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GLUING & QUALITY ASSURANCE SYSTEMS.

Best Practices for Manufacturer's Joints in Corrugated Boxes

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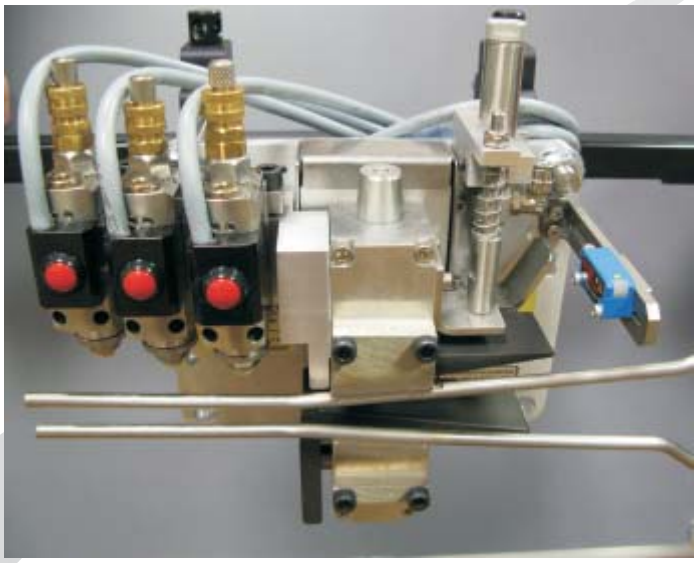
The two most common reasons cited for box rejections by customers are 1) defective glue joints and 2) skew, fishtailing or improper fold gaps at the glue joints. Both are avoidable by understanding the process variables that make up the construction of a glue joint. Many boxmakers rely on first article inspection and assume that the entire run is satisfactory thereafter. The danger in this strategy is that machine and operator conditions sometimes change during the run which change the variables and cause the process to be out of control. This has lead to the installation of many glue joint inspection systems over the years that assess 100% of the boxes sent through the machine. While inspection systems are necessary and mandated by many clients, understanding and maintaining the gluing and folding process is just as important and provides a second layer of protection from shipping bad boxes.

How are glue joints made?

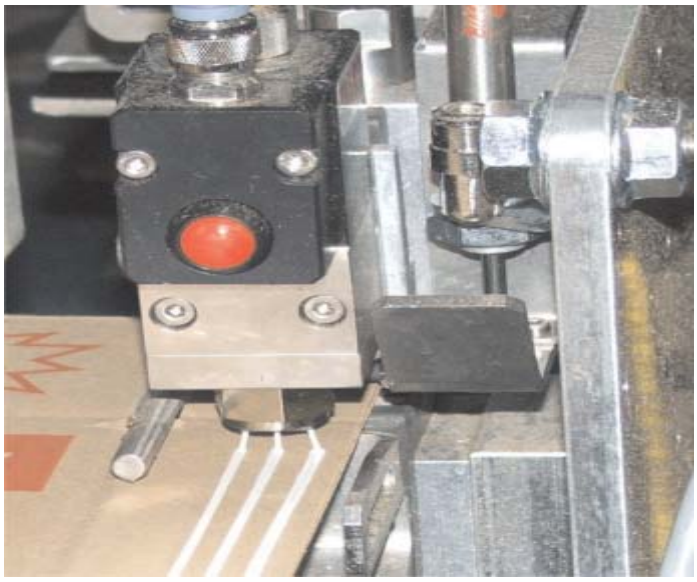
The vast majority of corrugated boxes used in shipping employ joints glued with cold, water-based PVA adhesive. The small remainder use either tape or staples at the manufacturer's joint. For the purposes of this article, the joints are assumed to be glued with liquid adhesive. Standard glue flaps are constructed to be 1 ¼" wide and, according to the National Railroad Packaging rule 41, and are to be covered 1 ¼" wide from end to end. While clearly originally intended for glue wheel applications, this rule can still be met with modern, high-speed extrusion systems that are most commonly used in box plants.

