

MODULE 8

Transfers, Merges and Sortation

Conveyor Solutions Engineering | Professional Training Program

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SECTION 1: INTRODUCTION

Transfers, merges, and sortation are the points in a conveyor system where product changes direction, multiple flows combine into one, or individual items are routed to specific destinations. These are the highest-complexity sections of any system from a product handling standpoint, and they are the sections most likely to produce jams, misdirects, and rate failures if they are not designed with full understanding of the product, the flow, and the controls architecture that ties them together.

Each of these three topics demands a different set of design considerations. Transfers are about product orientation, strand spacing, frame geometry, and the mechanical and controls challenges of stopping a package precisely over a divert mechanism. Merges are about product control, the risks of feeding air-based accumulation directly into a controlled merge point, and accounting for the throughput losses that PLC lane switching creates. Sortation is about right-sizing: matching the sorter technology to the product mix, the throughput requirement, and the system footprint, and doing it without overengineering or underengineering the selection.

This module covers all three. It draws on the Hytrol Sortation Technology white paper for the sortation taxonomy and product handling matrix and layers Michael Collins field knowledge on top of it to produce the engineering judgment that the white paper alone cannot teach.

SECTION 2: LEARNING OBJECTIVES

By the end of this module you will be able to:

- 1 Explain the strand spacing requirement for 90-degree transfers and apply the easy way versus hard way conveying principle to determine the roller center requirement on the takeaway conveyor.
- 2 Identify the side frame dead space problem at a transfer transition, explain what happens to specific product types when that gap is not addressed, and specify the correct mechanical solution.
- 3 Explain the photoeye placement constraint at a transfer, why PLC delays are required to compensate for the sensor offset, and what causes stopping position variation to drift over the life of the system.
- 4 Describe the three merge types and explain the fundamental product control principles that apply to all of them, including why air-based accumulation feeding directly into a merge is a design risk.
- 5 Use the Hytrol sortation product handling matrix and throughput ranges to make a right-sized sorter selection for a given product mix and throughput requirement.
- 6 Explain the three primary selection criteria for sortation: product type, throughput, and footprint and destinations, and apply them in sequence to narrow a sorter selection.
- 7 Distinguish between over-engineering and under-engineering a sorter selection and explain what inputs are required to avoid both.

SECTION 3: PREREQUISITES

Required Prior Knowledge

Module 2: Product and Package Analysis. The product envelope, MTBH, and the easy way versus hard way conveying dimensions are direct inputs to every transfer design decision in this module. Know your product before designing any change-of-direction point.

Module 5: System Design and Flow Layout. The flow diagram identifies every transfer, merge, and sortation point in the system. The layout context determines the consequence of a failure at each of those points. The flow diagram is the reference throughout this module.

Module 6: Rate, Speed and Capacity Calculations. Sorter throughput calculations, takeaway spur speeds, and gap requirements at merge induction points all draw directly from the rate calculations in Module 6. Have those numbers before selecting a sorter or designing a merge.

SECTION 4: THE THREE W'S

The Three W's in this module apply to each of the three major topics: transfers, merges, and sortation.

90-Degree Transfers

WHY	A 90-degree transfer diverts product off the main trunk line at a right angle. The transfer strands that accomplish this divert pop up between the rollers of the main line conveyor, spaced like roller centers. Everything that was true about roller center selection and product support on a straight run is equally true at a transfer, and then some. The product that was traveling the easy way down the trunk line is now traveling the hard way on the takeaway conveyor, with the short dimension in the direction of travel. That change in orientation changes the roller center requirement on the takeaway, the frame gap exposure at the transition, and the stopping position challenge on the main line. All of these must be designed explicitly.
WHEN	Any time the flow diagram shows a 90-degree divert off the main trunk line. The orientation change determines what the takeaway conveyor must support.
WHERE	Every 90-degree transfer point in the layout. The design considerations covered in this module apply regardless of whether the transfer is pneumatic or mechanical weather the takeaway is powered or gravity

Merges

WHY	A merge combines two or more product flows into a single line. Every merge is a potential jam point because product from multiple lanes is being forced into a single path. The PLC manages this by releasing one lane at a time and creating a zipper effect where products from different lanes interleave into a single file. That controlled release is the entire basis of merge reliability. Anything that compromises the PLC's ability to release and stop product precisely at the merge point compromises the merge. Air-based accumulation conveyor feeding directly into a merge is a specific and well-documented reliability risk that must be understood and addressed during design.
WHEN	Any time the flow diagram shows two or more product flows combining into one. Merge design begins at the flow diagram stage when buffer requirements and lane switching timing are first established, and is refined during layout development when the physical merge geometry and controls requirements are specified.
WHERE	Every merge point in the system, regardless of merge type. The product control principles and the air accumulation risk covered in this module apply across straight merges, spur merges, and sawtooth merges.

