vision inspection technology will best suit your production processes.

This Guide also contains a detailed summary of typical reasons for product recalls which a vision inspection program will help to identify, followed by a detailed introduction to the types of vision technology which are currently available.

The Guide then concludes by describing how to build an effective vision inspection program that will help protect your products, your brand and your consumers.

The vision inspection processes described in this Guide are applicable to many types of manufacturing environments, although the primary focus is on the manufacturing and packaging of consumer products in ISO-certified environments covered by HACCP (Hazard Analysis Critical Control Points); consideration is also given to those pharmaceutical manufacturing facilities governed by 21 CFR Part 11 (Code of Federal Regulations).

Notes

Introduction to Vision Inspection Programs

A vision inspection program is an essential tool for enhancing the efficiency, quality and productivity of operations such as manufacturing, assembly or packaging. Vision inspection achieves these aims by preventing defective product from being distributed to consumers; vision inspection also monitors for excessive defects, and provides warnings when they occur.

1.1 Introduction to Vision Inspection Programs

In recent years, retailer and end-consumer product expectations have increased; consequently, people have become much less patient with poor product quality – especially when it leads to health risks.

However, if a vision inspection program is correctly implemented and managed, it can become a powerful tool that will:

- Protect manufacturers, retailers and consumers from the consequences of mislabeled packages and unidentified allergens
- Safeguard the reputation of a brand
- Help companies adhere to industry Best Practice guidelines
- Conform to retailer standards

Research shows that 65% of consumers refer to the packaging when buying products. When confronted with a poor-quality package — for example, a package with a wrinkled or torn label — consumers are overwhelmingly likely to pick a different product.

PackagingWorld.com, a major Canadian packaging materials supplier, confirms that 55% of food industry recalls are caused by improper labeling; and a frequent problem arising from improper labeling is the omission of ingredients that can cause consumers to suffer allergic reactions or even death. This can result in irreversible damage to a company brand, as well as the exceptionally high costs of a product recall. Additional negative outcomes can include re-work, replacement costs, disruptions in the distribution channel, fines and lawsuits.

There is, therefore, a clear need to preserve the integrity of brands, to protect customers, and to satisfy rising consumer expectations. That's why most companies that originally relied on human inspectors are now implementing vision inspection programs.

These programs allow manufacturers to detect and reject products which are defective for a number of different reasons; it could be that the containers are not completely filled, that they have incorrect labels – or perhaps because they have wrinkled labels or improperly fitting caps.

Unlike human inspectors, vision inspection systems never blink, never tire, and are able to detect 100% of the defects that they are programmed to capture. This virtually guarantees that a defective product will never reach a consumer.

As well as detecting 100% of product defects, vision inspection systems are also programmed to:

- Compare production-line packaging with 'ideal' images (i.e. images of what the correct product should look like) – and reject products which do not match
- Measure product dimensions and reject out-of-tolerance product, such as:
  - Label x & y position
  - Label skew
  - Cap height
  - Cap skew
  - Read data on products to verify that correct data is shown and is printed to acceptable quality standards
- Count the number of products in a case or package, and reject it if there are too few or too many items

While every vision inspection system performs essential functions, most manufacturers require some level of customization in the development of their specific system. For this reason, system purchasers should be cautious of vendors claiming to have 'one-size-fits-all' solutions; systems perform best in their own tightly controlled, highly specialized environments.

Reasons for a Vision Inspection Program

When considering the advantages of investing in a vision inspection program – and whether that program will add value to a production process - it's important, firstly, to consider the reasons why an organization should want to acquire a vision inspection system.

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Reasons for a Vision Inspection Program

This chapter describes how manufacturers can benefit from a vision inspection program, for the following reasons:

- Minimizes quality defects
- Helps to protect customers and consumers
- Protects companies, their brands and reputations
- Delivers a worthwhile Return on Investment (ROI)
- Supports adherence to industry Best Practice guidelines and standards
- Minimizes the risk and impact of product recalls and returns

2.1 Minimizing Quality Defects

Dealing with production-line quality problems can reduce output, particularly on high-volume automated lines. However, the costs incurred by such losses can be easily overshadowed by the problems arising when a defective product is discovered by the customer or end consumer after it has left the packaging facility. These problems can result in product recall, damage to the brand, adverse publicity – and even potential legal action.

Time and money spent preventing such problems from arising in the first place yields a far better return than the time and money spent solving those problems after they have occurred. A correctly implemented vision inspection program will lead to fewer defective products, provide statistical data to improve production processes, alert operators to increased failure rates, lower associated costs, as well as improved customer and consumer satisfaction; this, in turn, will lead to higher profitability and more effective protection of the manufacturer's brand.

2.2 Protection of the Manufacturer and Consumer

Modern manufacturing techniques are constantly improving so as to reduce quality defects; however, there is always the risk that processes or procedures can break down, resulting in defective products reaching the market.

Manufacturers and their employees have an obligation to customers and end consumers to minimize the occurrence of these events; they should also ensure consistent product quality and take all possible steps to protect the welfare of the end user. A proactive approach to quality management will make a major contribution to supporting improved relationships with retailers; it will also help to protect future business opportunities.

2.3 Protection of Brand and Reputation

Strong branding gives retailers and consumers assurance of product safety and quality. Positive branding is frequently responsible for generating repeat purchases, making it an important contributor to maximizing sales. Positive branding and a solid reputation can also justify premium product pricing.

For these reasons, organizations have a duty to protect brands, which are important assets that need to be managed carefully and must be protected from adverse publicity. In the event of a company being investigated as a result of a customer complaint, appropriate documentation will provide tangible evidence that the manufacturer had the correct product protection programs in place.

2.4 Return on Investment

Implementing an effective vision inspection program can also offer a quick, positive Return on Investment (ROI). This invaluable contribution to performance and profitability can be secured when first acquiring and applying an effective vision inspection program.

When calculating ROI, the main factors to consider include:

- Reducing product recalls and returns
- Avoiding retailer fines for delivering defective product
- Reducing the number of staff required to visually inspect product
- Ensuring faster notifications of quality issues in order to reduce the number of defective products manufactured (this reduces the amount of scrap and/or wasted product and packaging)

The Return on Investment resulting from avoidance of fines and a reduction of product recalls can be difficult to measure in financial terms; therefore it is frequently considered to be an intangible factor and is ignored for the purposes of calculating ROI. Avoiding fines and reducing product recalls are, however, important financial benefits which should be borne in mind when making sure that a vision inspection program is installed and managed effectively.

When a vision inspection program has been designed and set up, it should provide many years of on-going benefits; however, manufacturers should be aware that changes to products and packaging over time can make certain vision inspection systems obsolete, reducing the system's value and effectiveness over time.

It is critical, then, to consider potential product changes and to seek out a flexible design when specifying a vision inspection system. This will ensure that the system will continue to perform at peak capabilities, delivering the greatest potential value well after the initial Return on Investment is achieved.

2.5 Adherence to Industry Best Practice and Industry Standards

While new laws have significantly increased requirements for product packages and labeling, manufacturers are not legally required to install vision systems. However, if legal action is taken against a manufacturer as a result of a mislabeled product, the vision system can be an invaluable tool to help prove that the manufacturer has followed Due Diligence procedures.

Failure to demonstrate Due Diligence could result in serious consequences – and it's worth bearing in mind that Due Diligence is easier to prove when an organization has a documented system which continuously assesses risks to product safety and allocates resources to minimize those risks.

Vision inspection systems are a valuable tool for the maintenance of proper quality standards, which are often the focus of customer or retailer audits, especially if those audits are used as Critical Control Points in a HACCP (Hazards Analysis & Critical Control Points) program.

The benefit of having a vision system as part of a wider HACCP program is that the required documentation will already be in place to provide evidence that the system is being used correctly, as part of a plant-wide quality program.

Audit types that will benefit from a fully documented program comprise:

- Internal food safety and management system audits
- Retailer audits
- Quality management system audits e.g. ISO9001:2000
- HACCP audits, including BRC, IFS, SQF 2000, and ISO 22000

Vision System Return on Investment Calculator

Item		Enter your data	Sample data
A	Parts per minute produced		500
B	Hours of production per day		8
C	Days of production per week		5
D	Average fully burdened hourly rate of inspectors		$18.00
E	Number of inspectors		1
F	Estimated defects as a percentage of Production per week (PPW)*		1.0%
G	Additional finishing costs to products (packaging, additional processing, assembly etc)**		$0.10
H	Dollars spent on Vision system		$70,000.00

* This calculation conservatively assumes no difference in percent defects identified between human and vision system. In actuality, a vision system will identify 100% of defects it is programmed to identify – significantly more then a fatigued inspector on a high speed line.

** This calculation assumes that products deemed to be rejected have incurred the full finishing costs.

PPW = A x 60 x B x C		1,200,000 parts
Inspection Cost per week (ICPW) = B x C x D x E		$720.00
Cash added each week to flawed products (CAFP) = PPW x F x G		$1,200.00

ROI (Return on Investment) in weeks

ROI calculated by added cost to flawed products = H / CAFP		58.3 Weeks
ROI calculated by cost of inspectors = H / ICPW		97.2 Weeks
ROI for both cost and labor savings = H / (CAFP + ICPW)		36.46 Weeks

2.6 Minimize the Risk and Impact of Product Recalls and Returns

These days, defective products are resulting in ever more complex and difficult consequences when they reach end consumers. Increasingly aware of their legal rights, consumers are now far more likely to take legal action when they find a faulty product. They are also more likely to contact the media or share their dissatisfaction on social networks in order to draw negative attention to a producer or to make money as a result of selling their story.

In order to protect themselves when faulty products reach end consumers, retailers are also taking precautions – often by demanding fines from manufacturers, should they supply faulty products.

As well as having to deal with the negative (and often costly) actions of consumers and retailers, manufacturers are also responsible for the costs of removing faulty products from the market. Furthermore, there are also significant costs due to the disruption of distribution channels due to product removal and replacement (i.e. the cost of expedited manufacturing and delivery), as well as lost business due to products not being present on retailer shelves. All these consequences can be devastating to a manufacturer's short-term and long-term business success (see example of a Recall Notice right).

Fortunately, an effectively installed and well-managed vision inspection program can provide a great deal of help to manufacturers who want to make sure that defective product does not reach the market.

A vision system can detect a wide range of defects (see chapter 8) – and, reassuringly, it can inspect 100% of products in real time, rejecting any product which is defective, and so preventing it from reaching the market.

Typical FDA Recall Notice

Announce Voluntary Recall due to Incomplete Allergen Labeling

WEDNESDAY, 05 MAY 2015 07:30
PRESS RELEASE RECALLS

OHIO – (ENEWSPF) – May 5, 2015. Initiating a voluntary recall of select boxes of Product X, because the outer containers of some of the boxes were distributed without a complete allergen precautionary statement. Consumers who have allergies to peanuts run the risk of serious or life-threatening allergic reactions if they consume products containing peanuts.

The boxes of Product X are seasonal items distributed nationwide in supermarkets and club stores. The only products involved in the voluntary recall include Box Product X distributed during the 2009 holiday season with day codes beginning with 9XXX through 9XXX, and a 'Best By' date of June/July 2010. The UPC codes for the affected products are 5XXXX-6XXXX for the retail version, and 5XXXX-6XXXX for the club store version. No other products are impacted by this recall. The defect was brought to the manufacturer's attention by a consumer complaint, but no illnesses have been reported.

The components contained in the boxes were completely labelled, including a precautionary statement on one component stating: 'Made in a facility that also processes peanuts'. However, the outer containers of some of the boxes were distributed without a complete precautionary statement. As the health and safety of our consumers is paramount, we are initiating this voluntary recall. We have advised the U.S. Food and Drug Administration and will cooperate with them fully in this voluntary recall. Providing safe, high quality products to our consumers is our number one priority.

Consumers who are allergic to peanuts and who have purchased the recalled products are advised not to consume them. Instead, we ask these consumers to contact Consumer Services directly for instructions. Consumers should not return Product X to retailers.

Consumers with questions should contact Consumer Services at and/or visit their website.

Key Design Features

If a vision inspection system fails, the manufacturer faces a difficult choice: stop production until a service engineer visit can be scheduled, or continue running the production line whilst risking the manufacture of faulty goods.

3

Key Design Features

3.1 Factors to consider when selecting a vision inspection system

The best way for a manufacturer to avoid this unwanted challenge is to select a vision system that delivers exceptional reliability and performance. This chapter provides valuable information on the key factors to consider when selecting a reliable vision inspection solution that will provide years of dependable service.

Put simply, manufacturers should seek a vision inspection solution capable of delivering consistent, reliable detection and rejection of faulty products, without false rejection occurring. This will win the confidence of both line operators and management, ensuring the best long-term protection of both the brand and product customers.

At all costs, it is important to avoid systems that are subject to erratic detection, a complex set-up, and generation of false rejects – all of which lead to difficulties with production and dissatisfaction by operational staff. In most circumstances, it is best to choose a vision systems provider who has standardized offerings with configurations designed to address these factors from the start.

Stability

Stability is the distinguishing factor of a top-quality vision inspection program, and highlights the difference between equipment sensitivity and performance. In this instance, 'performance' is a measure of equipment capability under full-scale plant operating conditions.

A stable vision inspection solution can operate consistently without false rejects or erratic detections, and should not require frequent adjustment. When tested in a laboratory, most vision inspection systems will show similar sensitivity levels side-by-side; however, over an extended period on a production line, significant differences become evident – so an unstable solution (particularly when linked to an automatic reject device) can quickly become a focus of criticism.

Repeatability

In addition to false rejections, instability may cause the defect detection rate to vary over time. Having a solution that correctly detects the test sample(s) repeatedly every time it is used (over a period of weeks or months) instils confidence in the user and ensures that defective product is detected, so that it can be removed from production.

Ease of Set-up

A vision inspection solution which has a complex or confusing set-up procedure is unlikely to be properly calibrated during installation or product changeover. By contrast, a vision inspection solution with a straightforward set-up should be simple and easy to adjust by the user right from the start. In fact, after initial training, the user should be able to change product profiles and run the machine without further reference to an instruction manual.

This is why the presence of logical procedures and an intuitive Human Machine Interface (HMI) are so important when choosing a suitable vision system; together, the presence of these factors means that the user does not have to memorize special sequences, and they allow changes to be made correctly long after initial training is given.

Flexible design

One of the significant benefits of using a complete vision inspection system is that this kind of system is designed in order to accommodate modular hardware components, software and flexible frames. These allow the system's inspection capabilities to grow as manufacturers' inspection needs increase, saving time that would otherwise be spent designing a new system.

3.2 Design Factors for Vision Inspection Systems

Environmental Protection

Any vision inspection system's design should take into account the hygiene requirements of the product, and should also be compatible with the hygiene demands of the environment in which the system will operate.

If production conditions are particularly demanding, then the vision inspection solution should be constructed to withstand such harsh conditions, which may involve wash-down and sterilization routines.

For producers of meat, poultry, dairy and similar products, a vision inspection solution's inability to withstand frequent heavy-duty wash-downs is a common problem; and when a vision inspection solution suffers from water ingress, its repair is often both expensive and time-consuming.

As long as performance parameters are correctly specified at the time of purchase, system performance should remain unaffected when equipment is subject to water or steam on the production floor.

Vibration and Ambient Light Immunity

Every vision inspection solution uses light to create contrast between the inspected area and the background. However, if ambient or shifting lighting conditions in the production environment are present; the system could struggle to operate effectively.

In addition, if there is unplanned movement of the product in relation to the cameras, this will lead to false rejects or will result in defects not being rejected. For example, vibrations along a production line can slowly move cameras out of alignment if they are not secured properly. Such vibrations can also shift products so that the spacing changes; this can result in cameras failing to properly acquire images.

To avoid these undesirable outcomes, the vision inspection system must have correctly designed mechanics, software, and lighting configurations. Solutions that fail to take these factors into account will require additional maintenance and monitoring to keep them operating effectively.

3.3 Product Handling

It is critically important that products are presented properly to the cameras in the vision inspection system, so as to ensure that the inspection is taking place correctly. The inspection could be compromised if, for example:

- Products are too close together
- The product does not present the inspected area consistently
- The product is unstable
- Product accumulation occurs at point of inspection or point of rejection
- Productions rates exceed the maximum inspection capabilities of the system

The vision inspection solution provider should take all these matters into consideration when developing the system, and when developing any product-handling hardware that may be necessary. (See chapter 6 for more detail)

3.4 Reject Mechanism Design

Ineffective reject systems, generally caused by poor tracking of products on the line, are probably the weakest part of most vision inspection systems, and result in defective product not being effectively and reliably rejected from the production line.

A correctly specified solution should be fool-proof, and should be capable of rejecting all defective products under all circumstances. (For more information on reject mechanisms, see chapter 5)

3.5 Hygienic Design

Vision inspection systems operating in hygienic environments should follow hygienic design principles; in other words, the design should be free of possible dirt traps and allow for easy cleaning. Design features should include:

- Elimination of cavities/bacterial traps
- Sealing of hollow sections
- Avoidance of ledges and horizontal surfaces
- Use of open-design continuous welded frames, for easy access and cleaning
- Hygienic management of electrical cables, trunking and pneumatic services

3.6 Failsafe Solution Design

Consideration should be given to what will happen if a vision inspection system fails to function properly (e.g. a reject device does not remove defective product, or some other system fault occurs). It is good practice to integrate fail-safe design features into the vision inspection system, so as to minimize the possibility of malfunction and its consequences – for example, reject confirmation systems can be used to confirm that the defective product has been rejected into the reject bin, while sensor fail-safes can be implemented to fault should any sensors be disconnected or blocked for too long.

3.7 Mechanical Design

A vision inspection system's mechanical design is determined by the camera(s)' field of view, lenses and light source. Mechanical design must also account for the existing production line and hardware, including line height, available free space and any machine safety regulations in place. When designing the mounts for the cameras and lights, the components of these mounts must be protected against vibration or shock; they must also be capable of being easily adjustable, as necessary.

In addition, the positions of the cameras and lights themselves must be easily adjustable when the areas of inspections change. The cameras also need the ability to be locked down after adjustment, to avoid being moved accidentally by operators. For ease of positioning, cameras and lights should be able to move independently of one another when making adjustments.

3.8 Inspection Speed

While minimum and maximum inspection speeds rarely become limiting factors for vision inspection solutions, there are definitely maximum limits, depending on the number of inspections being performed by the system — particularly on conveyor-type applications. The limit will vary from manufacturer to manufacturer, but those limits will be defined by product-handling capabilities and image-processing power.

3.9 Lighting

Illumination for vision inspection is critical if reliable and accurate results are to be obtained. Effective lighting solutions are usually developed by the vision provider through a process of experimentation or based on a deep understanding of successful lighting arrangements.

Together, the quality and effectiveness of illumination determine the visual quality of the features to be inspected in the image. These features need to be presented in order to show maximum contrast against their backgrounds; this process will also expose defects.