Extrusion glue systems are found in generally two forms: 1) contact and 2) non-contact. Both serve the roll of applying beads of adhesive to the tab or 4th panel of the box at the outlet of the slotter section of a folder/gluer. Some non-contact systems have up to 3 valves, each applying one bead. In these cases, the amount of adhesive applied must be sufficient so that upon squeeze out, virtually the entire tab is glued. If not, the separations between the glue lines can be weak spots that initiate premature tearing in the joint under load.



Non-contact, multivalve glue station

Other non-contact systems use a single valve and a multi-orifice nozzle. In this case, up to 4 beads can be applied. Since the glue jets are often angled, the height of the nozzle from the corrugated sheet determines how far apart the beads land.



Non-contact, single valve glue station

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Multi-orifice contact nozzle

Such non-contact arrangements have the advantages of applying beads regardless of board warp or how good the contact may be between the glue head and the box. In addition, glue beads can be different lengths to accommodate the angle in the tab. However, non-contact systems typically require higher pressure pumps (at least 500 psi (35 bar) and work with thinner, better quality adhesives.

Contact glue stations offer the advantage of having quick change heads that can glue from 2 beads to 25 or more. Contact heads can also be purchased to dispense up to 7 beads on a 1 ½" tab, ensuring better coverage after squeeze out. Many box plants standardize on 1/8" bead spacing rather than ¼" in order to be guaranteed to meet coverage requirements. Contact gluing systems also work with simple, diaphragm-style adhesive pumps that are easy to maintain and can serve and entire plant with a centrally located supply system.

Contact glue station

Contact glue head

Because contact systems don't need to "jet" the adhesive onto the sheet, they can use larger orifices that clog less frequently. Non-contact systems overcome this tendency of glue to dry on the tips with sealing devices that cover the nozzle tip when sheets are not being fed.

How do we make a good quality glue joint?

While elementary sounding, this question perplexes even the most seasoned boxmakers and can elicit as many opinions as interviewees. However, controlling the following variables will dramatically improve a machine's ability to produce high-quality consistent glue lines.

Sheet guiding through glue station

Although some machines use strong clamping force between the folding belts in addition to vacuum pressure to hold the box, others clamp the box only loosely. It is very important that the box travels evenly through the glue station and that the glue head is located far enough downstream into the folding belts that the box is under good control. When a box is stopped in glue station, it should not be easily moveable. If it is, the box will skew due to the guiding, clamping springs or valve contact force. Short boxes can even tear the panel off if the clamping is too strong. The glue station must be located at the same height as the top of the lower folding belt and completely parallel with it, otherwise the path will be too tortuous through the station and poor glue patterns will result. The tab or 4th panel of the box should not be allowed to move up or down in the glue station but should be controlled with good top and bottom guiding bars that run parallel to the glue station. Older style glue stations that use clamping springs should be adjusted so that the force is enough to keep the tab or 4th panel touching the contact head, but not enough to skew the box. Newer stations that "ride" the box contour should have their compensating air set higher to lessen head force or lower to increase force (top-down).

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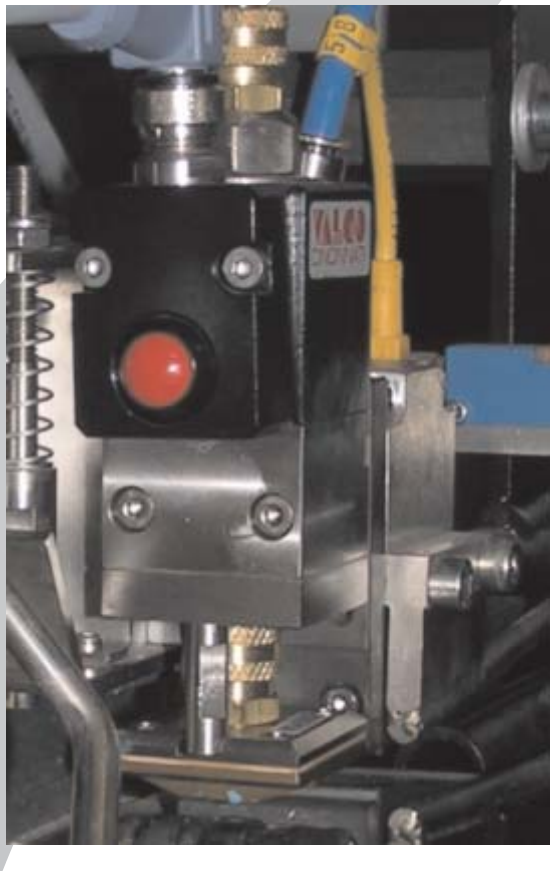
Condition of Glue station