Sortation

WHY	Sortation is the process of identifying products on a conveyor and diverting them to specific destinations. The selection of the right sorter technology requires a clear understanding of three things: what product is being sorted across the full product mix, how many pieces per minute must be sorted at peak, and how much floor space is available and how many destinations must be served. Answering those three questions correctly and then matching the answers to the sorter technology that fits them, without overbuilding or underbuilding, is the discipline this section teaches. The Hytrol product handling matrix and throughput ranges are the primary tools for making that match.
WHEN	During the flow diagram phase when sortation points are first identified and throughput requirements are established, and again during layout development when sorter selection is confirmed and takeaway lane geometry is designed.
WHERE	Every sortation point in the system. The selection discipline applies whether the system has one sorter or ten. Right-sizing each sorter independently based on the specific throughput and product mix at that point produces better designs than applying a single sorter standard across the whole system.

SECTION 5: CORE CONTENT

5.1 90-Degree Transfers: Strand Spacing, Orientation Change, and the Frame Gap

A 90 degree transfer works by raising transfer strands up between the rollers of the main line conveyor to contact the underside of the package and redirect it off the trunk line at a right angle. Those strands are spaced across the width of the conveyor in the same way rollers are spaced along the length, and the same rule applies. The product must have enough strands under it at any given moment to remain stable during the transfer. The number of strands required depends on the size and rigidity of the product and the strand spacing. As a rule of thumb, the product should have multiple strands under it throughout the transfer to maintain stability. Products that are too small or too flexible for the strand spacing will rock, tip, or misalign during the divert.

The second critical consideration is orientation relative to the direction of travel. A package that travels easy way down the trunk line, with its long dimension aligned with the direction of travel, may divert 90 degrees onto a takeaway conveyor. Because the package itself does not rotate during the divert, its orientation remains the same. As a result, the short dimension of the carton is now in the direction of travel on the takeaway conveyor.

This is not a minor detail. The dimension that runs in the direction of travel is the dimension that must be supported by the roller centers of the takeaway conveyor.

For example, consider a 15 inch by 8 inch carton. When conveyed easy way on a conveyor with 3 inch roller centers, the 15 inch dimension spans multiple rollers and the carton remains stable. After diverting onto the takeaway conveyor, the carton travels hard way, meaning the 8 inch dimension is now in the direction of travel.

With only 8 inches spanning the rollers, the carton may not be supported by enough rollers at the same time if the roller centers remain at 3 inches. The spacing between rollers is simply not close enough to provide adequate support, and the carton may teeter or dip between rollers.

For this reason, the takeaway conveyor must use tighter roller spacing, such as 2 inch roller centers, so the carton remains properly supported while traveling the hard way. The key point is that the roller centers for the takeaway conveyor must be selected based on the hard way dimension of the product, not the easy way dimension used on the trunk line.

FIELD INSIGHT | MICHAEL COLLINS

When designing a 90 degree transfer, every change in direction must be evaluated in terms of the products moving across the MTBH (material to be handled). Roller centers are not the only concern. The width of the conveyor side frames also matters.

For example, if two 24 inch OAW Hytrol conveyors are installed side by side and touching, their between frame width is 21 inches. The remaining 3 inches is frame thickness, which means the two conveyors create roughly 3 inches of combined side frame between them.

Now imagine a 12 by 5 package traveling across that transition hard way. This dead space becomes critical when the product is conveyed the hard way. The package must cross the gap between the two frame edges, and there is a high likelihood that it will catch or become stuck in that space.

There are several ways to address this at the transition. One option is to spread the conveyors slightly apart and install a transition roller that bridges the gap. This provides a supported surface for the product to cross instead of leaving an open space between the frame edges.