The better the quality of the illumination, the better the system's inspection performance and reliability will be.

There are a number of ways to improve illumination quality, such as:

- Different methods of lighting: including diffuse, dark field, on axis, and backlight
- The light spectrum, which influences the contrast: effects of fluorescence, infra-red or ultra-violet light on the product's surface should be checked to see if they can better highlight product defects. For color applications, the color of the lighting needs to accentuate the contrast between colors, helping to find the defect — blue light, for example, makes yellow colors look dark.
- Polarization: in comparison with diffuse reflection, the effect of polarization increases the contrast between object areas that directly reflect light. On metal and glass, polarization will highlight features that would normally be obscured by a reflection.
- Different illumination set-ups: sometimes, separate, but simultaneous inspections will each require different lighting conditions; these need to be set up to avoid interfering with one another – which may require the use of multiple inspection stations. Another solution is the use of colored lights in combination with color filters for the cameras.

Notes

How Vision Technology Works

In order to properly evaluate the contributions that vision inspection can make to the efficiency, productivity and profitability of a production-line operation, it is important to understand how vision inspection systems work. This involves understanding the technology that makes up the system, as well as understanding how environmental variables are compensated for in the design of a complete vision inspection system.

4

How Vision Technology Works

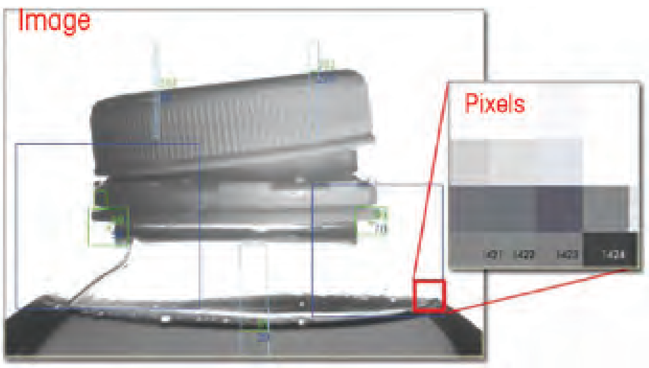
4.1 Fundamentals of Vision Inspection Technology

Simply defined, vision inspection involves taking a picture of a product and communicating to the user whether or not the image is of a good product. The system takes a picture and converts it into data that is analyzed by the vision software to ensure that the object meets the quality control standards configured by the manufacturer. Products failing to meet the manufacturer's quality standards are tracked and rejected.

The image

The camera captures an electronic image of the object to be inspected. The image is sent to a processor, which can either be contained within the camera itself or can be a separate computer within the vision inspection system. Electronic images are composed of small squares arranged along a grid.

Internally, these squares are represented by numbers – but when displayed on a screen, each number corresponds to the grey scale intensity of a particular section of the screen. These squares are known as 'pixels.' To visualize the process described above, imagine a piece of graph paper placed over a photo. Each square of the graph paper gets colored in by the corresponding part of the photograph, representing a pixel.



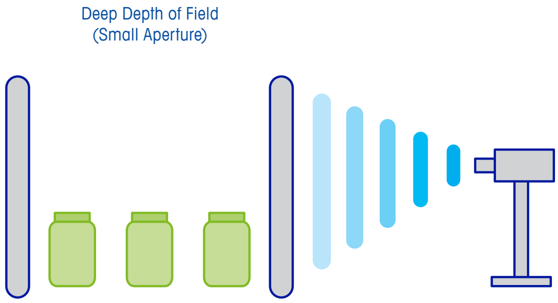
Above: Illustration of a pixel

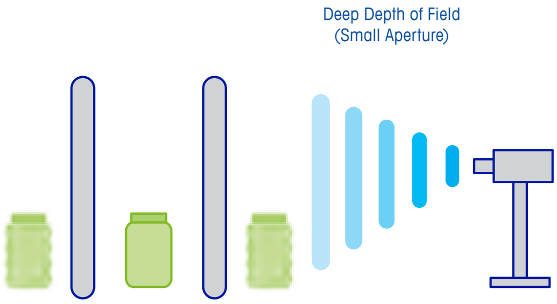
The number of pixels representing the image is called the 'resolution'; the higher the resolution of an image, the greater the number of pixels it contains — and, by extension, the sharper and more accurate the image is. In a vision system, the resolution of the image determines the inspections that can be performed; so, the higher the image resolution, the smaller the size of the defects a system can detect or the smaller the codes which can be read. A common camera image has a resolution of 680 x 480; a higher-resolution camera can have a resolution up to approximately 6,756 x 4,384.

Camera and Lens

A vision inspection camera has four variables which need to be adjusted, in order to optimize the quality of the captured image:

- The f-stop
- The contrast
- The gain
- The shutter speed





1. The f-stop controls the amount of light passing through the lens. It operates by adjusting the aperture, which is an opening in an opaque structure (the diaphragm) that allows light from the lens through to the inner workings of the camera. The higher the f-stop setting, the smaller the aperture will be, allowing less light to pass through the camera.

The amount of light let into the camera determines the amount of data the camera has to work with in order to produce an image. A wider aperture means the camera will have a greater depth of field — allowing it larger search areas for inspection functions. A smaller aperture narrows the depth of field, which provides greater focus on inspection details. Therefore, the f-stop setting needs to be fully and accurately adjusted in order to obtain the best image.

2. Contrast is simply defined as the difference between dark and light areas of an image. The brightness settings in a vision inspection system primarily affect the ability of the system to define edges.

An extremely high contrast setting turns the image's light areas white and the dark areas black, which usually results in detail being lost. A low contrast setting turns the image grey, with not enough contrast to clearly define details such as edges. When contrast has been adjusted properly, there is a balance between light and dark areas.

3. Gain is essentially a brightness multiplier. It takes whatever level of brightness the camera senses, and then multiplies it by a factor of x when sending its data to the image processor.

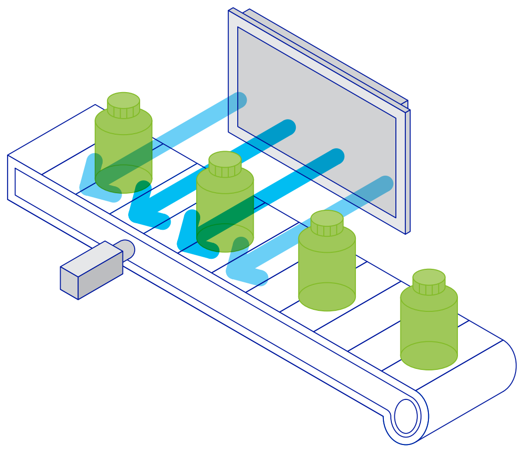
This allows sections of an image to be brightened to a higher level – creating results which are better than those that can be obtained by inspection system's lighting on its own. The 'gain' function makes it easier for finer edge details to stand out in an inspection image.

4. Shutter speed is the amount of time a camera's shutter is open when taking a photograph – in other words, the length of time that light is allowed to pass through the aperture to the camera sensor. Long shutter speeds can result in blurred images, particularly on high-speed production lines. Shorter speeds avoid the blurring, but will result in darker images. The proper shutter speed will allow for a crisp, well-balanced image.

Lighting

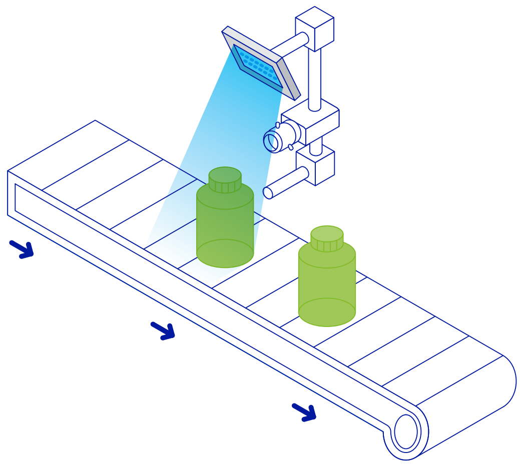
Proper lighting is critical in order to create the required contrast for an effective inspection to take place. When designing an inspection system, a considerable amount of time is spent determining the lighting geometry, taking into account the color and shape of the product in question. The key to accurate inspections is contrast — meaning that both the color and intensity of the light need to be perfect.

In many cases, the system will use back-lighting to bring out shapes more clearly, especially when looking for formation defects. Back-lighting creates dark silhouettes against a bright background, maximizing the contrast between the product and its surroundings. Back-lighting is most commonly used for detecting the presence or absence of materials, for part-placement/orientation and for the precise measurement of objects.

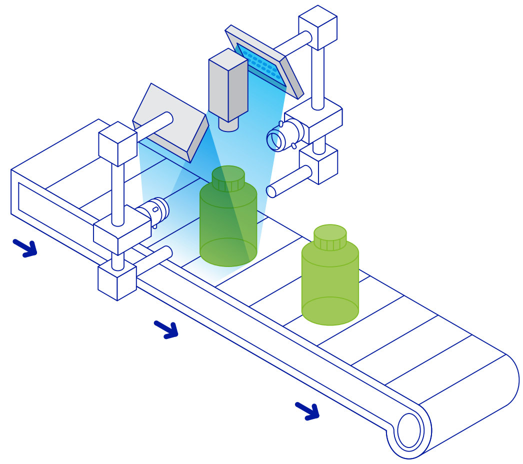


Some other lighting configurations used to create maximum contrast include:

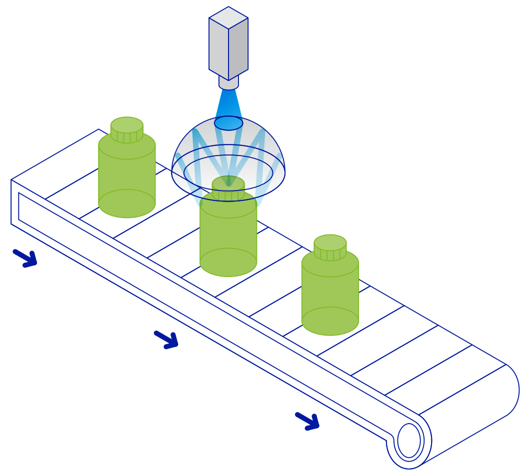
- **Direct or Bright Field Lighting:** the most commonly used lighting technique is a direct or bright field light. This type of lighting is typically used when generating contrast to enhance topographic detail.



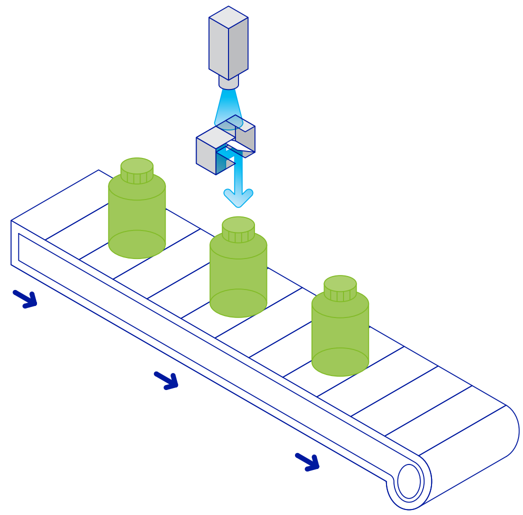
- **Dark Field Lighting:** this contains a low angle of light incidence and, typically, requires close proximity to the inspected object. Small amounts of light are reflected back to the camera from the edges of the object to be inspected.



- **Cloudy Day or Diffuse Light:** Diffuse dome lights are very effective at lighting curved, highly reflective surfaces. To be effective, diffuse lights need to be located very close to the object being inspected.



- **Diffuse On-Axis Light (DOAL):** light rays reflect off a beam splitter directly onto the object at nearly 90°.Using this approach, specular (i.e. mirror-like) surfaces perpendicular to the camera appear bright, while surfaces at an angle to the camera appear dark.



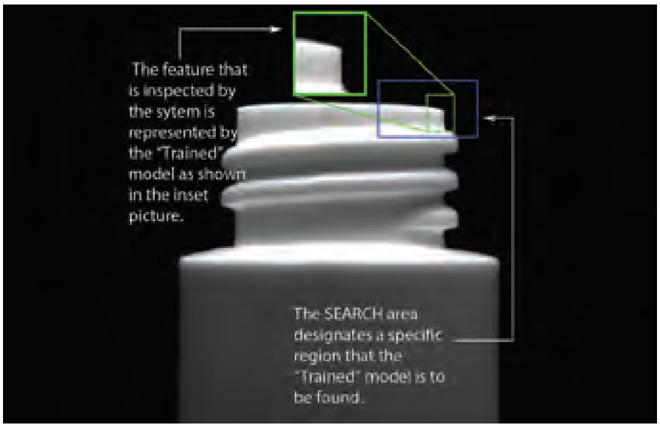
Vision Inspection Software Tools

Vision inspection systems use software to process images, using algorithms known as 'tools' to help analyze images. The number of tools needed to analyze images varies in accordance with each analytical process, and each inspection tool is programmed with a set inspection area, function and tolerance, using the vision system's Human-Machine Interface (HMI). This is usually a touch-screen that allows users to scroll through the list of inspection tools being used, adding or subtracting inspection tools as necessary.

Any inspection software will contain an enormous amount of tools — far too many to comprehensively list here. What follows is a list of tools most often used by a vision inspection system:

Search Tools

The Search Tool looks at (and stores) a specific 'Region of Interest' in an image, for later use by a different tool in the inspection process. When operators train the Search Tool, they designate part of the target image (the 'model') to remember and where to look for that target (the 'search area') during run time.



The bigger the search area, the more processing power the vision inspection solution will need to make the analysis. The smaller the area, the less processing power will be required — but there will be less tolerance for variations in product positioning.

Edge Tools

The Edge Tool looks for the boundary or transition between dark and light, and allows for measurement between light and dark areas. When setting up an Edge Tool, it must be configured to include both the background to the inspected item, and the inspected item itself, in order to find the edge.

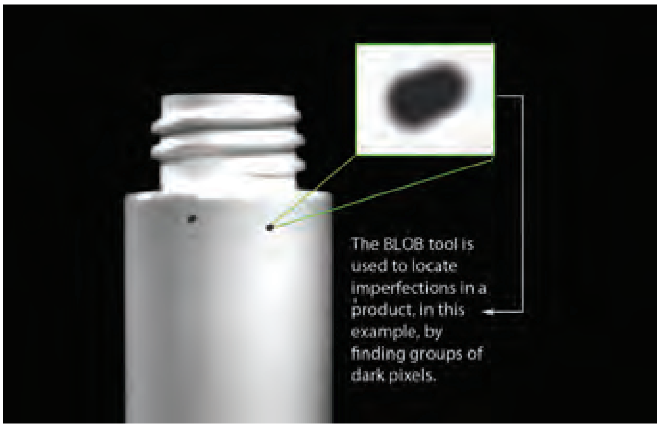
If the Edge Tool inspection area extends too far into the background, it may find another edge before it reaches the desired edge. The same will be true if the Edge Tool area extends too far beyond the desired edge.

Blob Tools

A 'blob' is a cluster of pixels that are next to each other. Blob tools find these clusters, which are usually features that are oddly-shaped – or they could be features that change shape from inspection to inspection.

The Blob Tool allows the user to define a range of grey scale values they are interested in detecting. This is also known as 'thresholding' the image.

A threshold level will be set for the Blob Tool before it undertakes the inspection. This way, the tool can search for surface contamination or flaws, such as burn marks on plastic. The user determines the size of any mark or flaw that is unacceptable, and the Blob Tool counts the pixels in each cluster within the thresholded range. This allows the Blob Tool to determine whether or not the mark is large enough to merit rejection.

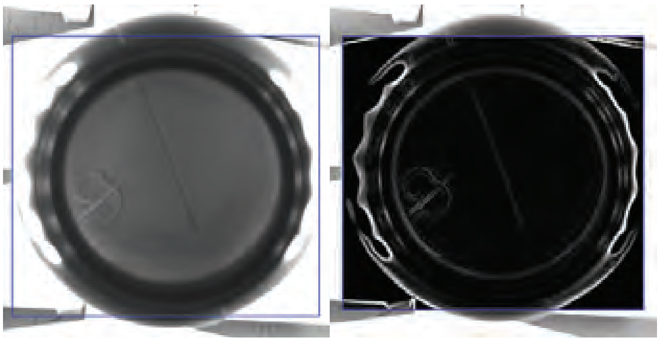


Process Tools

The Process Tool modifies a specific region of an image in order to make an inspection possible. By allowing only a small portion of an image to undergo processing, the tool is able to work quickly (running a process tool on an entire image could take too much time).

The system user designates the area to be processed when 'training' the software on the product. As shown below, the Process Tool can be 'trained' to use many sub-processes, in order to manipulate an image before it is examined by another tool. Some of the sub-processes run by the Process Tool include:

- **Sharpening:** clarifying an image (to bring out detail)
- **Edge Detect:** highlighting transitions between pixel grey scale values in an image. This sub-process can be used to find less obvious defects
- **Smoothing:** enhancing the useful appearance of an image by removing detail that is unimportant



Left: Image before process tool applied.

Right: Process tool applied to create contrast – making swarfs (a common defect) inside a bottle easier to find.

Print Tools

These tools are used to read, inspect and qualify printed alphanumeric codes, mainly with application to Optical Character Recognition (OCR), and Barcode tools:

OCR (Optical Character Recognition) Tool

The OCR Tool recognizes printed text by noting the shapes of characters that it sees in an image. It hen compares these character shapes with a separate set of characters that are contained in a stored font.

The system takes the string of characters found in the image and compares them to a user-defined match string to ensure the proper string is present on the product.

OCV (Optical Character Verification) Tool

The OCV Tool inspects printed characters and verifies that they are correct. It undertakes this process by matching the image of the characters to those characters contained in a stored font.

This process is unlike that undertaken by the OCR Tool, checks detected characters against all characters in a font set to determine which character is the best fit. . OCV only checks to determine the quality and readability of a pre-determined character. The vision inspection system can hold an unlimited number of stored fonts in its font library. Operators can choose which font to use during an inspection. If the desired font does not exist in the library, the system must be trained to recognize the new font.

Code Tool

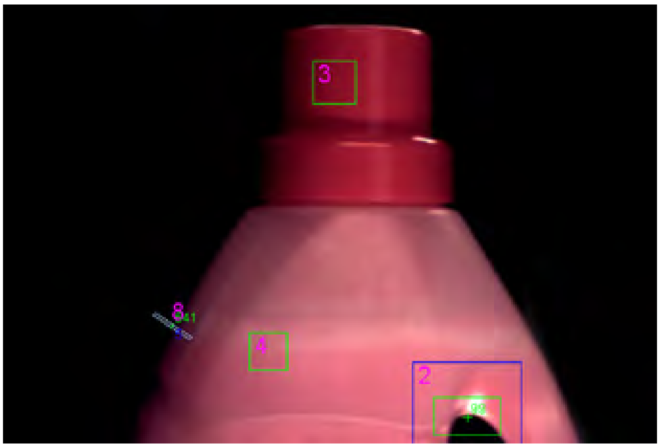
The Code Tool is used to compare printed barcodes on products with codes that were 'trained' into the system. This tool's principal function is to act as a decoder, enabling it to read multiple 1D and 2D barcode formats, as well as carrying out readability and correctness checks.