Glue stations should be clean and free of dried adhesive. If pulling the box through by hand is difficult, the glue joint will be poorly made. Any moving parts such as tip sealers or ball-slides should be tight and in like-new condition. If not, patterns will sometimes appear skewed, lack sufficient volume or not be applied at all. Any missing parts should be replaced. Photoeyes should be correctly aligned and tightly fastened to their brackets. Poor photoeye positioning will result in glue patterns shifting during production.

Condition of glue valve (electric/pneumatic)

A glue valve that is in poor condition, has dried glue inside or has old springs and/or diaphragms will result in sluggish performance. Glue lines will not have crisp starts or clean cut off at the end. Pneumatic glue valves require maintenance approximately every 10-20 million cycles. Newer electric valves require cleaning, spring replacement and sometimes needle and seat replacement after 100-150 million cycles. When purging, shutoff should be clean and quick with no residual adhesive building up on head after shutoff. Electric valves should never be submerged in water as residual moisture could cause coil and purge wires to short out.



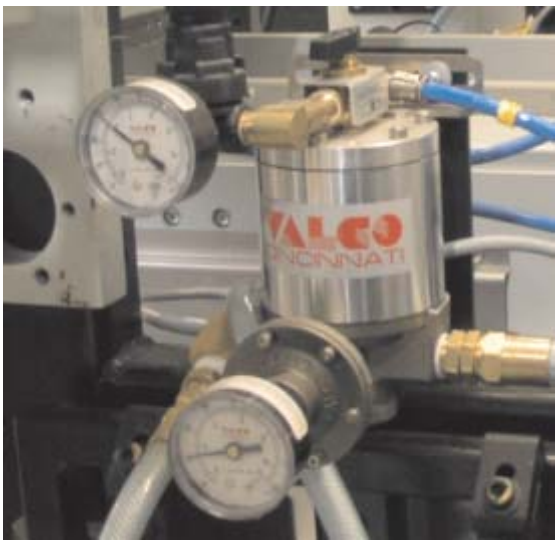
Electric glue valve

Pneumatic glue valve

Glue lines back to the regulator should be inspected for kinks and should be flushed periodically to check for clogged sections. A $10 section of tubing can be very costly if it causes a flow restriction and results in poor glue volume at high speeds.

Glue regulation & volume

The glue regulator is the most important adhesive delivery component in determining how much glue volume is applied at a given machine speed. Glue regulators work by using a variable air solenoid from the pattern control that increases or decreases air pressure in relation to machine speed. This air pressure pushes down on a diaphragm or piston and through the ball/spring/seat in the regulator, creates higher adhesive pressure. Newer, compensating regulators actually relieve glue pressure from downstream glue lines when the machine slows down eliminating the excessive adhesive at the beginning of the pattern at machine restart.



