

Technical News Bulletin



FleXinspect™ BC Application Notes

May 2018

Section 1 Overview

The FleXinspect BC (also known as FleX BC) is a configurable multi-station, servo-controlled inspection system that combines contact (belt handler) and non-contact



inspections to provide a comprehensive suite of vision inspections for glass containers. Combined standard and optional inspections can capture and correlate up to 24 individual views of the sidewall, plus sealing surface, base, base stress, vision plug, wire edge, and mold reading. The FleX BC comes equipped with SCOUT technology software, where everything is based on defect classifications, automatic learned variations and predefined defect limits.

The FleX BC is designed to inspect round and non-round glass containers at speeds of up to 600 containers per minute (bpm).

NOTE: *Actual maximum speed and inspection capabilities of the FleX BC can vary depending on container size and characteristics, as well as inspection setup.*

The FleX BC is capable of performing the following inspections:

The FleX BC is comprised of two sections. The “B” section (belt handler) includes all base and sealing surface inspections, as well as vision mold number reading. The “C” section (non-contact) includes all sidewall and dimensional inspections.

Standard Inspections – “B” section

- **Sealing Surface** – Image acquisition is performed using two super bright LED light sources with a 1396 x 1024 pixel resolution, area matrix camera.

Common defects detected: chips, lineovers, finish blisters, seeds, and overpress.

- **Base Inspection** – Image acquisition is performed using a super bright LED light source with a 1396 x 1024 pixel resolution, area matrix camera.

Common defects detected: blisters, seeds, fused glass, plunger pulls, dirt, deep or damaged baffles, tramp glass, and birdswings contacting the lower heel or base.

Standard Inspections “C” section

- **Opaque sidewall defects** – Image acquisition is performed using patented wrap-around lighting from super bright LED light sources, and 1396 x 1024 pixel resolution, area matrix cameras providing 6 views of the container.

Common defects detected: stones, birds wings, seeds, dirt, fused glass, mold dope, and other opaque, aspect-related defects.

- **Dimensional sidewall defects** – Image acquisition is performed using patented wrap-around lighting from super bright LED light sources, and 1396 x 1024 pixel resolution, area matrix cameras (up to 6 views).

Common defects detected: height, lean, filler offset, profile diameters

Optional Inspections – “B” Section

- **Base Stress** – Image acquisition is performed using the same light source that is used for base inspection, but with a cross-polarizing filter and dedicated 1396 x 1024 pixel resolution, area matrix camera.

Common defects detected: seeds, stones, viscous knots and other stress causing defects that may be impossible to detect with conventional base inspection.

- **Vision Plug Gauge** – Image acquisition is performed using a super bright LED light source with a 1396 x 1024 pixel resolution, area matrix camera.

Common defects detected: choked neck, oval neck, spike, and birdswings contacting the neck or appearing in the field of view.

- **Vision Plug with Wire edge** – Image acquisition is performed using vision plug gauging optics with an additional light source to illuminate the wire edge defects.

Common defects detected: wire edge, overpress, run-in finishes, and chipped finish.

- **Mold Number Reading** - Mold number reading, part of the “B” section of the FleX BC, enables mold-defect correlation for all inspections in the FleX BC. The standard mold number reading capability is provided at the base inspection station and uses the base inspection image. This mold number reader may be effective with both heel dot, and base codes, but only if the codes can be seen clearly in the base inspection image with enough contrast to determine the mold code. This built in feature of mold reading in the base inspection image is not intended to be used for mold/cavity sorting of defective containers. For more efficient mold reading capabilities, the FleX BC can be equipped with dedicated vision mold number readers, which provide mold number reading using dedicated cameras and light sources that enable image optimization specifically for mold number reading.

- **Vision Dip Gauge** – Image acquisition is performed using four super bright LED light sources with a 1396 x 1024 pixel resolution, area matrix camera. The chart below provides additional information on kits available for various finish sizes.

Max. Finish Size	Lens
75 mm	12 mm
50 mm	16 mm lens with high resolution insert
150 mm **	12 mm
150 mm **	16 mm lens with high resolution insert

** Special for wide mouth jars and large containers larger than 120mm diameter

Common defects detected: Dipped finish and saddle finish.