Above Left: 1D Barcode

Above Right: 2D Barcode

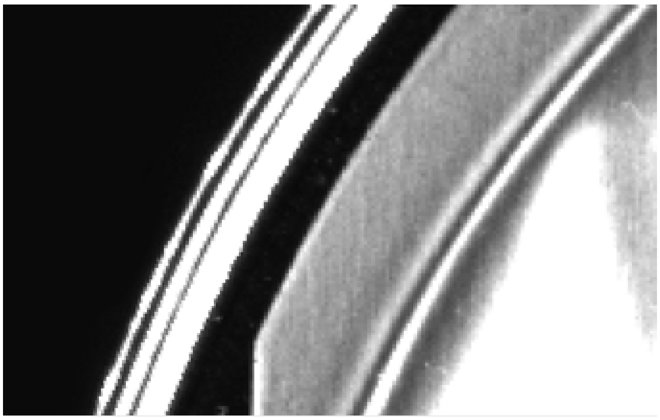
Contour Tool

The Contour Tool follows an edge along its length and finds points along that edge to ensure container formation. Like the name implies, the tool's main function is to map contoured edges. The Contour Tool measures both trained points on the edge and points found on an inspection image. It then calculates the differences between them, allowing the system to find irregularities in container formation.



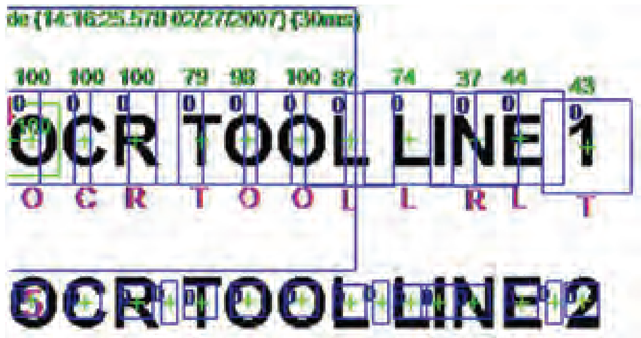
Arc Unwrap Tool

For tools which are normally unable to function on arcs or circles, the Arc Unwrap tool allows them to perform such inspections. The Arc Unwrap Tool takes an arc and flattens it out, creating a flat view of the arc that can be successfully inspected by other tools. The Arc Unwrap Tool is only used in conjunction with other measurement tools, since its only function is to enable other tools to be used.



PQV Tool

The Print Quality Verification tool verifies that printed characters on the package match what was trained into the system. Unlike OCR, Print Quality Verification does not require training in a font set ahead of time. This is because the trained image is compared directly to the inspection image.



Double-Blind Data Entry Tool

This is designed for products which require strict control over lot codes or bar codes. To ensure the system is looking for the proper code, two users must log in, enter the code the system should look for, and log back out. By forcing two distinct log-ins, it ensures only the proper code has been entered.

4.2 Vision Inspection Types

There are three different types of vision inspection technologies that can be used when designing a vision inspection solution. These are:

1. PC-based systems
2. Smart cameras
3. Sensors

When deciding which technology to use for a particular vision inspection system, the following variables should be considered:

- The speed of the line and number of products being inspected
- Other components required in the solution, such as printers, sensors or rejection mechanisms.
- The complexity of the inspections and whether customized lighting or lenses and higher-resolution cameras are required. The number of inspection tools the vision software will need to run in order to perform the inspection also needs to be determined, since it can have an effect on the speed with which the inspection is performed. In addition, consideration should be given to the number of different product sizes, shapes and colors the system will be inspecting in the course of normal operation.
- Who will operate the machine on a daily basis
- What effort is required for routine tasks such as product changeovers
- Whether the vision system has the capability to produce data for evaluations of production-line performance
- How products on the line will be tracked by the system, if at all
- What is needed to integrate the vision inspection system into the production line, in order to communicate with other hardware and the plant management system
- Security system log-in, including log files of the vision system's inspection activities and the user changes to the system

4.3 PC-Based Vision Systems

Vision Configuration and Control Unit

In a PC-based vision system, the PC serves as a central Vision Configuration and Control Unit for all of the system's hardware, handling communication between separate components (i.e. product tracking sensors and rejectors) and enabling easy communications with other systems on the production line.

This centralizes the operation of the system through one central screen, allowing changes to be made to the system's settings (product changeovers, new inspection applications, etc.) through one screen rather than each individual camera – as occurs with many smart camera systems. The raw processing power and expanded storage capabilities of a PC also allow for better data collection – and, depending on the complexity of the inspections required, significantly faster inspection times.

Human-Machine Interface (HMI)

PC-based technology also lends itself to having an integral touch-screen Human-Machine Interface (HMI), allowing for convenient interaction between the operator and the vision inspection system. An intuitive HMI makes several processes (adjustment of vision analysis tools, changing parts, monitoring of system performance) faster than a system of smart cameras, which would require changing the settings of each camera individually. This process might even require connecting a PC or laptop in order to change the program.

Using a touch-screen HMI also eliminates the risk of damage to the internal components. So, rather than worrying about dust getting into a keyboard or mouse, a touch-screen is relatively easy to keep clean and functional.

Cameras

Camera selection is directly linked to the application requirements and involves three main criteria:

- Monochrome (black and white) or color acquisition
- Frame-rate
- Image resolution

Monochrome cameras are used for the majority of inspection applications, since monochrome images provide 90% of the available visual data. In addition, they are less complicated and more cost-effective than their color counterparts.

Color cameras are used when inspection applications require color-specific image data to be analyzed. In addition, the camera's resolution should be high enough to ensure that it can capture the proper amount of information needed for the inspection task.

It is important that cameras should be of high quality and rugged enough to withstand vibration, dirt and heat that is often present in an industrial environment.

Recent years have seen the availability of cameras with faster capacity to transfer data to the vision configuration and control unit. These cameras use an Ethernet connection to transmit data at speeds of one gigabit per second. Known as GigE cameras, they have become the vision systems camera of choice for several reasons:

- Using an Ethernet connection allows the camera to supply streaming, uncompressed image data to a host computer for processing in real time – and across long distances. This capability is unaffected by the number of cameras networked to the system – presenting a distinct advantage over USB, which lacks such long-range capabilities.
- The evolution of GigE cameras eliminates the need for expensive and complicated frame-grabbers to compress and display the camera-captured image to the image processor.

Optics and Lighting

Optics and lighting are perhaps the most overlooked components when designing a vision inspection system. These components, however, are crucial to an effective solution — and even the best vision software will find itself out-performed by a less capable system if the optics and lighting are not of sufficient quality.

Good optics will be geared to produce the largest usable image, in order to provide the best possible image resolution to the system software. Similarly, a good lighting set-up will bring out the key features being inspected, giving the system an accurate picture of the item being examined.

Another major goal is to create as much contrast as possible between the acceptable product conditions and the defective product conditions. Frequently, the type of light used will be dictated by factors such as color, texture, size, shape and reflectivity.

4.4 Smart Cameras

Smart cameras are equipped with image-processing capabilities that have been integrated into the camera. This makes them a small, compact and simple solution for basic vision inspection applications.

Smart cameras don't have the same amount of processing power as PC-based technology, plus they suffer from performance issues when:

- Trying to operate at medium-to-high speeds
- Performing more than one inspection or complex/ processor-intensive inspections
- Attempting to use multiple analysis tools at the same time

Typically, smart cameras come with a set of predetermined analysis tools, which are selected on the basis of the inspection requirements of the given application. Without an HMI, adding new tools is either impossible or requires an external system to be connected to the cameras to make changes to the inspection program.

A smart camera can be an effective solution for single-station vision applications, but there are significant limitations to its capabilities, such as:

- Difficulty when trying to link multiple pieces of hardware (other cameras, rejection mechanisms, product handling, etc.) in a production line
- An inability to provide real-time statistical feedback about recurring failures to plant management systems without attaching an HMI.
- When an inspection is required, there is limited ability to correlate data between multiple cameras (such as dimensional measurements between multiple cameras) without implementing specialized software
- Part-changeover can be made difficult if an integrated HMI is not included, making an additional PC, laptop or tablet connection necessary in order to make changes

Many smart cameras come with integrated lighting – so if the light provided is not sufficient for the inspection in question, a solution to this problem needs to be found. This takes time and effort that could be better spent on other tasks.

4.5 Sensors

Sensors are a relatively simple form of vision inspection technology, so they require minimal effort to integrate into a production line. In addition, they function perfectly adequately in basic barcode reading/presence/absence, and color verification applications. Sensors require high-contrast packaging, since subtle color variations are beyond the capabilities of a standard sensor.

For the most part, sensors are used for barcode applications, although they are not able to cross-verify the barcode data with printed codes on other parts of the package. They are effective for the simplest inspection applications, but lack flexibility.

The Importance of Product Handling and Tracking

When considering any vision inspection solution, it is important to consider whether or not product-handling is required, so as to ensure that products are displayed correctly to the cameras. Proper product-handling is critical to ensure good, reliable, and repeatable inspections.

To achieve valid inspections:

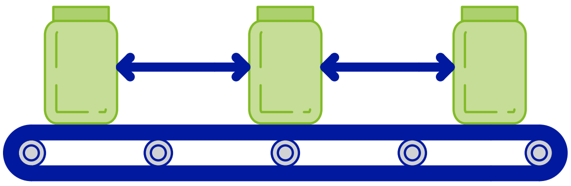
- The product must be displayed at a consistent distance from both the cameras and the lights. Failure to do so results in out-of-focus or poorly illuminated images, which result in false positives or rejects.
- The product should be presented so that it is subject to minimal movement. The more vibration and instability in the product, the lower-quality the inspection will be.
- The product must be properly spaced. If products are too close together, the cameras will not be able to inspect the correct area of interest of the product.
- If possible, the product must be properly oriented. However, this is not always possible – and in the case of round, un-oriented products, a different solution is required. PC-based vision systems can easily inspect round, un-oriented products using multiple networked cameras – and recently, smart camera systems have been developed with similar (though reduced) capabilities. The inspection of round, un-oriented products will be covered in greater detail later in the guide.

5.1 Conveyors

Some applications require an integrated conveyor within the vision system, in order to guarantee correct orientation of the product as it approaches the camera. In these cases, the spacing of products on the conveyor is also controlled to ensure that defective products are properly tracked and rejected.

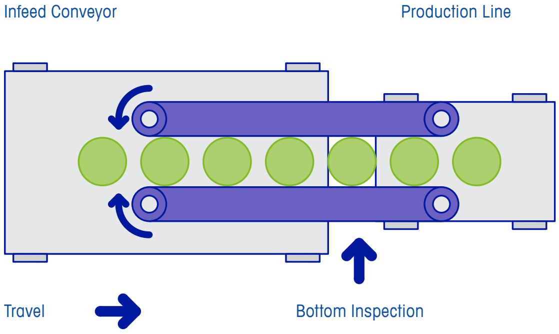
Flat-Belt Conveyors

Flat-belt conveyors are often integrated into a vision system when parts must be stabilized for inspection. These conveyors eliminate the vibrations and shakiness of chain-link conveyors, which can make accurate measurements of product features difficult. A flat-belt conveyor ensures that products are stable as they pass through the system.



Side-Grip Conveyors

Side-grip conveyors are most frequently used to suspend products over a camera for inspecting the bottoms of containers — such as looking on the bottom of a jar for debris, or reading codes or other information on the bottom of bottles. When combined with an outfeed conveyor running faster than the infeed conveyor, side grips are also good for changing product spacing, to ensure that there are proper gaps between bottles for inspection and to secure optimum rejection accuracy.

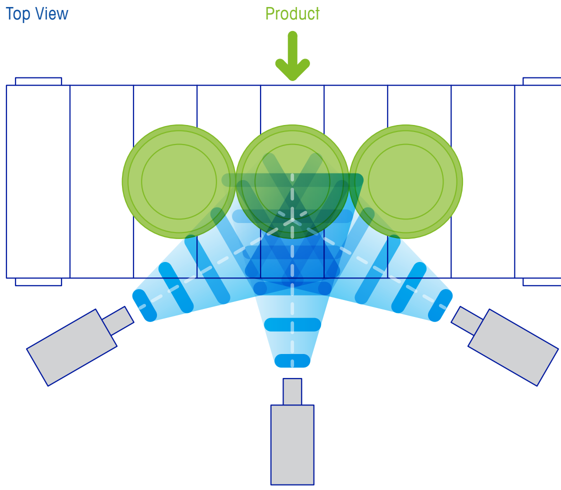


Above: Side grip conveyor

Product Spacing

To inspect products accurately, it is essential that only one item at a time be in line with the camera. For example, when performing inspections on a bottle, the presence of another bottle in the camera's field of view would confuse the inspection software and cause an error. In order to create or maintain an appropriate spacing (or 'pitch'), conveyor belts are run at a faster speed than the rest of the production line, creating the required space between products to ensure accurate inspections.

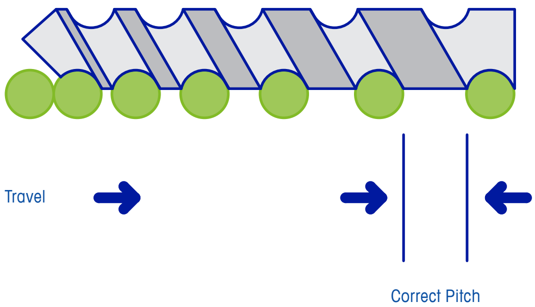
Similarly, items without consistent spacing between them can be slowed down by a timing conveyor, which helps to create a uniform spacing between products. Typically, the timing conveyor will slow the packages to create end-to-end spacing, where the pitch equals the length of the item. By carrying out this process, the timing conveyor prepares items for the spacing conveyor.



Above: Example of bottle spacing

5.2 Other Spacing Solutions

It may not be possible to use conveyors to ensure that difficult-to-handle products are spaced correctly. This is mainly due to stability challenges caused by a sudden acceleration or deceleration of the products. Numerous spacing solutions are available, and two of the most common include a timing screw or a star wheel.



Above: Timing screw is used to space product evenly through vision inspection solution.

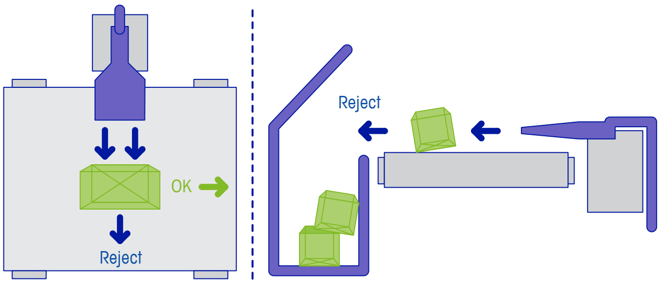
5.3 Automatic Reject System

Automatic Rejection Systems are used to remove imperfect or defective products from the production line, and choosing the appropriate reject system depends on a number of factors. Therefore specific advice should be sought from the inspection system provider.

Some of the most common types of Automatic Reject Systems include:

Air-Blast (also known as an 'air jet')

A pulse (or jet) of air blows the product into the reject location. This type of reject device is ideal for lightweight, single-file discrete products running on a narrow belt width. Timing is important when using an air-blast rejection system, since it is important that only the defective product is removed from the line. For lighter products, blow-rejecters — which produce a much less forceful jet of air than air-blast rejectors — are utilized.

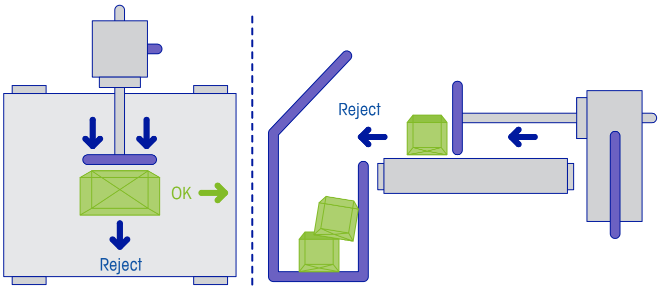


Above: Air blast

Punch / Pusher

Pneumatic punch-rejection or push-rejection mechanisms are made to operate at high speeds, using a paddle to direct packages into the reject location (usually a bin). Recovery times on these mechanisms must be extremely fast; otherwise, packages behind the defective one will be blocked by the reject mechanism.

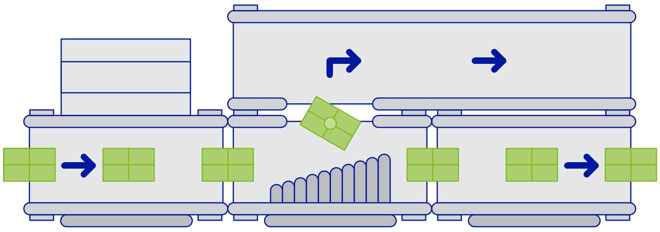
This type of reject device is suited for light-to-medium-weight products which are spaced and oriented on a narrow belt. Again, timing is critical to ensure that the paddle strikes the center of the defective product and retracts before the next product on the line approaches.. Ideally, the system needs to be able to adjust when the puncher fires, in order to compensate for variations in conveyor speeds. Loose or fragile products should not use a punch rejection mechanism, since it may damage the product.



Above: Punch/pusher

Soft Finger Rejecter

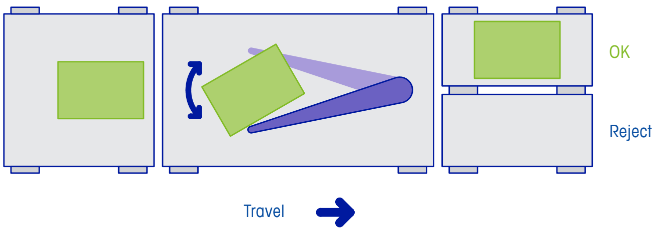
A series of 'fingers' (generally between 8 and 16) gently extends, in sequence, to direct fragile containers off the production line and into the rejection area.



Above: Soft finger rejector

Center Gate Rejecter

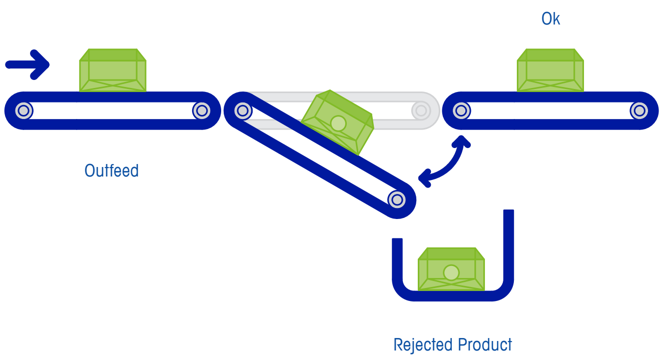
Gates can divert and guide products between multiple lanes; they can also be used as a soft rejecter or as a classifying tool to sort different defects into separate areas — although to accomplish this, the vision system in question will require the proper product-tracking capabilities. Center gates pivot on a vertical plane and direct items down a specific lane.