Picture Balance regulator

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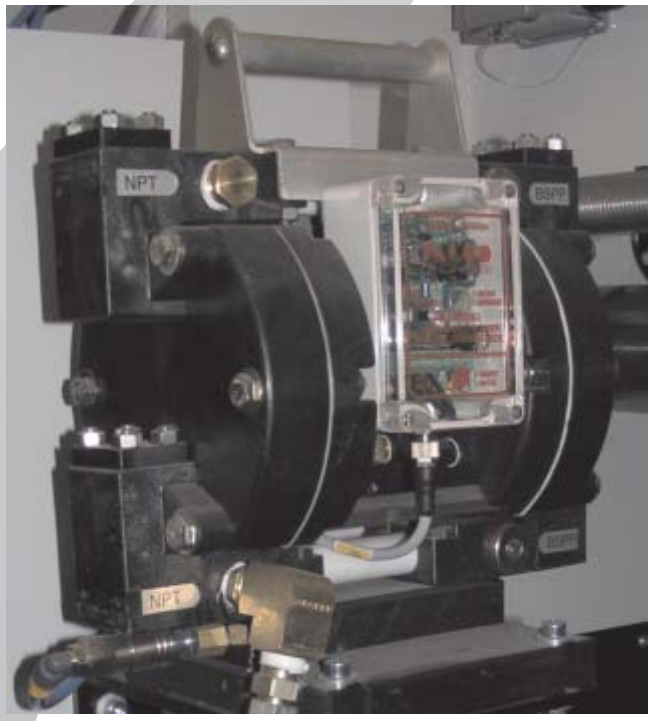
Regulators often have a "T-handle" or other manual override at the top. Often, these are screwed in all the way so that the system is running at one pressure all the time. This means that if the machine slows down, there is too much glue on the joint and if it speeds up, there may not be enough. Proper adhesive quantity should be applied at all machine speeds. Boxes are rarely inspected by humans for excessive volume and this "one pressure" practice creates bad boxes under a number of normal manufacturing conditions. Glue regulators should be cleaned and rebuilt annually.

Pump/Filter

When interviewed, many maintenance managers insist their staff cleans adhesive filters every two weeks. Subsequent investigation reveals a filter completely caked with coagulated, dirty glue. To avoid this embarrassment and flow restriction, this process can be completed in minutes using a rotating stock of filters and normal downtime created while changing adhesive drums or doing a setup on the machine. A plugged filter will create unpredictable glue applications that will worsen with higher speed. Keeping glue pumps clean and check valves maintained will ensure that enough adhesive pressure is available to produce good glue joints. There should be more pump pressure available that what is needed at the glue regulators. Regulators can only regulate pressure down. Central pumping systems offer the advantage of only maintaining one or two pumps in the plant near the glue supply. Large totes of glue can be used and pumped to each machine. Normally, 2" pipe is used in the ceiling to deliver adhesive near each machine and 1" drops are installed with gauges to monitor possible pressure losses.



Diaphragm Pump

Piston Pump

Controller setup/photoeyes/encoders/glue length

Pattern controllers are the "brains" of an adhesive delivery system. Because they are more complex than fluid handling components, the control's features and functions should be well understood. Often, fluid handling problems are misdiagnosed as controller issues. Glue controllers count incoming pulses on the machine from an encoder and when a photoeye sees a box, trigger the glue valve to fire for an appropriate length of time. Some controls require a glue delay and length to be entered for each box size. Others take advantage of the "Auto-Glue" feature that glues to within a certain distance of the beginning and end of any length tab. This is particularly useful on tab side glue joint installations. Photoeyes must be kept clean, adjusted to trigger a few inches deeper than the box and firmly attached to their brackets. It is best to install the photoeye near the valve and not half-way across the machine. If the photoeye sees the middle of the box and the sheet is skewed, the glue application will not be registered properly with the tab.

Encoder installation

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Laser photoeye

Pattern control

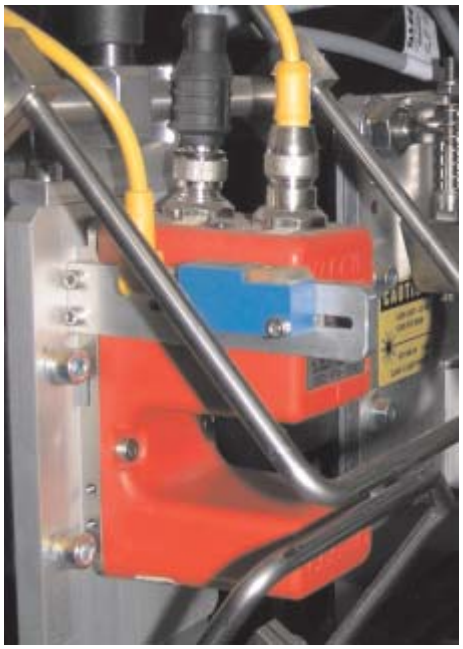
Encoders should be regularly inspected for smooth rotation, good wheel or toothed belt condition and secure mounting. The relationship between the number of pulses per revolution and the distance that the sheet travels is often referred to as "ratio compensation" or "ratio comp." This value should be very accurately set, especially when glue inspection is involved. If not, glue patterns must be cheated from their expected values to get good results. If operators have to adjust glue length on every order, the likelihood of a customer rejection is significantly higher. Glue volume and its relationship to machine speed is also programmed from the controller and should be checked for correct settings. Controllers and inspection equipment now have complex hardware and software and should be kept clean and free of dust inside.