Optional Mold Number Readers

- **Dedicated Universal Vision Mold Number Reader (U-VMNR)** – Image acquisition is performed using a super bright LED light source with 1396 x 1024 pixel resolution, area matrix camera positioned under the base of the container imaging the code off of a set of parabolic reflective mirrors. The U-VMNR supports the following types of heel codes:
 - 9 dot heel
 - Extended 9 dot heel
 - Owens 8 dot heel
 - 10 dot heel
 - Owens 9 dot heel
- **Dedicated Top- Down Vision Mold Number Reader** – Image acquisition is performed using a super bright LED light source optimized to illuminate the bottom codes on a glass container with a 1396 x 1024 pixel resolution, area matrix camera positioned over the finish looking at the bottom plate of the container.
 - 6 dot mini
 - 7 dot bottom
 - 10 dot round bottom
 - Owens 8 dot bottom
 - 8 dot peanut
 - MSC numeric

Optional Inspections – “C” section

- **Transparent sidewall defects** – Image acquisition is performed using patented patterned lighting with super bright LED light sources, and 1396 x 1024 pixel resolution, area matrix cameras providing up to six views of the container.

Common defects detected: large soft blisters, ribbon tears, loading marks, heavy washboard, blow-out, and other transparent, aspect-related defects.
- **Stress sidewall defects** – Image acquisition is performed using fixed cross-polarizing filters with polarized lighting from super bright LED light sources and 1396 x 1024 pixel resolution, area matrix cameras providing up to six views of the container.

Common defects detected: stones causing stress, viscous knots and other stress causing defects.

NOTE: *The Shoulder Inspection options for the FleX BC are available for transparent and opaque defect detection OR stress defect detection. A Shoulder Inspection kit also is available to detect transparent, opaque, AND stress defects. When equipped with both options, six cameras are dedicated to transparent/opaque defect detection and six cameras are dedicated to stress defect detection.*
- **Shoulder Inspection (transparent/opaque defects)** – An optional shoulder defect detection kit is available for improved opaque and transparent defect detection of containers with steep shoulders. With the shoulder inspection kit, six additional cameras with 1396 x 1024 pixel resolution, area matrix are mounted so that they capture a straight-on image of the shoulder.
- **Shoulder Inspection (stress defects)** – For stress inspection, the optional shoulder cameras are equipped with fixed polarizers to detect stress in the shoulder area of a container.

Section 2 Ware Range

The FleX BC is designed to inspect round and non-round containers

Standard Ware Range:

Body Diameter:	16 to 170 mm [0.625-to 6.7 in.]
Height:	38 to 381 mm [1.5-15.0 in.]
Finish Inner Diameter:	4.5 mm [0.177 in.]
Finish Outer Diameter:	144 mm [5.67 in.]

Round containers include almost all cylindrical round shapes and most tapers within the machine's ware range.

Non-round containers include most non-round shapes; however some non-round containers that are rectangular in shape may need to be oriented prior to entering the FleX BC. Certain shapes with rounded bottoms such as ampoules, light bulbs, etc. are excluded.

Some containers may cause handling problems and should be tested by Emhart Glass. Examples of these containers include:

- Containers with extreme tapers
- Containers with offset necks or finishes.

CAUTION: **Misshapen and structurally weak containers may break during handling in the FleX BC. This may cause unscheduled down time and/or damage to handling components. The installation of a squeeze tester or freak detection device upstream of the FleX BC is strongly recommended.**

Tapered containers and containers with different diameters usually can be inspected in the FleX BC. The upper and lower belt handler arms can be adjusted independently to permit handling of many different container shapes.