Above: Center gate diverter rejector

Drop Gate Rejecter

Drop Gate rejecters are hinged conveyors which slant downwards into a rejection bin when triggered. They are useful for products which are difficult to guide away from the direction of travel, but their slow recovery time and speed impose significant limitations on throughput and product height.



Above: Center gate diverter rejector

Line Control

If desired, vision systems can be given control capabilities over the production conveyor. This allows the system to stop and start the production line at any location required by the manufacturer. This is often set up to send a shut-down signal to the line after a certain number (or percentage/pattern) of product defects occur.

5.4 Variable Speed / Stop-Start Applications

Accurate rejection and timing become more complex when dealing with conveyors that travel at variable speeds. Without a constant time between the product entering and exiting the system, it is impossible to use a timing mechanism to track and reject products.

To deal with this problem, vision systems can use an encoder, which monitors the movement of the conveyor. In addition, the conveyor reports to the system the position of products on the belt. This is achieved using a pulse generator or encoder — a device which rotates in synchronization with the movement of the conveyor.

Each degree of rotation (or x degrees of rotation — it depends on the resolution of the encoder being used) sends a pulse. The vision system counts these pulses in order to determine the location of a product as it moves along the conveyor.

Instead of waiting x amount of seconds before firing the camera/triggering the rejection mechanism, the system waits x number of pulses; and because the pulse generator does not move unless the conveyor is moving, the system can adjust when the point of inspection, depending on the speed of the conveyor.

PC-based vision systems can also track a number of different products at the same time, so that lines moving at higher speeds (and with multiple rejection sites) can accurately reject defective products, and even sort rejected products – by defect – into separate rejection areas.

5.5 Typical Reject Problems and Failsafe Design

Ineffective reject systems are probably the weakest link in most product inspection machines, which can result in unreliable product rejection. A correctly specified system, however, should be fool-proof and capable of rejecting all defective products under all circumstances.

The following are common application problems which should be taken into consideration when specifying an effective vision inspection system:

- The application may require a different rejection procedure than the one currently in place on the production line
- The system is not capable of removing consecutive defective products
- Rejecter failure occurs due to low air pressure, blockage or solenoid failure
- Conveyor speed is changed without changing reject timings
- Product spacing and reject design are not compatible

Many of these functionality issues can be avoided by using a single provider for all motion-control, as well as product-handling design and installation. Vision system providers should include any requirements for motion control or product-handling in the design of their system – and, if possible, should install the equipment along with the vision system. This allows problems such as those listed above to be detected early in the design and installation process, avoiding functionality issues later on in the life of the system.

5.6 Satisfying Retailer and Food Industry Requirements

Additional control devices can be included in the Product Inspection system design to ensure proper functionality of rejection mechanisms, and to monitor the performance of the vision system itself.

Implementation of the following design requirements is good practice and will satisfy most brand retailer and food industry requirements:

- An automatic reject system to effectively remove defective product from the production line
- A warning device to indicate when the reject bin is full of product
- A full enclosure between the point of inspection and the rejection bin
- A sensor to detect each product passing through the system – this is for product-tracking purposes
- An automatic belt-stop failsafe system that operates in response to the following events:
  - Reject bin full
  - Loss of air pressure
  - Reject confirmation fault
  - Vision system fault

It should only be possible to re-start the system after a fault or shut-down, using a security password or a key held by a nominated person. When the inspection system belt has stopped, suitable procedures should be in place to ensure that any products backed up on the in-feed conveyors to the vision system are passed through the system after re-start, or through a back-up vision system of the same configuration.

5.7 Reject Receptacles

Tray, hood, and bin are the simplest and most economical forms of reject receptacles. Normally, they are mounted on the vision inspection system at the point of rejection designated by the manufacturer.

Tray

A tray is a simple three-sided holding table with no cover. Rejected products are pushed off the production line into the tray.

Hood

A hood is a box-shaped structure with openings on one side and in the base, similar to a chute. The rejected product enters through the side-opening and drops through the base. The hood funnels rejected products down to a re-work area or into a receptacle, e.g. a stainless-steel bin.

Bin

A bin is a box-shaped structure. It has an opening on one side to admit rejected products, and a side-access door, for removal of rejected products. To ensure proper levels of cleanliness, there should be drainage holes in the base. It is recommended that the door is lockable, so that only designated personnel can remove rejected packs.

Chute

A chute is a long, narrow and horizontal bin which is usually angled downwards, away from the production line. Rather than dropping (maybe 500mm) into the base of a bin (with the risk of damage), rejected products slide to the bottom of the chute. A chute is typically used for fragile containers – or for containers that require detailed inspection.

Declined Roller-Track Reject Conveyor

A declined roller-track reject conveyor is a reject chute with rollers in the base. Rejected products are easily and smoothly transferred via the rollers to the bottom of the receptacle. Since no damage is caused to the product on rejection, this is ideal for use on re-workable high-value products.

A declined roller-track reject conveyor is also applicable to products that may have a missing or damaged component. Once rejected from the production line, these products can be fixed; alternatively, components can be replaced and the products can be re-inspected. Ideally, drainage slots in the base, a viewing panel, and a lockable access hatch should all be part of the design specification.

Rejection confirmation

It is also good design practice to include a rejection confirmation process into the system. Rejection confirmation involves placing sensors on reject receptacles, so that products can be detected when they enter a receptacle. Combined with product tracking, this allows the system to verify that products identified as being defective have been removed from the production line.

Reject confirmation is a powerful tool that supports quality programs with data about products which are being detected and rejected. A reject confirmation system proves due diligence in claim cases – such as when defective products are found by retailers or consumers.

Notes

Typical Vision Inspection Applications for Packaging

On any automated production line, the most desirable outcome is to produce zero defects. However, given today's high-speed technology and the potential for the introduction of human errors, this goal is often difficult — if not impossible — to achieve.

Nevertheless, an achievable goal is the delivery of zero-defective products to the customer – and this is achievable by making use of a range of product inspection technologies. Modern automated production lines operate with incredible speed and precision, yet many companies expect human inspectors to successfully inspect containers that are being filled, decorated and coded at speeds reaching hundreds of parts per minute (ppm).

The only way to ensure that 100% of products on an automated production line are accurately inspected before leaving the factory is to utilize an automated vision inspection system capable of keeping up with these high production speeds. This chapter outlines typical defects which a vision inspection solution can identify, as follows:

- Label defects
- Closure and cap defects
- Product and package integrity defects
- Print defects
- Container defects

6.1 Typical Defects Addressed by Vision Inspection Solutions

Any one of the defects listed above can occur at different points in the production process, and might be easily missed by manual inspection methods. These defects may well lead to a range of problems such as:

- Product leakage
- Line jams
- Damage to other line equipment
- Damage to the company's brand image
- Possible legal action by end customers if faulty products are allowed to leave the production facility and enter the marketplace

Example: A label is applied incorrectly, as a result of a bottle not drying fully after washing. This misapplied label can result in:

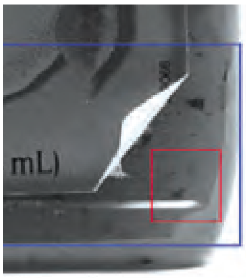
- Damage to brand image
- Obscuring of a listed allergen
- The retailer sending the batch back and fining the manufacturer

6.2 Inspecting for Label Defects

High-speed labeling of packages (which can be made of cardboard, plastic, glass or metal in any shape or size) can produce a wide variety of defects. These may lead to label errors which can be harmful to a brand – or can even present liability issues for a brand owner.

This section covers the potential defects which can occur during labeling of the front, back and necks of products.

Label Presentation Inspections

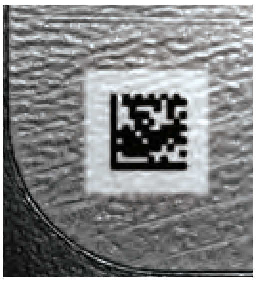
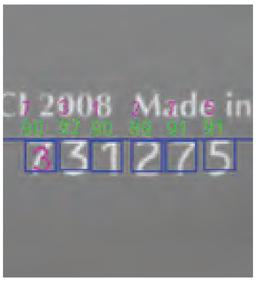
Defect	Defect Description	Defect	Defect Description
	**Label Presence Verification** Inspects for absence / presence of label on package or container.		**Skewed Label Detection** Ensures that labels are applied straight and in the correct positions.
	**Dog Ear Label Detection** Verifies that labels have been securely applied to the container or package.		**Double Label Inspection** Ensures that only one label has been applied to the same location on the package.
	**Overwrap Alignment Inspection** Ensures that wrap-around labels are placed properly and put on straight; 360 degree inspection.		**Graphical Label Verification** Inspects for unique graphical item on the label to confirm that proper label is being applied.
	**Label Control Number (LCN) Verification** Verifies the correct label control number is present on the label.		**2D Barcode Verification** Confirms that proper label has been applied by verifying 2D data matrix code is present, or that the code has been printed correctly.
0 123456 789010	**Barcode Verification** Confirms that proper label has been applied by verifying that the correct barcode is present, or that the code has been printed correctly.		

6.3 Inspecting for Printed Code Defects

Labels and packaging are printed using a wide range of different print methods, including:

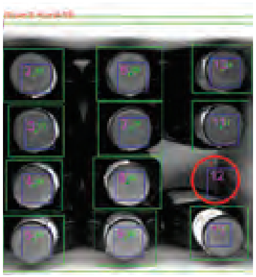
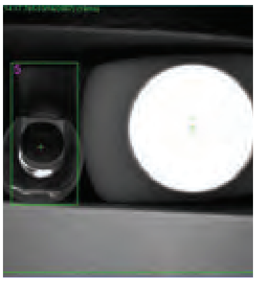
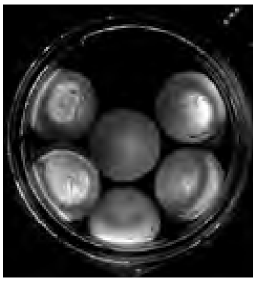
- Ink-Jet
- Hot Stamp
- Laser
- Silk Screen
- In-Mold
- Thermal
- Ultra-Violet
- Embossing

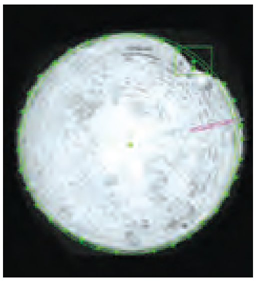
A range of problems may occur during the print process, but vision inspection technology can verify both the quality and accuracy of the print prior to distribution. Vision systems work on any form of printing, from laser etching to ink-jet.

Defect	Defect Description	Defect	Defect Description
	**Barcode Validation** Verifies that the barcodes are properly formed and readable.		**2D Barcode Verification** Ensures that non-human readable code is well formed, readable and correct.
	**Lot / Product / Expiry Code Verification (OCV)** Confirms that product codes are present, readable and correct.		**Label Control Number (LCN) Verification** Verifies the correct label has been applied to package by verifying proper label control number is present on the label.
	**Bright Stock ID Verification** Verifies that the proper filled and unlabeled cans have been pulled from stock after labels are applied.		**UV Print Verification** Confirm proper UV printed codes are present and correct.

6.4 Inspecting for Package and Product Integrity Defects

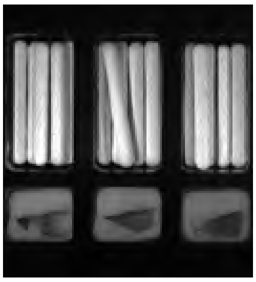
Package and product integrity refers to the completeness and integrity of the package or finished product. The following examples are focused on filled bottles, cases, cartons, pouches, packets, kits and cartons.

Defect	Defect Description
	**Full Bottle Inspection** Proper fill level; Cap presence, height, color & skew; Label presence, position and identification.
	**Case Pack Inspection** Internal inspections: Product presence, placement, orientation, count and cap correctness. External case inspections: case decoration, ID, and flap position; printed product code and date/lot code.
	**Product or Kit Content Verification Inspection** Verify all components of kits or pouches are present, oriented and positioned correctly. **1.** Packet content inspection
	**2.** Jar content verification
	**3.** Vitamin packet confirmation

Defect	Defect Description
	**Correct Cap Placement Inspection** Cap inspections: presence, height, skew, color, safety band integrity.
	**Anti-Counterfeit and Tamper Proof Band** Presence and integrity of safety tamper -evident band.
	**Product Shape Inspection** Verify that the shape and size of a product falls within production tolerances.

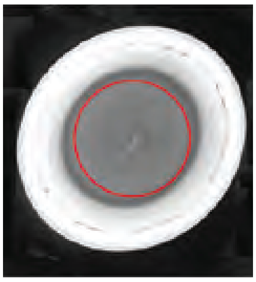
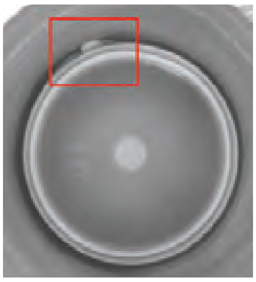
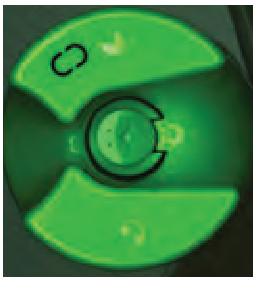
6.4 Inspecting for Package and Product Integrity Defects continued

Defect	Defect Description
 	**Assembly Verification** Verifies presence, placement, color and completeness of nozzle, shroud, trigger and cap. On PET bottles, can also verify fill level and fill tube presence. Confirms that all intended pieces are present and in the proper place

Defect	Defect Description
	**Cracker Inspection** Verifies that the proper number of crackers are present, in the correct position and whole.
	**Tray Integrity** Ensures proper placement of product in food trays and clear sealing surface.

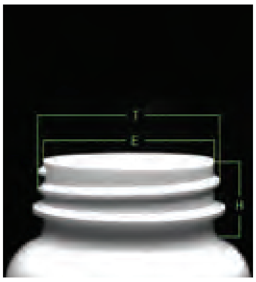
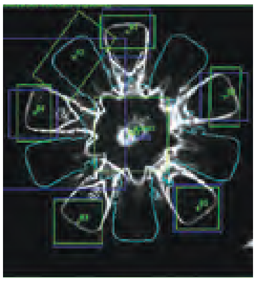
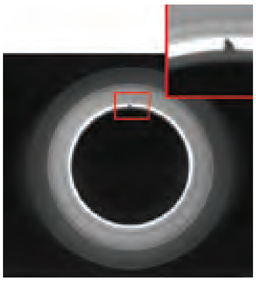
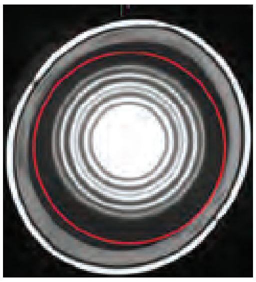
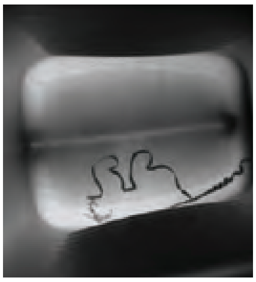
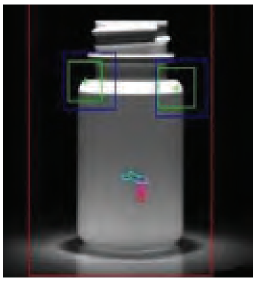
6.5 Inspecting for Closure and Cap Defects

Vision inspection systems are used to detect errors in molded plastic closures and caps. They are typically positioned immediately after the molding machine, and then again just before the closures or caps are applied to a filled bottle. Defects in caps and closures can cause damage to other machinery or lead to spillage, spoilage and contamination.

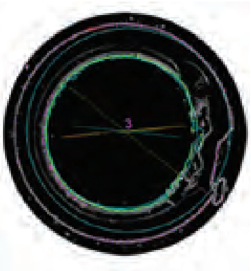
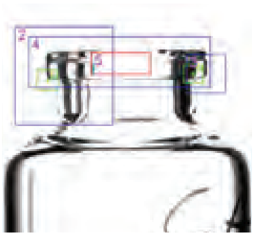
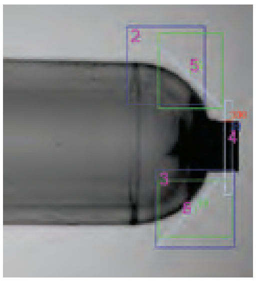
Defect	Defect Description	Defect	Defect Description
	**Closure Liner Presence / Absence Verification** Verify that closure's liner is present.		**Liner or Closure Short Shot** Check that during the molding process that the shot was sufficient to form the liner and closer correctly.
	**Liner contamination** Detects loose particles including dust, dirt, plastic fragments and carbon in the closure itself or material embedded inside the liner during formation.		**Liner Placement Verification** Confirms that the liner is properly placed inside the closure.
	**Closure Ovality Verification** Verify that the closure was formed into the proper ovality or roundness.		**Closure Liner and Flash Detection** Detects if extra product was left on the closure or the liner during the molding process.
	**Closure Tab Inspection** Detect and inspect the presence / absence, shape, color and location of the tabs.		**Component Verification** Verifies the presence, position, color and orientation of the parts of the closure or cap assembly.
	**Product ID Verification** Ensure any product ID codes are present, correct and readable.		

6.6 Inspecting for Container Defects

The types of empty container defects included in this section are typical for bottles, tubes, cans, tubs, glass bottles and jars.

Defect	Defect Description	Defect	Defect Description
	**Neck Measurements (E, H & T)** Inspects the width (E – edge to edge), height (H) and thread width (T) of the bottle neck.		**Gate Inspections** Inspect for pulled, blown out, burnt, mushroomed, or mis-positioned gate.
	**Planarity Inspection** Planarity of container top is checked for hairs, filaments and / or waviness caused by uneven cuts during the trimming process.		**Sealing Surface Inspections** Detects nicks, gouges, contamination and deformities on or in the sealing surface.
	**Surface Finish Defect Inspection** Inspect the container for swirls, scratches and other blemishes in the color or finish of the container.		**Ovality Check** Verifies that the neck of an empty container is round, dent free and the mouth is oriented in the proper position.
	**Foreign Debris Inspections** Inspects for chips, swarfs, or any other materials that have fallen into the container during the manufacturing or shipping process. **1.** Swarf inside container		**Contamination Inspections** Detect any defects on the sidewalls of the container including dirt, burns, discoloration and embedded or surface particulate matter caused by carbon buildup in the molding process.
	**2.** Plastic chip in spice jar		**Blisters and Bubble Inspections** Verifies the sidewalls and bottom of the container is free from blisters and bubbles in the material.