Glue dry time in machine

Some gluing controls keep track of boxes that have been glued and are in the folder when the machine stops. If enough time has elapsed since the machine stop that the liquid adhesive is dry, (15-30 seconds) then those boxes are rejected with a spray valve, bundle ejection system or alarm. This ensures that boxes whose glue joints are not properly adhered but that may appear perfectly good after being stacked are not shipped to the client.

Inspection systems

Over the years, many methods for inspecting glue joints have been used in the field with varying degrees of success. Systems requiring UV additives to be blended with glue have been largely rejected due to the inconvenience of obtaining the adhesive and the signal noise from sheets with high UV content. Moisture sensing has become ubiquitous as a reliable method of detecting the moisture in the glue joint because the sensor is durable and relatively immune to contamination. The information extracted from the analog glue signal includes length, gaps, volume and missing glue lines.



Glue sensor

More recently, vision-based systems have become available. Due to high line speeds, specialized vision systems have been engineered to be able to evaluate each sheet and the glue lines on them and compare them to a learned "sample." While the algorithms required for seeing white glue on kraft liner are more straightforward, distinguishing white glue on white liner is more challenging. However, some systems accomplish this task while running at speeds up to 400 mtrs/min (1300 ft/min).

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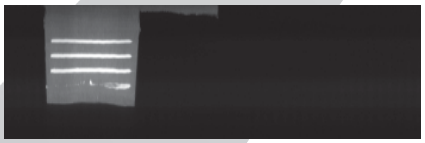
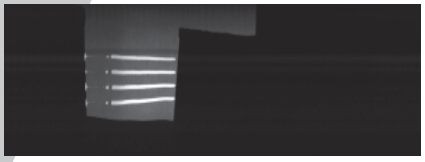
Vision system screen showing inspection of white board and white glue

Vision systems have the primary advantage of being able to show the operator the image of a bad box that was rejected and store a record of faulty boxes for future review and evaluation. When used as a process control tool, vision systems can see recurring problems such as tab scrap in the glue joint, skewed boxes, plugged glue head veins, insufficient glue volume and glue length faults.



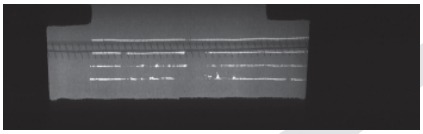
Missing glue line

Skewed box

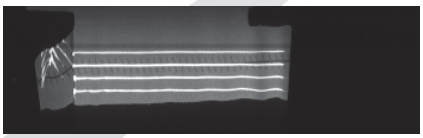


Late start

No glue



Light glue volume



Damaged extended tab/late start

Glue gaps

Of course, the value of any inspection system is only as good as the certainty that the offending article will be removed from the production stream. The most common method of identifying boxes discovered to have faulty glue joints is to spray then with water, UV dye or ink. However, this process relies on an operator to sort these marked boxes from the bundles after the counter-ejector. Some plants have adopted bundle ejector systems that allow the bundles with at least one bad box in them to be ejected to a holding area and for production to continue. This means the sorting can be done off-line and no bad boxes are missed.

Condition of glue/adhesive selection

Liquid adhesives used in the manufacture of corrugated boxes come in a variety of types and price points. More expensive adhesives tend to bond better, dispense better under pressure and produce better quality consistent patterns. Each plant has to decide what balance of price and application quality is best for their product mix. For those running very high speed machines, the consistency of a good quality adhesive will be more important. Most liquid adhesives have a shelf life of approximately 6 months. Although additives are used to prevent mold, settling and other deterioration, an old adhesive can clog an extrusion system quickly. Mixing adhesive types is also poor practice than can result in coagulated glue and hours of maintenance to clean the system. For best results, extrusion systems should be purged with warm water every 6 months to 1 year to keep components and glue lines clean. Adhesive stock should be rotated and not allowed to sit in very hot or very cold environments. Auditing glue samples from each machine periodically is a good way to assess that the glue inventory is being turned over enough and that the adhesive quality is appropriate.