Section 3 Machine Speed

The FleX BC is designed to acquire images at a maximum speed of 600 bpm (approximately 1200 mm/sec. [47.2 in. /sec.] linear conveyor speed). The actual maximum speed is based on container diameter, container spacing, and conveying speed. The machine's integrated bottle spacing belts are designed to provide a minimum spacing of two bottle diameters to maintain accurate sidewall inspection. The following formula can be used to calculate the maximum inspection speed of the FleX BC for any container diameter within the machine's ware range:

$$\text{Max. BPM} = \text{Conveyor speed per minute} \div (\text{max. bottle diameter} \times 2)$$

Example:

- Max. Conveyor speed = 72,000 mm/min. (1200mm/sec x 60)
- bottle diameter = 68 mm
- $72000 \div (68 \times 2) = 529.41$ bpm

Section 4 Inspection Notes – Base & Sealing Surface Inspections

Sealing Surface. Sealing surface inspection is accomplished by illuminating the container finish with two separate light sources.

- *Axial illumination* is performed with a beam splitter. This provides light along the optical axis and illuminates the surface of the container that is perpendicular to the camera.
- *Diffuse illumination* is accomplished using a parabolic reflective bowl light. This provides light along the beveled edges of the sealing surface that are not perpendicular to the optical axis.

When properly illuminated, the sealing surface and the beveled edges of the container reflect the same amount of light into the camera. This gives the system a uniform gray scale image to inspect. Defects that occur on the finish will appear darker or lighter than the rest of the finish. This change in appearance is what the system will look for in detecting defects.

Base Inspection. Base inspection is accomplished by illuminating the container base with diffused back lighting. The camera then looks through the opening in the neck and is focused on the base of the container. Setting the light intensity and camera lens aperture to get the proper gray level is important. Defects that occur in the base will appear darker or lighter than the rest of the base image.

Base Stress. Inspection of the base for stress defects is accomplished by illuminating the base with diffused back lighting through a set of polarized filters. These filters cross polarize the light, canceling out all of the light being received by the camera. When a stress-causing defect is present in the base, it changes the orientation of the light allowing the camera to see visible light.

Vision Plug. Inspection for plugged or choked necks is accomplished by illuminating the part with diffused back lighting. The camera looks through a field lens creating a telecentric view of the part. This telecentric view gives the camera a focal depth of 140 mm [5.5 in.] into the container. Maximum finish is 50 mm.

Wire Edge Inspection. Inspection for wire edge defects, as well as many defects that occur on the inner finish of the container, is accomplished using the optics of the vision plug gauging option with an additional on-axis light source that illuminates the inside finish area of the container. The resulting image provides a black ring where a wire edge defect occurs. When a defect is seen, the black area reflects light into the camera, which appears as a bright white ring (or partial ring).

Vision Dip. Inspection for vision dip is accomplished by illuminating the finish with four separate light sources. Each light source provides a diffused backlit reflection of the finish on four separate mirror surfaces. The camera lens is then focused on these mirrored surfaces, and inspects 120° of the finish in each view, by fitting an ellipse to the images. Once an ellipse is created, it calculates the difference between the edge of the part and the ellipse to determine if a defect is present.

Vision Mold Number Reading. The Flex BC mold number readers (both standard and optional top-down, and the U-VMNR) are capable of reading most mold codes used throughout the glass container industry.

NOTE: *The mold reading capability of the Flex BC is limited to mold codes that are cut correctly, according to specification, and can be seen in the acquired image.*

For all vision mold number readers, the mold codes must be within specification and also have clearance from other container markings to allow proper sensing. Specifications for the engraving the various mold codes read by the Flex BC mold number readers are described in the following documents available from Emhart Glass:

- 16049A, *Code Specifications for Emhart Glass MNR*
- 22444A, *Bottom and Heel Code Specifications for VMNR.*

Heel code specifications from document 22444A:

Dot shapes and proper dot-to-dot spacings are crucial to the long-term capability of the VMNR to recover the mold codes at high rates of reliability. Dot size and spacing is dictated by the optical characteristics of the vision system, thus it is important that they are held within the following specifications for a standard dot:

Dot Diameter: 0.055" +/- 0.005" or 1.40mm +/-0.13mm

Dot to Dot Spacing*: 0.120" or 3.00mm (see note on page A.29)

*(Referred to throughout this specification as "T")

To calculate dot position on container surface in degrees:

Degrees = (Radians x 180°) ÷ π

Where Radians = Arc Length ÷ Radius

Where π = 3.14

Where Arc Length = .120"

And, where Radius is measured from the container's central axis at the elevation of the code

Dot Radius of Curvature: 0.039" or 1.0 mm

Dot Height on container: 0.012" +0.006"/-0.000" or 0.30 mm +0.15 mm/-0.00 mm

These Dimensions apply **after** forming.