Another consideration is the guardrail entering the takeaway conveyor. Tapering the guardrail at the entrance helps guide the product into the lane and reduces the chance that the leading edge of the package will catch on the frame edge at the transition point

TRANSFER DESIGN CHECKLIST

Design Element	What to Verify	Consequence of Getting It Wrong
Strand spacing	Product has adequate strands under it throughout the transfer given its size and rigidity	Product rocks, tips, or misaligns during divert
Takeaway roller center	Roller center selected based on hard way dimension of product, not easy way	Product teeter and dips between rollers on takeaway
Frame gap at transition	Combined side frame gap measured and addressed with transition roller if needed	Product hangs up in dead space between frame edges
Guardrail entry taper	Tapered guardrail specified at takeaway entry to guide product through transition	Leading edge catches frame edge, product rotates or jams
Max carton length clearance	Max carton length confirmed to clear both sides of takeaway opening with stopping variation margin	Leading or trailing edge contacts takeaway side frame, product rotates or jams

5.2 Transfer Controls: Photoeye Placement, PLC Delays, and Stopping Variation

Stopping a package precisely over the transfer strands is as much a controls problem as a mechanical one. The photoeye that detects the package cannot be placed directly over the strands, because a package in the process of transferring would strike and damage a sensor in that position. Instead, the photoeye must be located upstream of the transfer point, far enough away to remain clear of the divert motion.

Because the sensor is offset from the actual divert location, the PLC cannot stop the package the moment the photoeye is triggered. It must apply a calculated delay based on conveyor speed so the package travels from the sensor to the correct stopping position over the strands before the stop command is issued.

That delay calculation is straightforward when the system is new and operating at design conditions. Over time, however, it becomes less reliable. The O ring drives used in many roller conveyors stretch, dry out, and lose elasticity as they age. As the O rings degrade, slippage increases and the package travels a shorter distance per unit time than it did when the system was commissioned. As a result, the stopping position gradually drifts. A delay that positioned the package perfectly over the strands on day one may stop it short or long after a year of operation.

The design response is to provide clearance at the takeaway conveyor. The takeaway opening must be wide enough that the maximum carton length in the product mix clears both side frames even when stopping position varies within the expected range. If the maximum carton length is close to the takeaway opening width, a package that stops slightly short or long may have its leading or trailing edge contact the side frame of the takeaway conveyor. That contact can rotate the package in the opening, jam it, and stop the divert cycle.

The solution is not a tighter delay calculation. The takeaway conveyor must be sized so the material to be handled has adequate clearance on both sides to absorb the stopping variation that naturally occurs as the system ages.

In many designs the takeaway conveyor uses rollers set high so tapered guardrails can be installed at the entrance. When rollers are set high, the rollers are mounted near the top of the side frame rather than recessed into it. This allows the entry point to be slightly wider than the conveyor's standard between frame dimension, with guardrails that taper inward to guide the product into the takeaway lane.

The guardrails begin wider than the takeaway conveyor and taper down to the standard between frame dimension. This taper helps guide packages into the lane and can absorb small variations in stopping position. However, this approach can only accommodate minor differences. If the taper angle becomes too steep, the guardrails can force the package to rotate or bind as it enters the takeaway. For that reason, the takeaway conveyor must still be appropriately sized for the material to be handled, with tapered guardrails used only to manage small variations.

TRANSFER CONTROLS DESIGN PRINCIPLES

Photoeye must be placed upstream of the transfer strands, far enough that a package in the process of diverting cannot contact it. This offset is non-negotiable and creates the delay requirement.

The PLC delay that compensates for the photoeye offset must be calculated at commissioning for the specific belt speed and product weight of the application. Document it. It will need to be revisited as the system ages.

O-ring degradation is a maintenance and design variable. As O-rings stretch and dry rot, slippage increases and stopping position drifts. Factor this into the clearance calculation for maximum carton length, not just into the commissioning delay.

If pneumatic actuation is used for the transfer, air pressure variation adds another source of timing variability. Low pressure, moisture in the line, and worn valve components all affect actuation speed and must be accounted for in the stopping position clearance margin.

Maximum carton length clearance is the primary design safeguard against stopping variation. Design it in from the start. It cannot be added after the system is installed without changing the takeaway conveyor geometry.