6.6 Inspecting for Container Defects Continued

Defect	Defect Description
	**Chipped Top Inspection** Verifies that the top of a glass container is free of voids, chips, missing glass and cracks. Cork presence can also be determined. **2.** Top view of a chipped wine bottle lip
	**1.** Side view of cracked vial
	**Preform Gate Inspections** Verify preform's gate has been properly formed.

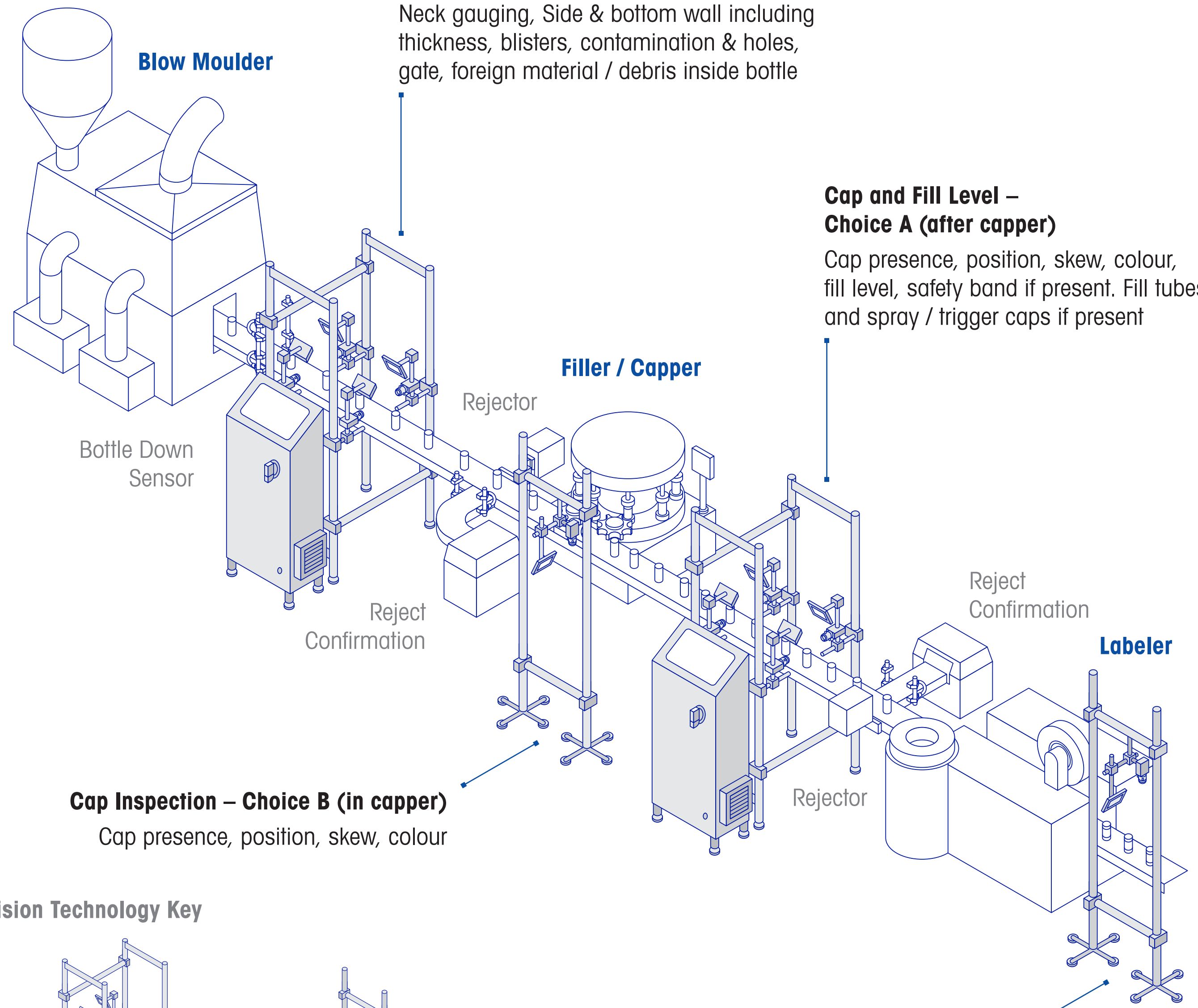
6.7 Bringing it All Together

To demonstrate how various vision technologies and inspections work together to form a total quality assurance program, consider the packaging line diagrams on the following pages.

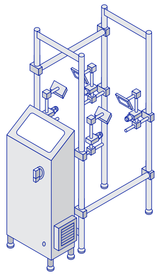
At each quality checkpoint that requires vision inspection, you will find a listing of the inspections that take place; you will also find a description of the best vision technology choice for the particular inspection requirement.

At some inspection points, more than one type of technology is presented. The choice of vision equipment at these points depends on the required level of inspection complexity.

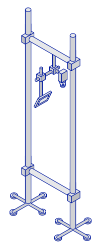
Liquid Fill Line



Vision Technology Key

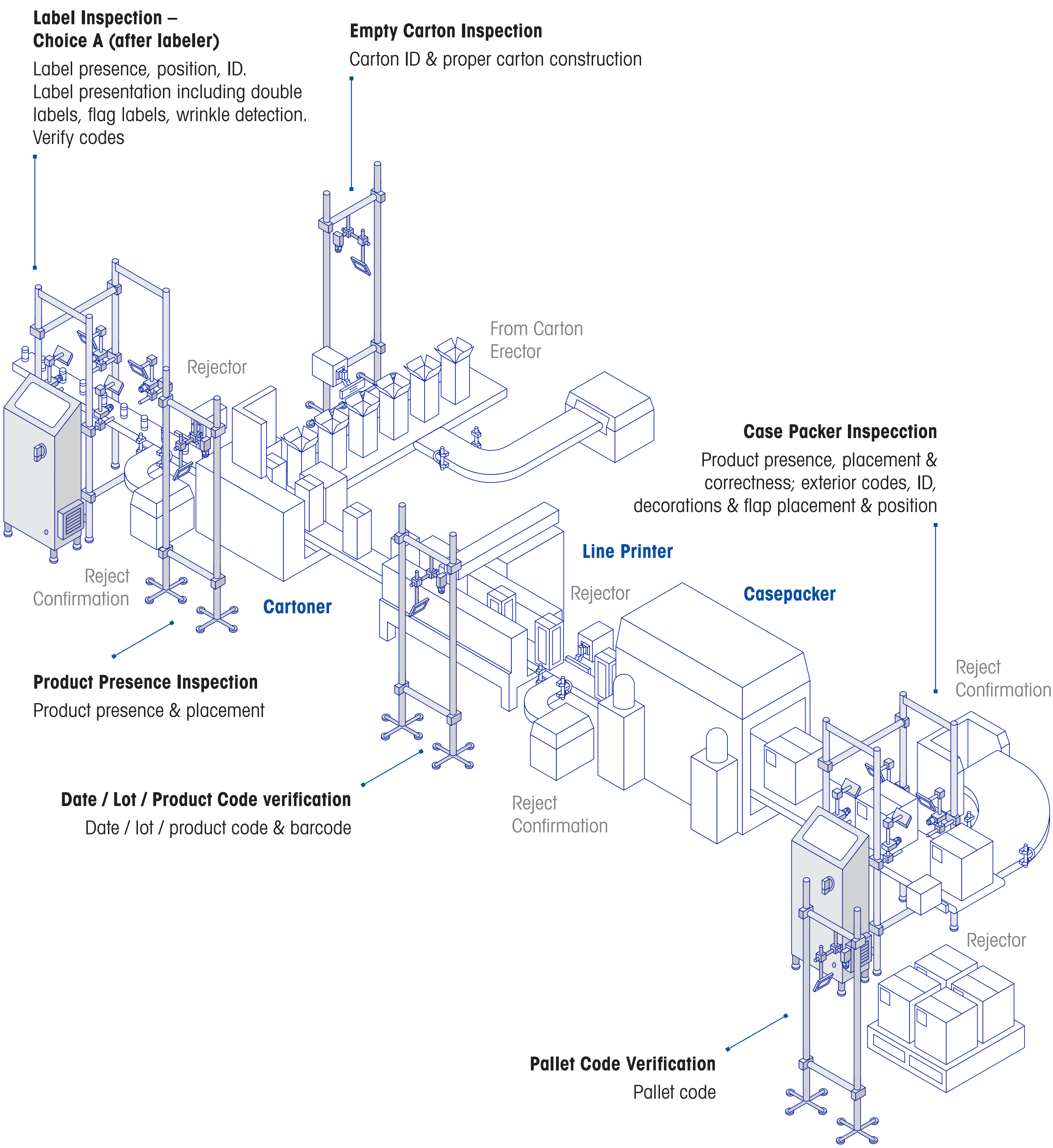


Complete Vision Solution

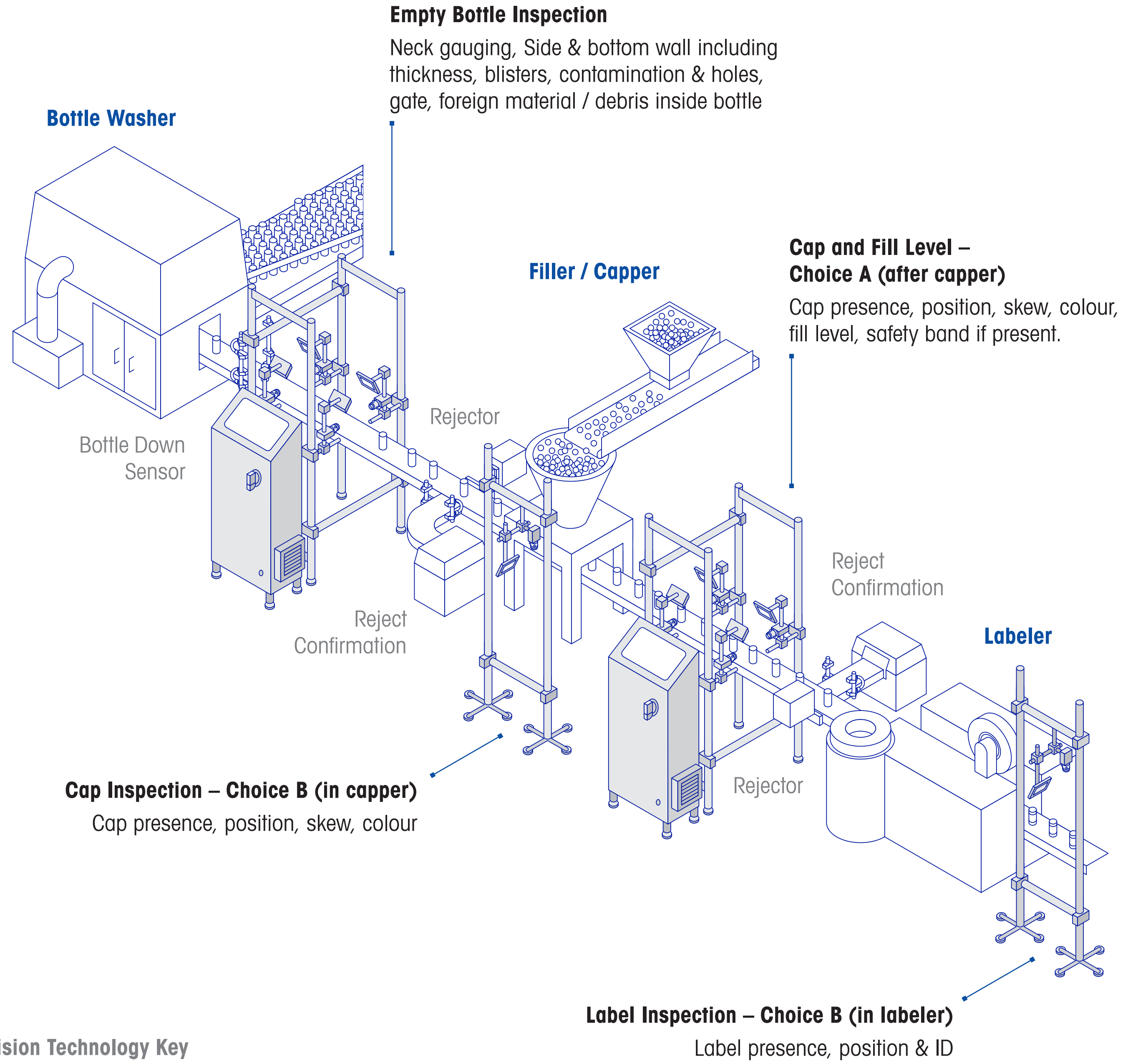


Stand-Alone Camera

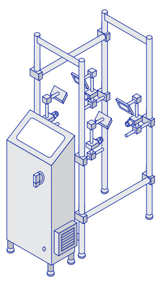
Liquid Fill Line



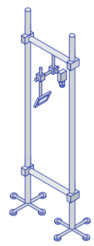
Dry Fill Line



Vision Technology Key



Complete Vision Solution

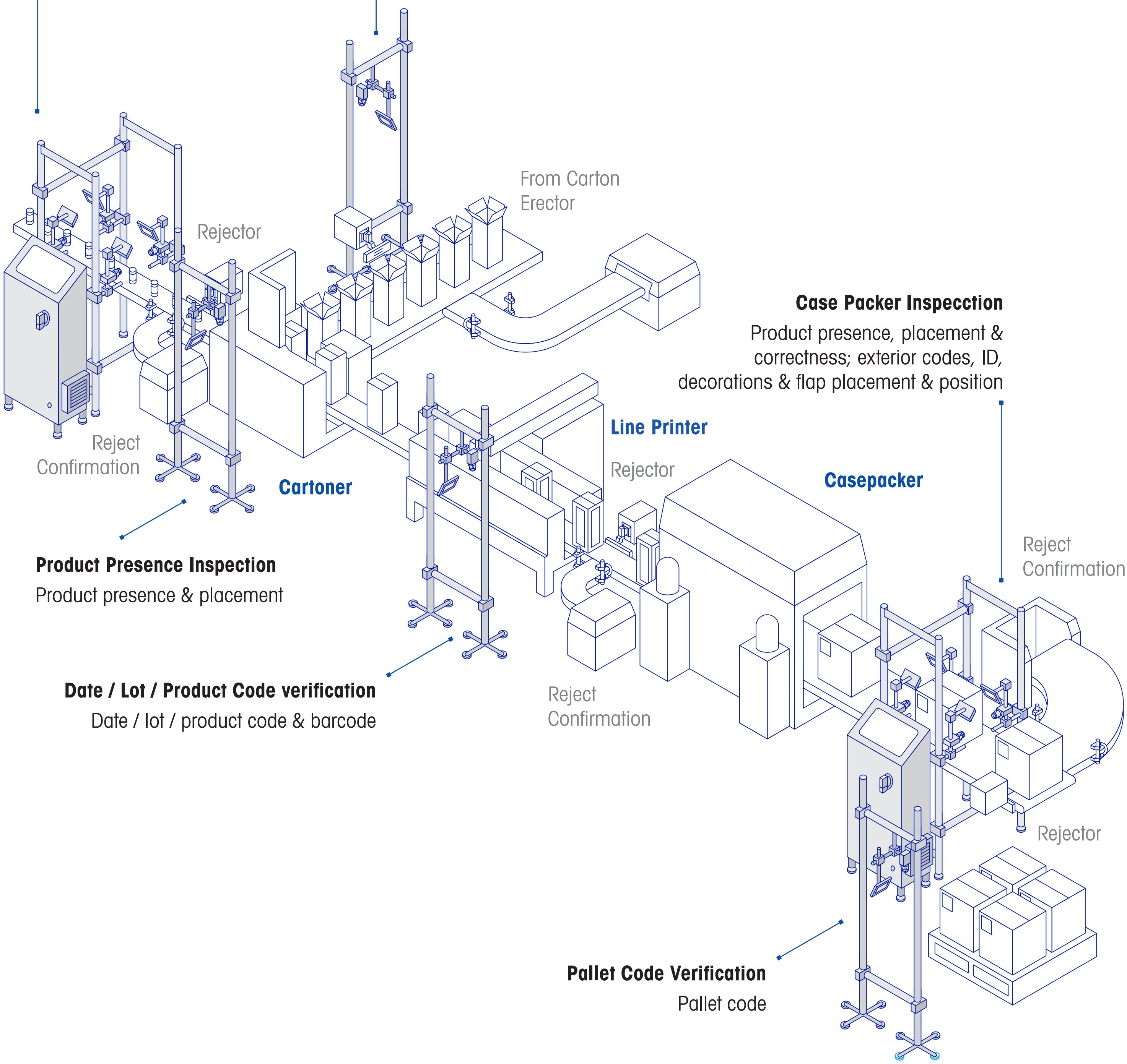


Stand-Alone Camera

Dry Fill Line

Label Inspection – Choice A (after labeler)
Label presence, position, ID.
Label presentation including double labels, flag labels, wrinkle detection.
Verify codes