Section 5 Inspection Notes – Sidewall Inspections

Three lenses are available for the sidewall inspection cameras on the FleX BC. The lenses used are determined by the container height. To maintain the highest image resolution, select the appropriate lenses from the table that meets the container height requirements. If you do not want to change lenses, select a lens that will inspect the entire height range of your production.

Example: A 16 mm lens can be used to inspect the maximum container height, 383.5 mm [15.1 in.]. It also can be used to inspect the shortest container, 38 mm [1.5 inches].

14848P Camera, B1R 1392 X 1040 19FPS

Focal length	Emhart kit part #	Maximum field of view (container height)
16 mm	27548A (single lens part #14483P)	383.5 mm [15.1 in.]
25 mm	27549A (single lens part #14484P)	281.94 mm [11.1 in.]
50 mm	27550A (single lens part #14485P)	139.7 mm [5.5 in.]

14847P Camera, B1E 1392 X 1040 18FPS

Focal length	Emhart kit part #	Maximum field of view (container height)
25 mm	26690A (single lens part #12744P)	383.5 mm [15.1 in.]
35 mm	26691A (single lens part #12869P)	281.94 mm [11.1 in.]
50 mm	26692A (single lens part #12745P)	139.7 mm [5.5 in.]

Opaque defect detection

Using LED lighting and up to 12 cameras, the FleX BC achieves a full 360° view of the container sidewall. The machine's unique wrap-around lighting design enables the FleX BC to inspect areas of containers that traditionally have been impossible to inspect. Features on the container such as embossing and uneven glass distribution (settle waves) now become inspectable areas of the container. In addition to the optics and lighting, the FleX BC uses powerful inspection algorithms and filters to help reduce the visual effects from embossing and distribution.

Transparent defect detection

Using the same cameras as the opaque defect detection, a second set of images is acquired. This second trigger of the LED light sources is performed using an adjustable light pattern. This patterned lighting is achieved by controlling rows of LEDs on the light board and illuminating them with different intensities. The result is an image of the container with defects on or near the surface of the glass being highlighted with sharp, easy to see edges (refer to illustration at right). Even very large soft blisters in the glass now appear with high contrast edges.

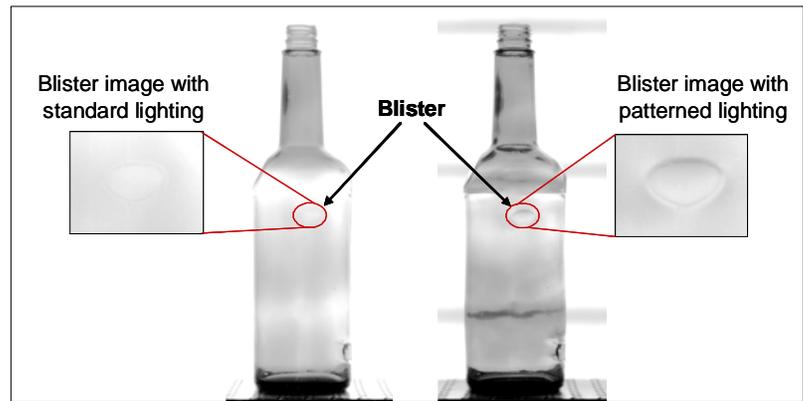


Figure 2: Illustration of transparent defect detection with patterned lighting

Stress defect detection

Using the dedicated cameras equipped with cross polarizing filters attached to the camera lenses, the system acquires a black image. If a container has any type of stress causing defect present, the image will have white areas highlighting the defect.

Dimensional defect detection

Dimensional inspection is performed on the opaque images. The dimensional defect inspection consists includes software tools that measure container height, lean, filler offset, and body diameter. This is accomplished by placing a virtual tool (calipers) where dimensional monitoring is desired, then teaching the software the required dimensional units and tolerances. A multi-trigger tool also allows the light source LEDs to be configured to darken the edge of the container, making it easier to place calipers for dimensional inspection. This multi-trigger capability is especially useful for detecting the edge (or outline) of flint containers.