5.3 Merges: Three Types and the Principles That Apply to All of Them

Merges are divided into three physical configurations: the straight merge, where two conveyor lanes converge at an angle into a single line; the spur merge, where a spur conveyor feeds into the side of a main trunk line; and the sawtooth merge, where multiple lanes feed into a single line at shallow angles in a sawtooth pattern to maximize the number of induct points within a given floor space. The physical configuration determines the geometry and the spacing of the merge point. The product control principles that govern reliability apply to all three.

In every merge configuration, the PLC controls product release to prevent simultaneous arrival of product from multiple lanes at the merge point. Lanes are released one at a time in a sequenced pattern so that product from different lanes zippers into a single file rather than colliding at the merge point. The gap between products in the merged stream is a function of the release timing, the belt speeds on each lane, and the gap that existed between products on each individual lane before the merge. All of those variables must be accounted for in the overall capacity calculation for the system, because the merge is a throughput constraint, not just a directional transition.

FIELD INSIGHT | MICHAEL COLLINS

When merging products together there is a high potential for jam. To mitigate that we use the PLC to control the release of product, releasing one lane at a time in such a fashion that when product is being merged, it zippers together into a single file.

Because control is critical, it is bad practice to use specific models of conveyor to feed directly into a merge. The types that create risk are essentially any type that uses air. Air is fickle. Air leaks, low pressure, high pressure, moisture in the line all cause the air components to be sluggish or fail, and all of those conditions affect the reaction time of the conveyor when the PLC tells it to stop. When using air-based accumulation conveyor feeding a merge, you would ideally install a belted conveyor at the end of that air accumulator, upstream of the merge point, to give you positive control of the package before it enters the merge.

It is also critical to understand the limitations of the controls team you are using. They may need a little extra gap to provide the level of robustness you need. Because the merge is a highly PLC-controlled area, gaps, delays, and lane switching timing must all be accounted for in your overall capacity calculations. The merge is not free throughput.

MERGE TYPES COMPARED

Merge Type	Physical Configuration	Best Application	Key Design Consideration
Straight Merge	Two lanes converge at angle into single line	Two equal lines combining into one trunk	Lane speeds typically matched to produce consistent gap in merged stream
Spur Merge	Side spur feeds into main trunk line at angle	Secondary flow joining a primary trunk line	Main trunk flow has priority; spur release timed to gaps in trunk stream Special note: trunk line can often be paused directly upstream of the merge point to switch priorities.
Sawtooth Merge	Multiple lanes feed at shallow angles in sequence	High lane count in limited floor space,	Cycle time per lane limits total throughput; controls complexity scales with lane count

5.4 Sortation: Right-Sizing the Sorter

Sortation is the process of identifying products on a conveyor and diverting them to specific destinations based on that identification. The selection of the right sorter technology requires a clear and complete answer to Four questions before any sorter model is specified. What is the product or product range being sorted. How many pieces per minute must be sorted. What floor space is available. How many sort destinations must be served.

New engineers consistently get sorter selection wrong in one of two ways. They either overengineer the selection, choosing a high-throughput, high-capability sorter for an application that does not need it, or they underengineer it, choosing a lower-capability sorter that cannot handle the product mix or the peak rate. Both errors are expensive. Overengineering wastes capital on throughput and capability that will never be used. Underengineering produces a system that fails to perform under real conditions. Right-sizing requires the full inputs: confirmed MTBH, confirmed product mix across the full range including edge cases, peak throughput from the flow diagram, and the physical footprint constraint from the layout.

FIELD INSIGHT | MICHAEL COLLINS

Engineers often over-engineer or under-engineer the sorter. It takes time and calculation and a full understanding of the MTBH and system requirements to right-size it. You cannot skip the product analysis, skip the peak throughput calculation, or assume a sorter that worked on a previous project will work on this one. Every application is different and the sorter selection must be driven by the specific inputs of that application.

5.5 The Three Selection Criteria: Product, Throughput, and Footprint

Product Type

Product type is the first filter in sorter selection. The product characteristics that matter are dimension, weight, shape, rigidity, packaging type, and surface. These determine which sorter mechanisms can handle the product without damage and which cannot. A sliding shoe sorter that is excellent for corrugated cartons may be a poor choice for bagged apparel. A cross belt sorter that handles irregular parcels well may be more system than a standard case sortation application requires.