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Sheet quality/ply-bonding/Surface strength

Fiber tear is almost universally considered as a reliable in-house test for manufacturer's joint quality. When the joint is torn, the entire glue seam should tear the liner on one of the sides. Low liner surface strength can contribute to a joint that demonstrates fiber tear that is not deep enough and can create a poor joint. Virgin, recycled, white, preprinted and water finished linerboard all have very different bonding characteristics and, in the extreme, may even require special adhesives. Multi-ply liner can even separate before the actual glue joint separates, causing a premature joint failure. It is a fallacy that quick-tacking adhesives are needed to ensure good bonding. In most cases, with good compression, even a slow-drying adhesive will work just fine. Many boxmakers find comfort in being able to see full fiber tear seconds after the box comes out of the counter-ejector. However, the cost of such high-speed tack performance is more applicator head clogging and poorer glue restart after a short period of downtime.

Warp

Warped linerboard can lead to problems in feeding, printing, scoring, slotting, gluing and folding. Some sheet warp is caused by imbalanced moisture content in opposite liner sides or tension issues in the corrugator. In other cases, the actual kraft stock's fiber orientation may play a roll in the degree of warp in the end product. Regardless of the cause, taking steps to reduce warped sheets will improve the quality of the manufacturer's joint. Because of its impact on the entire process of box-making, problems caused by warp can crop up at different points in that process. Steps are taken in machines and in gluing systems to produce the best possible joint in the presence of warp, but in many cases, addressing the root cause rather than the symptom is more effective in the long run.

Tab Design Extended/crush/which panel

Tab design can greatly affect the quality of a manufacturer's joint. For example, if a thin tab is needed, an extended tab design should be considered to add additional bond strength due to a longer glue line as well as to add strength to the flaps. This may help in cases using white linerboard where a lighter weight white liner may be employed. Further, the tab is better positioned on the long panel and glued to the shorter panel. Since most of the stress due to the content weight is on the long panel, this can cause the long panel to buckle, making the joint more likely to fail. Edge crush on tabs can also present glue joint problems. When using contact gluing, too much edge crush for the glue station height setting can cause poor contact and therefore a poorly glued joint. Heavily crushed tabs are also more likely to be uneven, which affects the gluing quality. In addition, the strength of the tab is reduced when it is crushed which can reduce the overall strength of the joint.

Skew and Manufacturer's joint gaps

Automated packaging equipment has raised the level of box squareness demanded by customers from folding equipment. Beyond the obvious implications of problems with box erection and filling, skewed or poorly folded boxes also result in poorer glue joints. Because the boxes will not load evenly, there is uneven stress on the joints. In severe cases, the glue lines may run off the tab or 4th panel compromising joint strength. Vision-based options for inspecting fold quality can point to issues with folding belt adjustment, belt compression, box guiding through the print stations and glue station adjustment. While the inspection process may not point out the root cause, it alerts the boxmaker that there is a problem. As with any quality reporting tools, a thorough root-cause analysis is the vital second step toward making the boxmaking process more consistent and less prone to variation induced by machines and humans alike.

Creating quality assurance & electronic monitoring systems, as well as strong, durable bonds through cold glue and hot melt adhesive technologies has been central to Valco Melton's prominence in the packaging, paper converting, graphic arts and nonwoven industries. Since 1952 Valco Cincinnati, Inc. has been responsive, adjusting rapidly to changing market demands through innovative solutions. The transfer of those solutions to the production floor continues today through **Valco Melton**, the newly named gluing and quality assurance systems division of Valco Cincinnati, Inc. with successful installations and an international service and support network. In addition to adhesives, Valco Melton systems dispense and control other products such as lubricants, food ingredients, paints/inks, waxes and solvents.