Sidewall shoulder detection

Shoulder inspection is performed using six cameras (three at each station) that are mounted on posts and set up to focus solely on the shoulder of containers as they pass through the inspection stations. Shoulder inspection can be set up to detect either opaque or transparent defects.

Sidewall shoulder stress detection

Using the shoulder mounted cameras equipped with cross polarizing filters attached to the camera lenses; the system acquires a black image. If a container has any type of stress causing defect present, the image will have white areas highlighting the defect.

Section 6 Site Preparation and Installation Requirements

NOTE: Machine clearances for the FleX BC are shown in Figure 3.

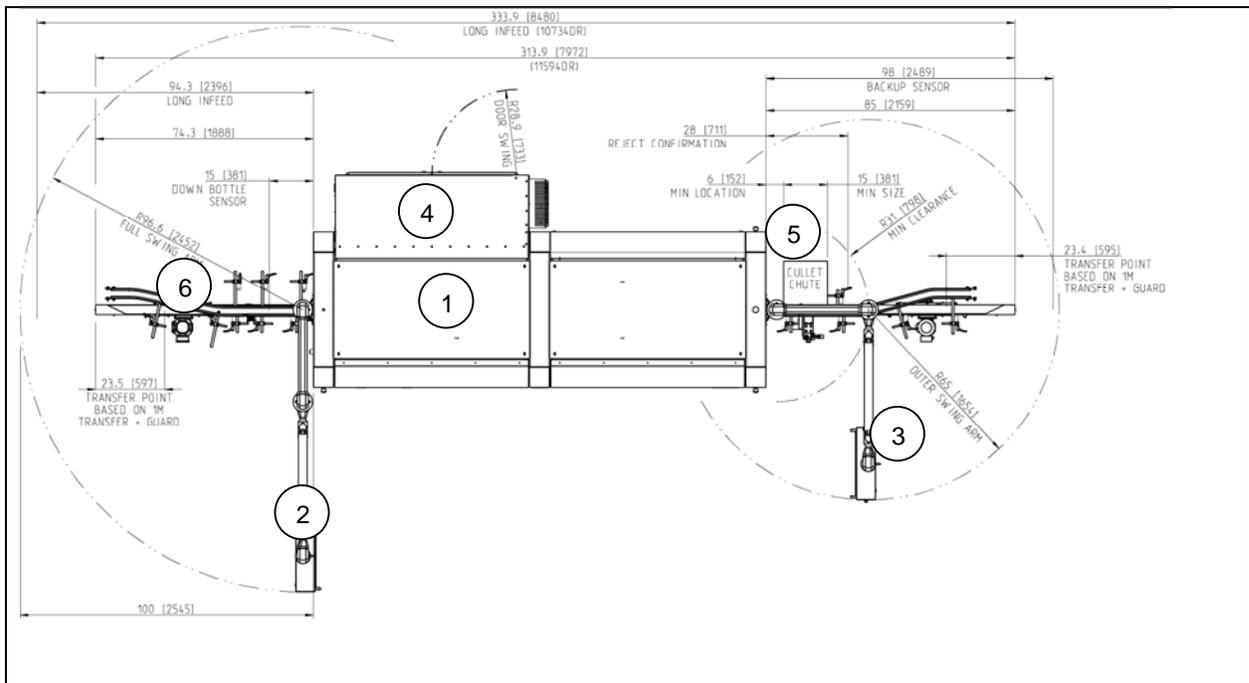


Figure 4: FleX BC layout drawing

- | | |
|---------------------------------------|-------------------------------------|
| 1. FleX BC machine | 4. Rear electronics access |
| 2. User interface (operator position) | 5. Cullet chute (customer supplied) |
| 3. Secondary user interface | 6. Ware backlog (prime) sensor |

Area Preparation. The area where the FleX BC will be located must be:

- A straight, level area that is free of legs and under-conveyor obstructions (minimum conveyor height is 914 mm [36 in.]). The FleX BC and its conveyor cannot be installed on an incline or decline.
- A break in the conveyor approximately 7.4 meters [approximately 24.2 feet].
- A clear height of at least 2225 mm [87.6 in.] above the top of the conveyor.
- A minimum of approximately 3.6 meters [12 feet] upstream and downstream of the FleX BC (measured from the infeed and outfeed sides of the machine).