The product mix is rarely a single product type. Most applications handle a range of products, and the sorter must be evaluated against the full range, not just the most common type. The Hytrol product handling matrix rates sorter technologies against nine product categories: corrugated cartons, plastic totes, bagged apparel, parcels, stretch wrapped, straps, strings, loose items, and large parcels. Each technology is rated excellent, good, fair, poor, or not applicable for each product category. The selection starts by identifying which technologies score adequately across the full product mix, not just for the majority product.

HYTROL SORTER PRODUCT HANDLING MATRIX (SUMMARIZED)					
Sorter Technology	Corr. Carton	Plastic Tote	Bagged Apparel	Parcel	Large Parcel
Pusher (N-Line)	Excellent	Excellent	Poor	Poor	N/A
Narrow Belt 90 Deg (N-Line)	Good	Good	Poor	Poor	Poor
Belted Pivot Wheel (M-Line)	Good	Good	Poor	Good	N/A
Narrow Belt 30 Deg (M-Line)	Good	Good	Poor	Poor	N/A
High Density Sliding Shoe	Fair	Fair	Excellent	Excellent	N/A
Sliding Shoe (M-Line)	Excellent	Excellent	Good	Fair	Poor
Sliding Shoe Very Large (M-Line)	Excellent	Excellent	Fair	Good	Excellent
Tilt Tray (Loop)	Excellent	Good	Fair	Fair	Poor
Cross Belt (Loop)	Excellent	Fair	Excellent	Excellent	Poor

Throughput

Throughput is the second filter. Once the technology options that handle the product mix adequately are identified, they are evaluated against the required throughput. The Hytrol throughput ranges classify sorters as slow, medium, or high throughput. Slow sorters handle up to 1,800 pieces per hour. Medium sorters handle 1,800 to 7,200 pieces per hour. High throughput sorters handle 7,200 to 30,000 or more pieces per hour.

The throughput requirement used for sorter selection must be the peak rate from the flow diagram, not the average. A sorter selected for average throughput will be saturated during every peak event. The selection must also account for the gap requirements and the identification system cycle time, because those factors reduce the effective throughput below the sorter's published maximum rate. A sorter rated at 5,000 pieces per hour in ideal conditions may deliver 3,800 pieces per hour in a real application with the required gap and the scan tunnel cycle time factored in.

SORTER THROUGHPUT RANGES			
Classification	Range (PPM)	Range (PPH)	Representative Technologies
Slow	0 - 30	0 - 1,800	Pusher, basic pivot wheel applications
Medium	30 - 120	1,800 - 7,200	Narrow belt sorters, sliding shoe, belted pivot wheel
High	120 - 500+	7,200 - 30,000+	High density sliding shoe, tilt tray, cross belt

Footprint and Destinations

The third filter is physical: how much floor space is available and how many sort destinations must be served. Line sorters are fed at one end and sort product off to the sides. They require a separate recirculation conveyor to handle missed sorts or Lane unavailability after induction to the sorter. Loop sorters are fed from the side, often at multiple points, and have built-in recirculation. Cross belt, tilt tray, and bomb bay sorters are loop configurations. The others are generally line sorters.

The number of sort destinations determines the physical length of the sorter. More destinations require more sort points, which require a longer sorter or a loop configuration. The centerline distance between takeaway conveyors and the required width of each takeaway lane are parameters that must be resolved in the layout before the sorter footprint can be confirmed. A sorter that fits the throughput and product requirements but cannot physically accommodate the number of destinations in the available floor space is the wrong sorter for that application regardless of its performance specifications.

5.6 The Typical Sortation System: Elements in Sequence

A complete line sortation system contains several elements that work together in sequence. Understanding the function of each element and how they connect is essential for designing the system around the sorter, not just the sorter itself.

Line Sortation System Elements in Order

Pre-merge accumulation: Accumulates product from multiple upstream sources and holds it in a controlled queue before it enters the merge. This is where air-based accumulation risk is most relevant. The accumulation section feeds the merge and must provide positive, controllable product release.

Merge: Combines product from multiple lanes into a single file using PLC-controlled lane release. The zipper release pattern produces the singulated stream required by the induction section downstream.