Empty Carton Inspection
Carton ID & proper carton construction



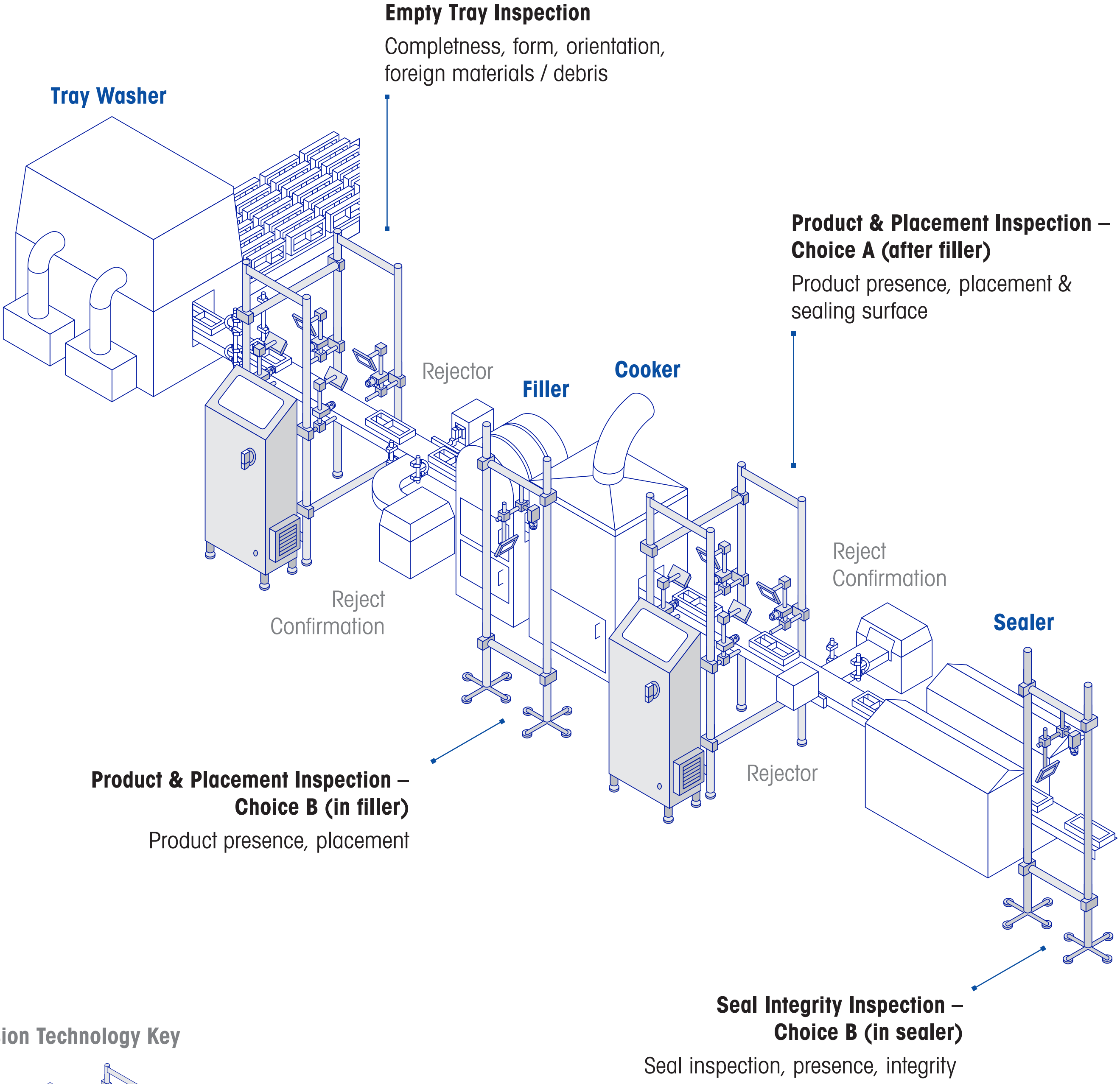
Case Packer Inspecction
Product presence, placement & correctness; exterior codes, ID, decorations & flap placement & position

Product Presence Inspection
Product presence & placement

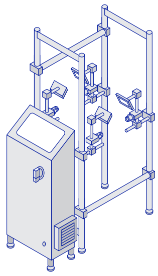
Date / Lot / Product Code verification
Date / lot / product code & barcode

Pallet Code Verification
Pallet code

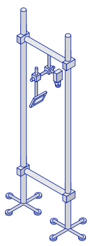
Ready Meal Line



Vision Technology Key



Complete Vision Solution



Stand-Alone Camera

Typical Vision Inspection Applications for Packaging

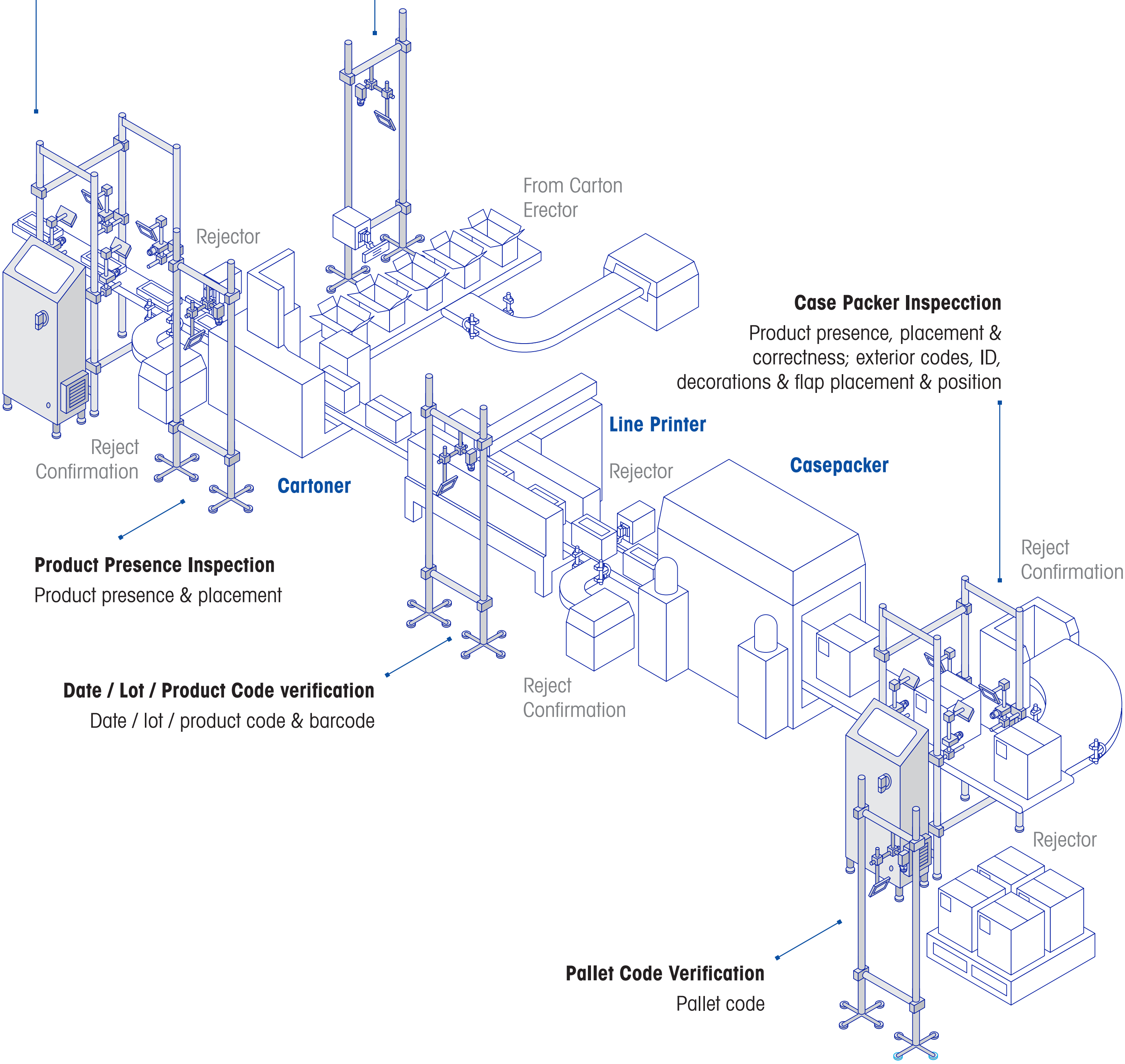
Ready Meal Line

Seal Integrity Inspection – Choice B (after sealer)

Seal inspection, presence, integrity, label, ID

Empty Carton Inspection

Carton ID & proper carton construction



Case Packer Inspecction

Product presence, placement & correctness; exterior codes, ID, decorations & flap placement & position

Product Presence Inspection

Product presence & placement

Date / Lot / Product Code verification

Date / lot / product code & barcode

Pallet Code Verification

Pallet code

Sustaining an Effective Vision Inspection Program

7.1 The Benefits of an Effective Program

When integrated into an overall quality control program, a vision inspection system offers a brand owner substantial benefits, including:

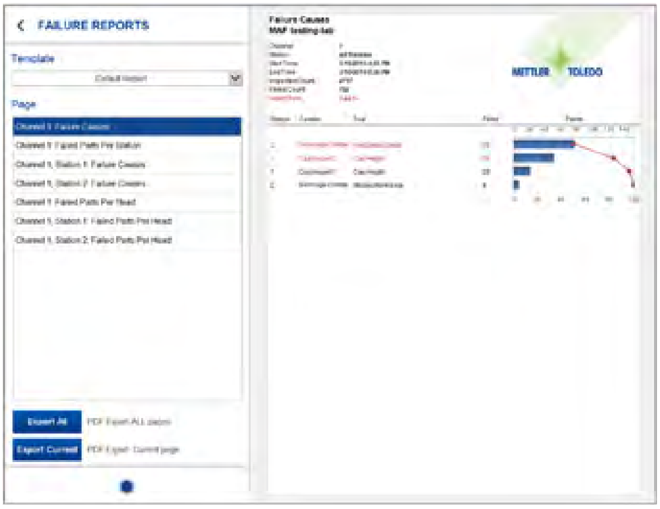
- Increased productivity
- Reduction of production costs
- Reduction of defective products leaving the manufacturing facility
- Consumer protection
- Preservation and strengthening of brand reputation
- Demonstration of commitment to quality products
- Adherence to industry quality and safety standards

Increasing Productivity by Reducing Defects and Mistakes

Having detected defective product on the production line, an effective vision inspection program should:

- Allow the vision inspection solution to pass data upstream to other machine controls, so as to help prevent continued occurrence of the defect
- Reject the product before it causes damage to downstream equipment (and before it reaches the consumer)
- Stop the line entirely if a number of consecutive defects occur — for example, an operator loading the incorrect label during a product changeover.

A good vision inspection system will also provide run-time data to the quality control team, allowing them to spot trends and warning signs of failing equipment or faulty processes. This information will help to improve the effectiveness of further trouble-shooting processes, and increase the likelihood of detecting the sources of defects.



Above: An effective vision inspection program collects and uses run-time data.

Increasing compliance – enhancing industry quality and safety standards

Vision inspection systems are also often used to help manufacturers seeking to implement a HACCP (Hazard Analysis Critical Control Point) program. This is especially true in the food industry, where concerns over mislabeled products or missing allergen information are of critical importance.

Should a manufacturer decide to implement a vision inspection system into their production line for HACCP purposes, they must be sure to manage the process with the same level of care and attention to detail as any other CCP (Critical Control Point).

Installing a vision system to improve overall quality is not currently a requirement of any government laws – although the US Food Safety Modernization Act does mandate a label control process which could include vision inspection – or industry regulations, although vision inspection has started to appear in retailer guidelines (such as the BRC's Food Safety laws) as an option for compliance.

These days, many retailer standards (such as those covering label placement and location) are playing a part in the selection of appropriate suppliers. As a result, these same standards influence the requirements or suggested specifications for manufacturers planning to install a vision inspection system.

In addition, retailers are insisting that full supporting documentation is in place to verify that manufacturers are following the appropriate industry standards. Retailers commonly request to see proof of audits by industry bodies; this is to confirm that manufacturers are effectively working to manufacture products of sufficient quality. In the event of a product recall or consumer lawsuit, this documentation can also prove that a manufacturer did everything possible to prevent defective products from reaching the marketplace.

Put simply, a well-designed vision inspection program can provide significant protection against both product and labeling defects, preventing a recall from happening, as well as demonstrate due diligence in the event of a product recall.

7.2 Using a Laboratory to Evaluate the Right Vision Inspection Solutions

To develop an effective vision inspection program, the manufacturer must provide a concrete set of specifications to the vision inspection provider — what inspections the manufacturer wants the system to perform, what their quality tolerances on those inspections will be, etc. All testing, auditing and training activities can then be completed against the standards established in this specification.

To complete a sufficiently detailed and comprehensive specification, the solution provider should perform extensive testing and evaluating. This process should aim to define the settings and components necessary to optimize vision system performance. Typical procedures include:

- Calculating camera resolution
- Defining camera type
- Determining field of view
- Choosing a lens
- Selecting lighting
- Product handling/rejection requirements

A comprehensive vision provider should have a vision lab in which they can test different lighting and camera configurations on a sample product provided by the manufacturer. If the laboratory evaluation is carried out correctly, the final vision inspection program will possess tolerances that will ensure the vision system is robust, repeatable and reliable. During evaluation, variables to be considered include:

- Product size and shape – this will determine the resolution and number of cameras needed to inspect the product
- Inspection area size – relative to product size, the inspection area must be defined in order to determine the resolution of the camera. If there is a small barcode on a large label, for example, a higher-resolution camera may be needed to verify the barcode and inspect the label positioning
- Product material – this will help to determine the lighting techniques needed to develop the best contrast for vision inspections.

- Product presentation – orientation of the product will help determine the angle at which a light and camera should access the inspection area. For instance, if material contamination needs to be inspected on an unorientated round bottle, multiple cameras and light angles will be needed to discover a defect located within a 360-degree arc around the bottle
- Product types – if multiple products are running on a single line, all products must be evaluated to determine adjustability, lighting solutions, resolution, and the number of cameras needed to inspect each product

Environmental factors, line speed and product-handling solutions on the line must be considered during the process of laboratory evaluation. These factors are critical when setting the tolerances which will determine how the system must be set up, tested and operated.

It should be remembered that product evaluations conducted with precision measurement equipment in a laboratory allow for very small margins of error when determining the final inspection set-up.

7.3 Selecting Optimum Line Placement For Inspections

Selecting the line placement for a vision inspection solution is crucial to the effective performance and efficiency of both the production line and the vision system. Four factors play a role in the placement of such a solution:

1. Available space
2. Product placement and presentation
3. Product development stage
4. Facility environmental conditions

Available Space

The vision inspection system must be installed in a location that can physically accommodate all system components. Correct positioning of the camera and lighting relative to the product is crucial, and there should be adequate space to allow sufficient light to be directed at the target. The camera must also be able to achieve a focused, full-frame image.

The ideal location of the HMI (Human-Machine Interface) for the vision system software is close to the inspection station. This allows for accessible fine-tuning and calibration of both the camera and lighting, producing optimal images.

The HMI interface itself must be located on the side of the line that gives operators easy and convenient access. If possible, the electrical enclosure should be placed beneath the line, but it can be remotely located if necessary. Occasionally, a vision inspection system may require a remote inspection station in order to perform additional inspections on a crowded production line.

Space is also required for reject mechanisms placed downstream of the inspection area. This gives defective products a place to be set aside for re-inspection, rework, or disposal.

It is well worth calculating system spacing requirements in advance of actual specification; planning spacing requirements beforehand will reduce the risk of costly re-work after the inspection system has been manufactured.

Product Placement and Presentation

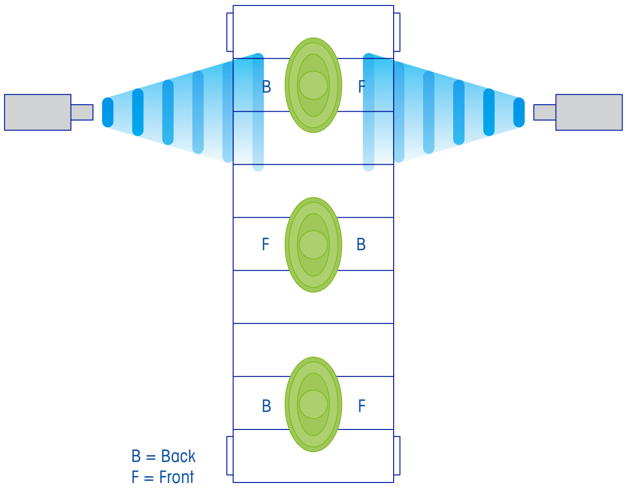
The vision inspection system needs to have a clear, unobstructed view of the target product to be inspected – so the inspected product should be consistently and properly positioned on the line, with consistent spacing between targets. If the product is not positioned in front of the camera in a consistent manner, there may be problems with measurements and focus.

Example: a camera is set up to read a barcode on a product at a two-inch two inch working distance; however, the product is presented to the camera at a distance of four inches. The barcode image will therefore be out of focus, and could result in a false reject.

Similarly, if the solution is used to confirm a measurement, a target object will appear larger in size as it comes closer to the camera, resulting in potential false rejects or false acceptance of a defective product.

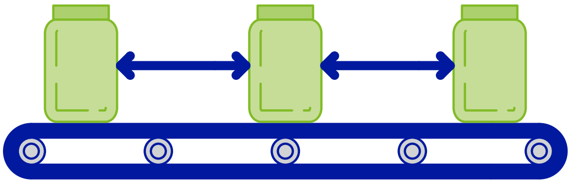
Product orientation on the production line also influences the location of the vision inspection solution. For example, if a system is designed with one camera to inspect a date/lot code on a carton, the code-carrying carton area must be facing the camera if a successful inspection is to take place.

For products (such as bottles) with front and back labels, cameras should be placed on both sides of the line. These cameras should also be programmed with intelligent search software capable of recognizing and performing inspections upon both the front and the back product labels. This eliminates the need for product orientation, reducing the overall cost of the system.



Above: An intelligent search system compensates for either front or back of bottle being presented to either camera.

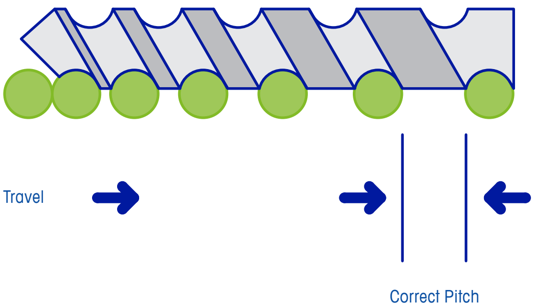
Products must have consistent spacing between them in order to prevent an inspection process overlapping onto two separate products. An accidental double inspection gives false data, as well as interfering with the rejection process – possibly leading to the rejection of both products. Products too close together may also cause obstruction of the camera view, especially if the camera is set at an angle.



Above: Example of bottle spacing

Product spacing is also essential to the rejection process. If there is a back-up in the reject area of the vision system, a faulty product may be rejected, but it may take a good product with it.

Back-up in the rejection area can also lead to bad product passing the rejection area due to triggering issues caused by the back-up. Correct product spacing can be achieved by techniques such as speed off-setting conveyor transfers, timing screws, star wheels or side-grip conveyors.



Above: Timing screw

A common way to avoid product-spacing issues without the need for additional product handling is to locate the vision system directly downstream from an automated system performing a specific task (such as a filler, capper, leak detector or labeler). Typically, the product exiting one of these stations is already properly spaced so that the vision inspection solution can perform its inspections accurately.

Product Development Stage

The vision inspection solution must also be placed to match the inspection required for the particular stage of the production process. For example, the inspection of the sealing surface of a bottle must take place before the line's capper, so that the inspection system has a clear view of the sealing surface.

As mentioned previously, however, PC-based vision systems are capable of supporting multiple inspection stations. This allows a product to pass through one inspection station, move through another part of the production process, and pass through a second inspection station controlled from the same HMI or with the placement of an additional HMI showing the same interface. For example, the sealing surface of a bottle is inspected as it enters the capper and is then inspected again as the bottle leaves the capper station.

Facility environmental conditions

The vision inspection system's operational environment also plays a role in the location of the system. The chart on the next page shows each significant individual environmental factor, its effect on the vision system, and a solution that can act as a safeguard.