Conveyor Control System Integration. The FleX BC is designed to interface with most plant conveyor control systems. However, ***Emhart Glass cannot be responsible for the modification or performance of a conveyor control system. Our responsibility is limited to the supply and performance of the FleX BC and its integrated Emhart Glass conveyor system.*** Any conveyor/machine control issues must be reviewed and resolved during machine specification. Emhart Glass will work with customers and/or their conveyor supplier(s) to meet specific line requirements; however, the customer has the ultimate responsibility for any changes that must be made to the conveyor control to enable interface with the FleX BC machine and conveyor.

Conveyor Control Considerations. When the FleX BC is interfaced with a plant conveyor control system, the speed of the FleX BC must be set in such a way that speed of the machine and the conveyor retain the same ratio.

There are two ways to achieve this machine-conveyor speed ratio goal:

- Configure the conveyor to follow the FleX BC and set the amount of time it takes for the conveyor to accelerate (ramp up) to its new speed to be as short as possible.
- Configure the FleX BC to follow the conveyor and set the time that it takes for the conveyor to accelerate to be longer than the time it takes for the machine to accelerate to the new speed.

NOTE: *If either of the above two goals is not achieved, ware can accumulate between the FleX BC and other machines on the line. If the accumulation of ware exceeds the capacity of the conveyor between machines, containers can fall over or back up into an upstream machine.*

The best way to achieve either of the machine-conveyor speed control goals is to control the speed of the FleX BC using a 0-10 VDC analog speed reference signal from the plant line control system to the FleX BC.

The line control system then must be configured as follows:

1. The line control system sends a speed control signal to the FleX BC.
2. Allow adequate time for the FleX BC to change its speed and provide a feedback speed reference signal to the conveyor controller telling the controller how fast the FleX BC is now running.
3. Set the conveyor controller to follow the speed of the FleX BC as closely as possible.

When the above procedure is followed, the FleX BC and its conveyors can maintain the correct speed ratio and the conveyor control system can respond to a speed change demand as quickly as possible, thereby reducing ware flow problems upstream or downstream of the FleX BC.

Air and Power Requirements

NOTE: *It is the customer's responsibility to provide a stable, clean power supply to the FleX BC. Power fluctuations (high or low voltage conditions) can cause the FleX BC to shut down and/or stop unexpectedly, as well as damage electronic components in the machine.*

Power: 380 to 480 VAC, 3 phase, 25 amps (max. consumption: 30 amps at 460 VAC)

Air: 3.5 bar [50 psi] nominal (consumption 0.8 to 0.85 m³/minute [105.9 cfm].

Section 7 Operating Environment

Enclosures: All electrical/electronic enclosures used in the FleX BC should be considered rated for NEMA 12 and IP20.

The FleX BC is equipped with a closed-loop air conditioning system designed to maintain the FleX BC internal temperature at or below 50°C [122°F]. The temperature is constantly monitored and the user interface will display the following conditions when temperatures inside the electronic cabinet exceed set points.

Fault Message	Description	Machine State
Over temperature warning	The temperature inside of the electronics cabinet has exceeded the user set warning.	<ul style="list-style-type: none"> Counters reset Machine status icon is yellow.
Over temperature fault	The temperature inside of the electronics cabinet has exceeded 50 C.	<ul style="list-style-type: none"> Machine stopped Red stop button is illuminated Counters reset icon flashing. Machine status icon is red.
Air conditioner fault.	The electronics cabinet air conditioner has stopped.	<p>Note: Machine will not restart until the condition that caused the alarm is resolved and cabinet temperature is below 50 C.</p>

Operating Temperatures: The FleX BC is controlled by electronic equipment that is designed to operate in the majority of glass plant environments without modification. However, since conditions can vary from one installation to another, the following operating conditions must be observed. Failure to maintain these requirements will affect the applicable warranties covering the Emhart Glass hardware and software associated with the FleX BC. If the proper operating conditions are not maintained, the electronic hardware will not function as designed.

The maximum allowable temperature inside the machine is 50°C [122°F]. Although control components can operate at this upper temperature, life expectancy of the electronic components will be reduced. The lowest recommended operating temperature is 5°C [41°F]. Maximum relative humidity is 95%, non-condensing.

CAUTION! **Components within the electronic consoles must be kept clean. The life expectancy of electronic components will be substantially reduced if they are contaminated with plant dirt (swab oil, dust, etc.). The accumulation of these substances on electronic components causes the actual temperature of these components to be much higher than the temperature of air within the control cabinet.**

Container Temperature: The machine handling equipment is rated for 60°C [140°F] maximum container temperature at machine infeed. Containers hotter than this can cause damage to handling equipment and can cause the internal machine temperature to rise above acceptable limits as outlined above.

Section 8 Conformity Statement

The FleX BC conforms to the provisions of the following European CE directives and standards:

- Directive 73/23/EEC and amendments (Low Voltage Directive)
- Directive 89/336/EEC and amendments (EMC Directive)
- Directive 89/392/EEC and amendments (Machine Safety Directive)
- EN292 Parts 1 and 2
- EN50081-2 Part 2
- EN50082-2 Part 2
- EN60204 Part 1
- CEN TC151 WG13 PrEN13042 Part 6: Specific Safety Requirements for Hollow Glass – Part 6: Multi-Station Multi-Inspection Machines

Section 9 Specifications Required for Order Entry

The following items are configurable and require specification when ordering:

- Machine hand
- Plant voltage
- Conveyor height
- Options
- Line layout drawings

Section 10 Spare Parts

Spare parts kits are available for the base machine, as well as for the optional inspections. Although the FleX BC is covered by a one-year parts and labor warranty, spare parts kits are strongly recommended. If an adequate supply of spare parts is maintained, critical parts, when needed, will be available if they fail or wear out prematurely. An adequate spare parts inventory also helps reduce downtime or extended unsatisfactory machine operation caused by occasional out-of-stock conditions and time required to order and ship required parts. Parts failing within the specified warranty period will be replaced free of charge when returned to Emhart Glass under a Return Authorization number provided by Emhart Glass.

Spare parts have been organized in the following manner.

Basic Kit PN 12602DSP1 – This kit contains parts that are the recommended required parts for the base machine.

Advanced Spares Kit PN 12602DSP2 – This kit contains both the basic spare parts, as well as parts to cover almost all failure conditions, including major vision system components (computer, optics, and light sources for base and sealing surface inspections).

Wear Parts Kit PN 12602DSP – This kit contains parts to be considered consumables, these are parts that need to be replaced over time. Items like belts, mirrors and protective windows are included in this kit.

Section 11 Training

Setup operation and maintenance training by Emhart Glass personnel is mandatory for optimum machine operation and extended life. A machine-specific service program also is available for the FleX BC. Training programs, offered at Emhart Glass training centers in Clearwater, Florida (USA) or Leipzig, Germany or at your plant, provide plant personnel with hands-on experience in all aspects of machine job change, maintenance, troubleshooting, and operation. We recommend training for all lead maintenance and setup personnel (at least one per shift). This helps facilitate optimum, 24-hour-a-day machine operation and can virtually eliminate costly machine maintenance and service calls.

Section 12 Shipping specifications

Shipment of the FleX BC consists of 2 crates;

- Machine, crated weight of approximately 2,971 KG {6,500 pounds}
- Conveyors, crated weight of approximately 571.5 KG {1,260 pounds}

Revisions

Rev.	Date	Description
	24 Feb. 2011	Preliminary release for review.
A	May 12, 2011	Initial release
B	June 1, 2011	Mold reader information modified
C	July 10 2013	Changed spare part kit # added wear parts
D	August 4, 2014	Added section 12, added maximum size of vision plug and temperature monitoring.
E	March 22, 2017	Changed lens kit part number, spare parts part number, training centers, layout picture.
F	November 30, 2017	Changed maximum FOV on lens chart
G	May 2, 2018	Added B1E lens selection
H	May 18, 2018	Added U-VMNR