7.4 Mechanical and Electrical Design

Once the line placement has been determined, system electrical and mechanical designs can be finalized:

- Electrical design – this must include all wiring, product tracking and powering components required for the vision inspection solution to operate. Proper documentation, certification and electrical drawings relating to all electrical equipment should be kept for reference purposes.
- Mechanical design – this can be set up to incorporate the cameras, lenses, distances and lighting devices that have been decided upon in the evaluation process. Robust, flexible brackets and structures need to be provided in order to avoid physical disturbance which could cause unintentional movement of lighting and camera; it is also important to ensure that the inspection system is adaptable to different product shapes and sizes running on a line. The mechanical design must take into consideration the correct height and angle required to maintain a consistent inspection on part changeovers and the laboratory evaluation. In addition, line placement selection will help to determine the required dimensions and flexibility of the final mechanical design.

Frame design

Selecting the proper frame of the vision system depends on:

- Available space,
- The type of inspections being performed
- Product-handling requirements
- The nature of the operating environment

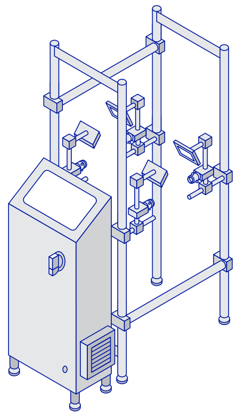


Figure 7.1

Complete vision inspection solution

Depending on lighting and environmental concerns, manufacturers may wish to select a vision system housed within a protective enclosure (see figure 7.1). The enclosure prevents intrusion of ambient light and protects the system from potential environmental threats –increasing overall repeatability and reliability.

Fully enclosed inspection systems can be mounted over the existing production line conveyor or in tandem with a product-handling solution, depending on the product presentation requirements specified during the evaluation stage of the project. The vision enclosure requires sufficient head-space to fit above the conveyor, while providing enough room for maintenance and adjustment access.

Inside other line machinery

A vision inspection solution can also be installed into other line equipment, such as a labeler or cartoner. This installation method takes up the least space in the line, although it may require integration procedures that need to be initiated between other line equipment suppliers and the vision inspection solution provider.

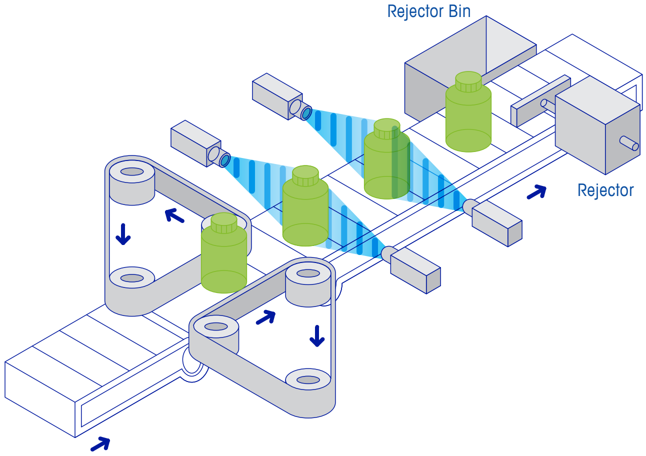
Fit to existing lines

Vision inspection solutions can be mounted directly onto the production line conveyor, or installed within the floor space under the conveyor. These types of installations can be ideal where space is limited – although the final installation location will be subject to influences of the production environment, such as conveyor vibration, ambient lighting and dirt.

Fitting a system to an existing line may require making modifications to the conveyor frame, such as drilling holes, re-directing wiring or mounting the timing equipment (encoder).

Product-handling

Product-handling can have a major impact on the quality, repeatability and reliability of the inspection procedures carried out by the vision inspection system. Variations in presentation of the product to the system can lead to false rejects – and, potentially, false acceptance of product. To solve this problem, the vision system may require its own product-handling solution (conveyor, side-grips, feed screw, etc.). For certain kinds of environment, however, this may not be necessary.



Double-Blind Data Entry

Depending on the product to be inspected, there may be codes that change frequently enough that operators need to enter in new codes — and this can be critically important, especially in pharmaceutical and food industries. Vision inspection systems with a double-blind data entry system require two separate operators to log in to the system, one after another, to enter the necessary codes. This helps to ensure that the proper code is entered every time.

Anti-Vision Circumvention Technology

Operators may try to bypass the system in order to meet their production goals, often at the expense of product quality. However, by monitoring product flow, Vision Anti-Circumvention Technology prevents production crews from bypassing vision quality checkpoints.

Pros and Cons of Installation Types

Installation Type	Pros	Cons
Inside Machinery	• Use existing bracketry • Automated positioning and adjustment • Communication and connectivity • Enclosure already provided	• Tight spacing • Difficult to install on pre-existing machinery • Expandability limited inside machinery
Vision Enclosure	• Protection from environmental factors • Protection from physical displacement of equipment • Robust placement of equipment • Modification to existing line unnecessary	• Might require additional spacing
Mounted Directly to Line	• Limited space required • Easily accessible	• Limited environmental protection • Interference from physical contact
Mounted Over the Line	• Limited space required • Easily accessible • Conveyor does not cause vibration	• Limited type of inspections • Limited environmental protection • Interference from physical contact

Training

A vision inspection system is only as good as the operator using it. To ensure that equipment is being used and operated correctly for optimum results, operators need to be properly trained in:

- Operation basics
- Power-up and shut-down
- Log-in and log-off
- Part change-over
- System safety product flow
- Equipment overview

A quality vision provider should offer comprehensive training courses for beginner and advanced users, to ensure that manufacturers get the most out of their inspection systems. Ideally, training courses should be available which cater to varying skill levels so as to ensure that the system is being used properly.

7.5 Documentation, Connectivity and Effects

Thorough documentation is a highly valuable safeguard if a company is under scrutiny because of a customer complaint; such documentation is equally valid in helping to ensure that quality product leaves the factory. Documentation should include:

- Vision laboratory evaluation results
- Solution specification
- Design of vision inspection solution (drawings and photographs)
- Installation and commissioning of vision inspection solution
- Tests and audits of vision inspection solution
- Rejects
- Data Analysis
- Records

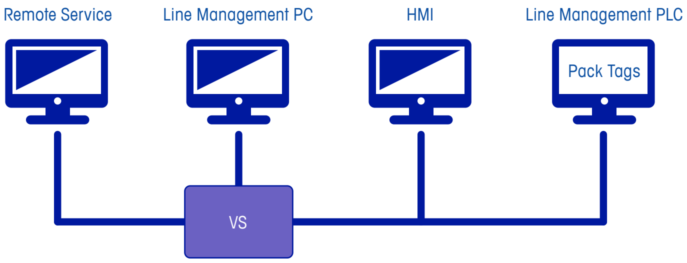
Records should be assembled, maintained and archived in order to provide evidence of an effective vision inspection program. Records should include:

- Permissions – a vision inspection solution will be operated by several people in the production environment. A robust and well-designed system should be able to provide multiple levels of access to a number of password-protected users, with designated individual permissions for each individual user. These permissions should allow only selected people to make critical changes to the system, such as alterations to measurement tolerances and inspection types.
- Adjustment logging – a properly designed vision inspection program will log each event within data log files. If tolerances or inspections are turned off, data logs will specify who turned them off and what the original setting was. Data logs will also record the time and date of the action.
- Data logging – this comprises the record of inspection results, including part measurements, types of defects detected, pass/fail rates and the number of products inspected. This data can be sourced into data management systems.

Importance of connectivity

Integrating vision inspection solution equipment into factory management systems will improve overall production efficiency – and a well-designed system should be capable of:

- Remote equipment management – changing product profiles
- Remote servicing and data back-up – online diagnostics from the solution provider
- Data collection and recording – recording performance data, test routines and vision inspection



Data from a vision inspection system can normally be retrieved straight from an external USB port. Alternatively, it can be exchanged via an Ethernet port.

Preventing Typical Defects and Problems

Defective products can come from three sources:

1. The material coming from suppliers used to make the finished product in the manufacturing facility. For example, surface contamination on a rigid plastic container shipped to a bottling plant.
2. Finished products made from supplier materials, such as an improperly applied label, poor print, and missing print or missing closure.
3. Human error can cause the wrong materials to be used in production, such as loading the wrong spool of labels into a labeller during a product changeover.

1). Defective incoming materials

A typical manufacturing facility uses many different types of packaging materials from different suppliers in a number of critical processes. Defects in these materials can cause production issues, such as loss of product, rejected defects and machine damage. However, if these defects can be detected in advance before they have a chance to enter the production process, issues such as the following can be easily avoided:

- Product spilling on the line
- Damage or jamming to downstream equipment
- Work performed on product and later rejected

Above: An undetected faulty closure after it has been placed on a filled bottle.

2). Defects arising from the production process

Every time a product or package is transferred from one process to the next on the production line (or moves to another line), there is risk of damage. Fillers, cappers, leak detectors, labelers, conveyors and other product-handling equipment are all potential sources of damage or mishandling that can cause product defects.

Most companies recognize the value of regular maintenance, and adhere to scheduled maintenance procedures. These maintenance programs can be scheduled by using the vision system's failure logs to identify equipment in need of repair. Manufacturers should ensure that:

- Product safety and quality are not jeopardized during maintenance
- A documented, company-wide, planned maintenance program is in place
- Clear instructions are available to maintenance personnel indicating what is to be done during planned maintenance (including strip-down and re-build)
- Personnel are trained by the equipment manufacturer – or by company staff who have been trained by the manufacturer
- Procedures are established to ensure that jobs are started and completed on time. If these jobs are not carried out for any reason, they should be highlighted.

- Systems that have undergone repairs, maintenance or adjustments are properly tested afterwards
- A system is in place for the management of spare parts

It is important that potential hazards, such as defective machinery, are reported immediately so that corrective action can be taken.

When production line products undergo changes (such as shape, color or content), production machinery may also have to change accordingly – so it is essential that vision inspection controls be reviewed and re-set to reflect the parameters of new or re-built equipment.

7.6 Inspection

Inspection in Controlled Environments

In today's competitive and legislation-driven market conditions, there is a zero-tolerance attitude towards packaging defects that can lead to misbranding, spoilage, contamination or leakage of a product.

Companies recognize that the direct and indirect costs of such defects can include demands for damages arising from customer complaints, as well as costly product recalls and/or lawsuits.

To guard against these potentially catastrophic losses, responsible brand owners establish strict packaging tolerances and inspection standards; these are designed to prevent packaging failure – including ISO certification. Manufacturers who undergo industry certification processes also expect their packaging suppliers to adhere to similar standards and tolerance demands.

For example, bottle blowers who implement these standards check bottles specifically for the correctness of factors such as:

- Ovality
- Interior dimension of container (ID)
- Outer dimension of container (OD)
- Surface contamination
- Burns/holes
- Container height
- Neck thread formation

These are the most critical measurements for preventing rigid plastic container failure -and, as such, would be required capabilities for any vision inspection system destined for use in a bottle-blowing facility.

Vision inspection for ISO standards

Vision inspection systems can compile documentation which can be extremely valuable for assessing the success of a quality standards program. Such documentation can also act as a valuable defense in the event of a complaint, lawsuit or regulatory inquiry. For packaging providers, such documentary evidence of quality standards adherence can also offer the end user vital reassurance of the provider's strict adherence to ISO standards.

Vision inspection for American National Standards Institute (ANSI) Standards for Barcodes

Standards and guidelines for barcode quality have been established by ANSI (the American National Standards Institute), ISO, CEN and UCC (the Uniform Code Council), based on the most common UPC barcode – ANSI X3.182-1990, EN 1635 and ISO/IEC 15426-1. ANSI verification ensures compliance for suppliers and retailers, because it focuses on print quality defects that can alter a barcode reading.

A vision inspection system will use tools to grade a barcode, based on the categories within the ANSI guidelines. ANSI software tools use the grading system of 0 to 4 (alternatively, the grades can be expressed as a letter grade {A, B, C, D, or F}) based on the measurements in each category, i.e.:

- Edge determination
- Minimum reflectance
- Symbol contrast
- Minimum edge contrast
- Modulation
- Defects
- Decode
- Decodability
- Quiet zone

A grade of '3/C' (or better) should read on most scanners at the first attempt. Some packaging suppliers and their customers require a grade of 'B' or better, since this allows for a larger margin of error.

Barcode quality has become increasingly important, as many production lines rely on real-time scanning to track product movements. Good print quality is essential; using a vision inspection system to grade barcodes allows label manufacturers to be certain that their codes are readable before sending them to customers for use.

7.7 An Introduction to HACCP

An Introduction to HACCP

HACCP (Hazard Analysis Critical Control Point) certification has now become part of most factory-based quality assurance systems and is now also included in the FDA's Current Good Manufacturing Practices. This is because of increasing HACCP-related legislation, as well as manufacturers seeking to protect consumers from possible hazards. Manufacturers also appreciate the value of HACCP in helping to secure and maintain the integrity of their own brand images.

When companies implement a HACCP program, the majority of retailers in most markets accept GFSI (Global Food Safety Initiative)-approved standards, which include BRC (British Retail Consortium), IFS (International Food Standard), SQF (Safe Quality Food), or ISO (International Organization for Standards) 22000.

There are seven HACCP principles, and these have been adopted by each of the globally approved standards mentioned above. The purpose of this adoption is to communicate how to maximize the effectiveness of vision systems (when installed as a Critical Control Point) in protecting against hazards such as mislabeling, label damage or poor-quality labels that prevent clear communication of package contents.

In reviewing product recall statistics from around the world, it is clear that most modern factories are undertaking effective hazard control programs aimed at eliminating physical contamination. Product recall numbers are falling every year, thanks to technology improvements and more effective implementations of strong HACCP programs. (For more information, please refer to Mettler Toledo's metal detection and X-ray guides, which available on the MT web site at www.mt.com/pi).

However, product recall statistics also demonstrate that manufacturers continue to struggle when trying to limit hazards such as mislabeling, label damage or poor-quality labels. As a result of these label-related defects, the ensuing threats to consumers include overdosing or ingesting of allergens — either of which can result in serious injury to the consumer, the brand and the manufacturer's profits. Fortunately, vision inspection systems are well-suited to label inspection applications, and frequently eliminate the risk of a mislabeled product leaving the facility.

The 7 HACCP principles are:

1. Conduct a food safety hazard analysis
2. Identify Critical Control Points (CCPs), i.e. points at which a hazard is most effectively controlled)
3. Establish critical limits for each CCP
4. Establish CCP monitoring requirements
5. Establish corrective actions
6. Establish record-keeping procedures
7. Establish procedures to verify that the system is working as intended

Vision and HACCP

These seven HACCP principles can all be served by a vision inspection solution when applied to label-related Critical Control Points such as mislabeling, code errors or label damage.

1). Conduct a food safety hazard analysis

Food manufacturers must consider a wide range of potential hazards when implementing their HACCP programs – and a well implemented HACCP program can address challenges such as:

- Unreadable expiration date
- Incorrectly labeled product, which could mean that an allergen is not identified, or a dosage is not correctly communicated
- Labels applied incorrectly, obscuring important health information

2). Identify the Critical Control Points (points at which a hazard is most effectively controlled)

Vision inspection systems should be installed where they can most effectively identify and remove potential label hazards. To ensure that this occurs it requires the same approach as determining where any other CCP should be located — as close as possible to the source of the potential hazard.

This allows the hazard to be tracked back to that source quickly, so that any problems can be efficiently resolved. This will ensure the least possible negative impact on production speeds, and will minimize the risk of a hazardous product being introduced into the supply chain. Typical hazard sources include:

- Operator error – an operator loads the wrong label or does not change the label during product change-over
- Operator circumvention, when operators try to 'fool' inspection systems so as to reduce product rejects and meet demanding delivery schedules. However, they do so at the cost of product quality and consumer safety
- Faulty or poorly maintained upstream equipment, such as printers running out of ink, improperly cleaned print head or an improperly calibrated labeler

A good vision inspection system can require operators to double-enter product codes to ensure that the system is looking for the correct label at all times; this reduces the risk of operator error going unnoticed. Similarly, vision systems with vision anti-circumvention technology can detect when operators are attempting to fool the system; they will sound an alert when such an event takes place.

3). Establish critical limits for each CCP

A vision inspection system can monitor and control a large range of variables, in accordance with the manufacturer's requirements. However, when using a vision system as a CCP for either mislabeled product or incorrectly-applied labels, there are only pass or fail conditions. Detecting and distinguishing a good package from a bad covers all failures.

4). Establish CCP monitoring requirements

If a problem is found at the CCP, the monitoring of vision inspection CCPs must be linked to the manufacturer's ability to recall product from the supply chain. Industry experts recommend that a vision CCP should be tested at regular intervals. The length of time between each test should allow for safe and reliable recall for faulty products manufactured between the time of the last test and the failed test.

In practice, the best solution is for manufacturers to have a shorter testing interval than may appear necessary. Whilst this might be considered over-cautious, it can make a major contribution to identifying and removing faulty products – avoiding the potentially massive cost and effort of recalling faulty products once they have left the factory. Equally damaging could be the costs involved in missing a faulty product that leaves the factory and harms a consumer or causes a problem with a retailer.

For the first three months of operating the CCP inspection system after installation, it is advisable to make hourly checks at the start of each shift; further checks should be made at the time of product changeover. As the operators' confidence increases, an increase in interval is recommended, in line with the manufacturer's confidence in being able to speedily recall faulty products manufactured between tests.

The testing procedure for a vision CCP is to introduce officially verified product of different types, namely:

- Good product
- Marginally good product
- Marginally bad product
- Bad product

These various levels of product should be introduced to the production line by the team responsible for Quality – and if the good-quality products pass, whilst the bad-quality products are rejected, the machine passes the test; if it fails, the line must be stopped and the problem should be investigated.

5). Establish corrective actions

When a hazard is identified by the vision CCP, steps should be taken to mitigate risk to the consumer and risk of a recall. The first step is to evaluate the hazard and take appropriate action. Typical hazards and responses include:

- A one-off label tear with a clear reason for the tear: continue production and quarantine the product for the Quality team to evaluate. If multiple products are damaged, a line meeting must be called as soon as possible (ideally with the line on hold), to reduce risk of these products getting into the supply chain.
- Multiple labels incorrectly applied and rejected: the vision inspection system should automatically shut down the line. A line meeting must be held quickly to identify the source of the problem before the line is impacted.
- The operator circumvention warning goes off: the line manager needs to remove circumvention devices, and disciplinary action needs to be taken to prevent this from happening again.

Industry experience indicates that if these actions are dealt with immediately, documented clearly and communicated promptly to management, they will contribute significantly toward gaining the confidence of the auditors; they will also make a major contribution towards passing HACCP inspections without delay.

6). Establish record-keeping procedures

If vision equipment is to be used as a CCP, the equipment supplier should also provide a full set of documentation, to ensure that correct procedures are followed when installing, setting up, commissioning, maintaining and testing the ongoing performance of the machine.

These are all documents that the auditor will require when reviewing any GFSI HACCP-based standards (BRC, IFS, SQF, and ISO 22000).

This documentation will also support manufacturers' set-up activities; also in addition, it will control internal quality procedures and help to provide support if a problem occurs.

METTLER TOLEDO can supply an example of the types of documents required to support CCP installation in a HACCP audit.

7). Establish procedures to verify system performance

In addition to the monitoring procedures outlined in HACCP principle 4, above, it is advisable that any CCP (not just vision) should, at the very least, undergo annual performance verification. Equipment operating in a harsh environment or dealing with a particularly dangerous hazard should undergo performance verifications twice a year.

These performance verification checks will significantly help to increase the confidence of manufacturers, retailers and auditors that the CCP is operating correctly. Furthermore, such checks will increase everyone's confidence that no consumer will be harmed.

Note: when installing a vision CCP, it is important for the end-user to keep in mind that the vision system is not restricted to monitoring label mix-up or poor label application–container formation and integrity applications can also be run on the same system.

7.8 Pharma-related Standards

The pharmaceutical manufacturing environment is very strictly regulated, and the equipment used in pharma manufacturing facilities must both comply with such standards and help manufacturers, by providing easy equipment implementation and operation.

Three of the key standards with which equipment suppliers must comply are:

1. 21 CFR Part 210 and 211

These standards oblige the manufacturer to ensure that:

- Operators are effectively trained on production equipment
- Specified equipment is appropriate and of the correct size
- Equipment is located in the best place for its intended purpose
- Equipment is to be tested and calibrated by a certified technician at the correct intervals
- Equipment is not additive or absorptive to product

2. 21 CFR Part 11

In addition, CFR regulations cover the use of electronic records and signatures under 21 CFR Part 11. Under these regulations, all software-controlled hardware must have traceable, auditable electronic signatures and records.

3. GAMP 4

When being developed, all computer-controlled equipment software must be designed in accordance with Good Automated Manufacturing Practices (GAMP) guidelines.

7.9 Performance Verification and Auditing

This section provides guidance on the essential elements of a verification procedure. It also covers the practical considerations necessary to demonstrate due diligence, and to balance the frequency and complexity of testing with associated benefits, costs and risks.

Verification Procedure

Any vision inspection solution should be periodically verified in order to demonstrate due diligence, and to ensure that:

- It continues to operate in accordance with specified inspections
- It continues to reject defective product when defects are detected
- All additional warning/signaling devices are effective (e.g. alarm conditions, reject confirmation)
- Installed failsafe systems are functioning correctly

Verification and audit procedures should ensure that company/line/product inspection standards are being complied with. These compliances should be documented and communicated to all relevant staff; they should also be readily available for use by those responsible for conducting necessary verification procedures and audits. As a minimum, the procedure should cover:

- Test sample to be used
- Effective use of test packs (where applicable)
- Frequency of testing
- Number of tests
- Detector and reject device test methods
- Failsafe systems testing
- Treatment of rejected / suspect product

Guidance is provided below on the technical considerations and practicalities for each of these requirements.

Types of Test Samples to be Used

The following samples should be used to test inspection systems:

- One confirmed good product
- One confirmed bad product, representing each defect type that the system is inspecting for
- One marginally defective product representing each defect type that the system is inspecting for

With the exception of the defect, the samples used during testing should contain exactly the same properties as an everyday product on the production line.

The testing will be compromised if the product test samples do not exactly replicate production-line items. It is especially important that the reflective properties and shapes of the product are exactly the same as production-line products.

Effective use of test packs (where applicable)

During testing, each test product should be placed on the conveyor in exactly the same location (relative to the inspection system), since each product that passes through the system during production.

Each of the defective products should be rejected, and then the good product should be passed through. If the system does not identify the defective products, the vision inspection solution provider should recalibrate the system.

Frequency of Testing

Procedures should clearly state when verification testing must be performed within the manufacturing cycle. Consideration should be given to implementing verification testing:

- At the start and finish of daily production/shift
- At regular intervals during the production run (as necessary)
- At changes in production batches
- At changes in machine settings
- After downtime for repairs

Considerations for each of the above stages are defined below:

1. At Start and Finish of Daily Production/Shift

Consideration should be given to verification testing at the start and end of the daily production/shift. This will ensure that the vision inspection system detects and rejects products in accordance with the specification; it will also ensure that any additional warning systems are functioning correctly, e.g. 'Reject Bin Full' indicator.

In addition, any failsafe features included as part of the system specification need to be verified at the start of each shift. If a failure is observed, this should be corrected before beginning the daily production/shift.

2. At Regular Intervals during Production Run

During a production run, the frequency of verification needs to be defined within the procedure. It will ultimately depend upon the probability and consequences of a failed test. The following factors should be taken into account:

- Quarantine period
- Customer, retailer and consumer brand codes of practice (if applicable)
- Margin of detection
- Failsafe system design

Quarantine Period

The quarantine period relates to the time it takes to produce the maximum amount of product stored on company premises before it is shipped.

The verification period should be shorter than the quarantine period. This will ensure that, if there is a test failure, the product manufactured since the last successful verification will still be on the company premises. That ensures that it will be easily identifiable and easy to isolate pending further action.

Customer, Retailer and Consumer Brand Codes of Practice

Customer, retailer and consumer brand codes of practice may well specify a frequency of verification greater than the quarantine period.

Margin of Detection

When there is a good margin of detection, and it is known that the systems will act in accordance with failsafe procedures, manufacturers may reduce the frequency of verification tests. This is based on the fact that, even if there are small changes in the vision inspection system, it will still detect the specified test samples.

Such decisions should only be taken when the margin of detection can be quantified, and when the risks are considered acceptable. In practice, the inspection standard may apply to many different solutions; these will probably vary by manufacturer, type, age, reliability etc. Consequently, the margin of safety may not be the same with all solutions.

Failsafe System Design

Robust failsafe system design and access control can be used to good effect in reducing the probability of a failed test and also reduce frequency of testing. For example, if production line operators are prevented from making setting changes (e.g. lowering sensitivity by means of access control),the potential for a verification test failure is reduced.

Similarly, if the vision inspection solution automatically requests a verification test each time there is a product change, this will limit the potential for a product to be run on the 'Incorrect Product' memory selection.

3. During Changes in Production Batches

Consideration should be given to performing a verification test to confirm detection and rejection in accordance with the inspection standard whenever there is a change in product type running through the vision inspection solution. This is most important when the product type change requires a selection of a different product memory within the solution.

4. During Changes in Machine Settings

A verification test should be performed to confirm detection and rejection in accordance with the inspection standard whenever there is a change in the solution settings.

5. After Downtime for Repairs

If maintenance work or repairs have been carried out on the production line during down time, the vision inspection solution and reject mechanism should be re-verified at the recommencement of production.

Number of Tests

The number of tests to be performed should be based on the level of confidence established during the original commissioning activity, when the capability of the vision inspection solution was first established.

If there was good, repeatable detection capability, then confidence in the system should be carried through to production verification testing, i.e. if there is a good margin of detection on a single test, what is to be gained by conducting further tests?

Alternatively, if a verification test is conducted and the test sample barely registers, then repeatability may be questioned. Further testing may give greater confidence – though if testing is conducted three times and the results obtained are one marginal detect and two good passes, then what is the statistical significance of this in relation to a high-volume production line?

Statistically, further marginal passes (or even a missed detection) could be expected. Therefore, the system probably does not have sufficient detection capability in the first instance. Consideration should therefore be given to increasing the frequency of verification testing.

Three tests per product defect type would be considered the minimum practical level for production verification purposes. If good detection capability was established during the commissioning and installation of the system, however, one test per sample is an acceptable practice.

The number of tests to be performed for each test sample is ultimately dependent on the level of statistical significance required within the producer organization. It is also dependent on the level of statistical significance required to fulfil any external requirements.

Detector and Reject Device Test Methods

Verification procedures should include precise details of the methods to be used. The methods will vary dependent on the vision inspection solution design and the actual application.

As well as ensuring that the solution is performing to the required sensitivity standard, it is important to test that the reject device is functioning correctly; this will ensure that it is still capable of rejecting the detected defective product.

For example, it is common for conveyor speeds in plants to be changed for a variety of reasons. If this occurs and the reject timing is not suitably adjusted, the wrong product may be rejected (this is not a problem for vision systems using encoder-based tracking).

Similarly the air supply to an air-blast reject device could be disconnected accidentally, resulting in failure to reject defective product. It is more efficient to devise a test method that tests the vision inspection solution (including the reject device) at the same time.

For the test to be considered successful, all the test products should be detected and rejected to the correct reject location. Should any part of the verification test fail, products manufactured since the last satisfactory test should be isolated and re-screened using a functioning solution.

Product Rejected During Normal Verification Testing

Defect-free product rejected during normal test procedures should be placed back in the product flow prior to the vision inspection solution for re-inspection. Thereafter, it should be regarded as normal production.

Failsafe Systems Testing

A test method should be established for each failsafe system built into the vision inspection solution. The following are examples of some common failsafe devices which may be incorporated into the vision inspection solution design and associated test methods:

Air Blasts or Punch/Pusher with Reject Confirmation

Testing should be carried out by passing a test pack down the line. This should take place while temporarily interrupting the electrical supply to the reject device solenoid and observing that:

a) The reject mechanism does not operate, and
b) The conveyor belt stops

'Reject Bin Full' Indicator

This should be checked by breaking the beam for the required length of time, and then observing that the belt stops.

Vision System Performance Audit

Performing regular audits of vision inspection systems is an additional and valuable service in supporting the overall vision inspection program – particularly when executed by the solution provider.

These audits ensure that equipment complies with the manufacturer's recommendations and good practice – and experienced vision inspection experts often spot potential problem areas when they inspect such audits. Solutions can then be suggested before such problems become apparent to the user.

Test Results

Test results should be documented, so as to demonstrate that all verification procedure requirements were executed. These records should include:

- Identification reference (e.g., serial number, CCP number)
- Product being produced
- Date and time of test
- Test samples used
- Name of the person who conducted the test
- Test results for both detection and rejection
- Test results for any failsafe devices
- Fault details and corrective action taken (as applicable)

Should any verification test (or part of such a test) fail, the cause should be investigated immediately – and it should be corrected before production re-commences. Product manufactured since the last satisfactory test should be regarded as suspect and treated accordingly.

The details of the fault (and the subsequent corrective action) should be recorded as part of the test record. The accurate recording of test results is extremely important; this is because, in the event of a customer complaint or audit, a manufacturer may need to rely on such records to prove that procedures were correctly followed. The records can also prove that the vision inspection solution was functioning correctly to the agreed inspection standard.

7.10 Dealing With Suspect and Rejected Products

This section provides practical guidance in relation only to those matters associated with the use of vision inspection systems. It does not cover more general aspects of dealing with rejected product, such as identification and traceability, final product disposal, and product recall.

If a vision inspection solution fails a periodic verification test, the product that has passed through the system since the last test should be considered suspect. Product rejected by the vision inspection solution during routine operations, should be considered defective until proven otherwise.

In both the above instances, it is important to note there must be a clearly defined process for dealing with product safety concerns from the point of identification, through to root cause investigation and final resolution. Only authorized personnel should be allowed access to rejected product for the purpose of evaluation and investigations, and proper controls should ensure there is no risk of mixing rejected product with good product.

Action Required if a Verification Test Fails

If the vision inspection system fails to detect or reject a test sample during a periodic verification test, production should be stopped if the failed inspection would result in a hazard for consumers.

Product manufactured since the last successful verification test should be regarded as suspect, should be identified accordingly – and then must be isolated from the rest of production while awaiting re-inspection.

The cause of the failure should be determined, and if it is established that the failure occurred as a result of tampering or a change in production conditions, procedures should be established to prevent this from happening again. System logs should be reviewed in order to put the original inspection parameters back in place.

If the vision inspection solution can be modified to bring it back to correct operation, this process should be carried out and noted in the system records. If the cause of the failure is due to a system fault, it should be repaired before carrying on with production. If the system cannot be repaired by the staff on site, the vision system provider should be contacted for further technical support. In each case, the system should be re-verified before production re-starts.

The suspect product should be re-inspected through a working vision inspection system which has the same measuring criteria as the original system used on the production line.

Product that passes the re-inspection process should be considered acceptable. Any product that is rejected during re-inspection should be considered defective and subject to further investigation.

Treatment of Rejected Product

Any product rejected during normal production operation should be regarded as defective and subject to investigation. The evaluation of rejected product should take place as soon as possible – ideally within one hour of rejection, but certainly within that production shift, and before the product batch leaves the manufacturing site. The best practice in this situation is to investigate as soon as the rejection occurs.

Rejected products should be disposed of after re-testing, ideally even if they pass inspection on a second time through. This is not always economically viable, however, especially if a producer is incurring high levels of rejected product due to excessive false rejects.

In such instances, the producer must ensure that the rejected product complies with the stated quality control guidelines before allowing them back on the production line. This is one of the ways in which a vision system is superior to a smart camera — allows users to pull up failure images, allowing for the quick identification of the defect which caused the system to reject the product.

Finding and identifying defects in the rejected product is important because:

- If the source of the fault can be identified, steps can be taken to prevent its recurrence
- If line operators can see the results, it will help to build confidence in the vision inspection system

Corrective and Preventive Action

If a defect is confirmed, procedures should clearly define the corrective and preventive actions to be taken going forward. Guidelines should also be in place to determine who is responsible for deciding the significance of the defects in question, who has the authority to hold product, and who assigns disposal of defective products.

If a rejected product is confirmed as defective, this should prompt an immediate risk analysis to determine the significance and potential for the occurrence of further product defects.

Procedures should clearly define under which circumstances production should be shut down, based upon the frequency of findings and the nature of the defect type. The results of any investigations (including details of defects found, source of the defect, and actions taken) should be fully documented for future reference and ongoing analysis.

Vision Inspection System Fault Condition

When a fault occurs during a normal production process, resulting in a situation where production is halted, the necessary repairs or corrective measures should be taken and the vision system must be re-verified to ensure proper functionality. Once the fault has been rectified, all product within the stopped process flow (downstream of the vision system) should be collected and passed through the system again.

Data Analysis & Program Improvement

The effectiveness of a vision inspection system is determined by collecting data and subjecting it to trend analysis. Using this information over a period of time will help determine the effectiveness of the vision inspection system – and, most importantly, it will be the first step in quantifying (in monetary terms) the savings or increased profit generated.

Data Analysis

Effective data collection and analysis is dependent on the needs and capabilities of the business. It is vitally important that there is integrity in the source data – and it is equally important that the results of the analysis are clear, so that there is successful buy-in throughout the organization. For those who are responsible for providing data, communication of analysis results (and resultant actions) will help to ensure the data flow is sustained.

If data is not being used to good effect, its value will be questioned within the organization, resulting in reduced discipline in data collection and recording. Wherever possible, a cost element should be included in analysis of data. This will have an increased impact on the prioritization of improvement initiatives; it will also provide justification for additional capital expenditures.

Program Improvement

The following are examples of the types of analysis that can prove beneficial when reviewing a vision inspection system for the purposes of its improvement. The same principles can be applied to a variety of data sources:

Customer Complaints

Each customer-related defect should be investigated in order to determine its cause. Program documentation and records will greatly assist in the investigation, and may even prove useful as evidence to defend an unjustified complaint or lawsuit. Corrective and preventive action should be taken as appropriate, and the vision inspection solution program should be improved accordingly.

The number of complaints and assigned causes should be monitored over time to make sure improvement is being made; such monitoring will also help to identify and eliminate underlying common causes. These kinds of actions can help to reduce complaints, with the overall aim of reducing them to zero.

Rejection Events

Rejection events are caused by actual defects or false rejects. Rejection event information should be regularly collated and, typically, monitored on a trend chart in order to identify common causes. Analysis of defect type and frequency of events organized line-by-line or system-by-system can identify sources of concern. These can include component supplier quality, inefficient production staff/methods or inadequate maintenance routines.

There should be a clear distinction between normal production reject events and reject events that occur when carrying out routine verification tests, line start-up and changeover activities.

Analysis of 'false rejects' can prove beneficial in identifying poor system installations, and in identifying equipment that has become unreliable. It can also identify inspection solutions that can no longer cope with the required operational tolerances. Such data could be used as justification for upgrading to a more modern and capable vision inspection system.

Verification Tests

The results of verification tests should be monitored and analyzed as an ongoing process. If high frequency of testing is taking place (e.g., every 30 minutes), and the analysis over time shows that the tests are always positive, consideration could be given to reducing the frequency of testing. Caution should always be exercised to ensure that external standards or codes of practice are not contravened and that the risks involved are known and acceptable.

Maintenance Records

If the analysis of preventive maintenance records and incident reports highlights that a particular solution rarely needs any maintenance, there may be sufficient justification to reduce the frequency of maintenance. This should only take place if it is not contrary to the manufacturers' recommendations or risk assessment.

General

There are numerous other sources of data that can be analyzed to good effect. It is important to focus on areas that can generate the greatest return, in terms of increased profitability and reduced risk.

Ongoing analysis of program data can identify underlying common causes that, in isolation, do not appear to have great significance.

However, when considered in terms of their frequency or pattern of occurrence, these common causes can provide the incentive to take actions that will prevent occurrence in the future.

7.11 Summary

Based on a survey conducted by METTLER TOLEDO in 2013, it is estimated that 90% of vision system implementations neither meet nor exceed user expectations.

Whether through poor planning, preparation or implementation, users rarely realize the full benefits that a vision inspection system can offer. As a result, they may be reluctant to utilize vision inspection in their quality programs.

This guide has been developed as an education tool so that expectations can be met whenever vision inspection programs are used within a production facility.

Vision inspection systems help to eliminate controllable product defects, especially label-related defects.

Financially, vision systems can be a large initial investment, but the reduced risk of recalls, brand damage or other problems caused by defective products is worth the cost.

With a well-planned, well-maintained vision inspection system, manufacturers can expect a drastic reduction in defective or poor-quality product appearing on retailer shelves.

Equipment designed to meet global needs

METTLER TOLEDO's vision inspection offerings are standardized products configured to suit the needs of manufacturers spread across the globe.

From initial conception to finalized product, METTLER TOLEDO works with manufacturers every step of the way in order to ensure the right vision solution is implemented.

Standardized system designs ensure that all systems feature the same interface, regardless of where they are.

The worldwide profile and presence of METTLER TOLEOD means any additional service or support is never too far away.

Providing a range of product inspection systems

Additionally, METTLER TOLEDO is one of the few companies that not only provides vision inspection equipment, but provides other product inspection systems – including x-ray, metal detection and checkweighing systems – all backed by the full weight of the METTLER TOLEDO organization.

For more information on METTLER TOLEDO's product inspection offerings, including vision inspection, visit www.mt.com/pi

Notes

Product Inspection Solutions

Protection

Productivity

Quality

www.mt.com/civision

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