Induction: Creates the minimum required gap between products before they enter the sorter. The induction section is a speed-up belt or series of belts that accelerates each package to create the gap the sorter needs to reliably identify and divert each item independently.

Identification system: Scan tunnel, camera system, or other identification technology that reads the product and assigns it a destination. The identification system cycle time is a throughput constraint that must be factored into the effective sorter rate calculation.

Sorter: Diverts products to their assigned destinations based on the identification system output and the PLC routing logic.

Takeaway conveyors: Accept diverted product from the sorter and convey it to its destination lane. Takeaway spur speed must be calculated using the Speed of Takeaway Spur calculator from Module 6 for each divert angle.

Recirculation system: Routes products that were not successfully diverted back to the induction line for another pass. Required on line sorters; built into loop sorters.

Products that are misread by the identification system, or rejected for other reasons divert to a hospital lane.

SECTION 6: TIPS AND TRICKS

TIPS AND TRICKS | MICHAEL COLLINS

Before designing any transfer, identify the hard way dimension of every product in the MTBH and use that as the roller center basis for the takeaway conveyor. Do not use the easy way dimension that was used on the trunk line. The product changed orientation. The design must change with it.

Measure the combined frame gap between any two butted conveyors at a transfer transition before finalizing the design. Do not assume the gap is acceptable. Calculate it, compare it to the smallest product dimension crossing that gap in the hard way orientation, and specify a transition roller if needed.

When designing a merge, find out what kind of accumulation conveyor is feeding it before you do anything else. If it is air-based, specify a belted conveyor section at the end of the accumulator, upstream of the merge point. Do not wait for the controls team to discover the reliability problem at commissioning.

Account for merge lane switching time in your capacity calculations. The merge is not free throughput. Every lane switch creates a dead time in the merged stream. The tighter your overall rate requirement, the more those gaps matter.

Right-size the sorter from the inputs, not from a previous project. Pull the peak rate from the flow diagram, the product mix from the product envelope, and the footprint constraint from the layout. Run those against the product handling matrix and the throughput ranges. Let the inputs select the sorter, not the other way around.

Never select a sorter based on average throughput. The system must perform at peak. A sorter selected for average rate will fail during every wave release and every high-volume period. Use peak from the flow diagram as the selection input.

SECTION 7: NOTES AND INSIGHTS

NOTES AND INSIGHTS

The easy way versus hard way conveying principle introduced in Module 2 is the conceptual foundation for the transfer design challenges in this module. An engineer who truly internalized that principle in Module 2 will recognize immediately why a product that was fine on the trunk line needs a different roller center on the takeaway. An engineer who did not will discover it during commissioning.

The air accumulation risk at a merge is the same reliability principle that appeared in Module 6 regarding gap slippage. The pattern is consistent: wherever a mechanical or pneumatic component introduces variability into a timing-critical operation, that variability must be accounted for in the design. The merge is simply another instance of that principle applied to a different mechanism.

The Hytrol Sortation Technology white paper provides the product handling matrix and throughput ranges that are the primary selection tools for this module. The matrix and ranges are starting points for selection, not final answers. They must be applied against the specific application inputs, including the full product mix from the MTBH, the peak rate from the flow diagram, and the footprint constraint from the layout, before a selection can be confirmed.

The recirculation system is often treated as an afterthought in system design. It is not. In a line sortation system, the recirculation conveyor is the safety net for every missed sort, every misread barcode, and every product that arrives before its destination lane is ready. A system without a designed recirculation path accumulates rejects at the end of the sorter until the system stops. Design the recirculation path during the flow diagram phase, not after the sorter is specified.

SECTION 8: EXPERT CALLOUT

EXPERT CALLOUT

Placeholder for expert insight on right-sizing a sorter selection. Reviewer to share a specific example of a project where the sorter was over-engineered or under-engineered, what the consequence was in system performance or project cost, and what the correct selection process would have produced.

[Reviewer Name, Title, Company]

SECTION 9: PITFALLS



Selecting the takeaway conveyor roller center based on the easy way dimension of the product. After a 90-degree transfer the product is traveling hard way. The hard way dimension is what must be supported by the roller centers on the takeaway. Using the easy way dimension produces a takeaway conveyor that cannot support the product in the orientation it will actually be in.

- ! Ignoring the combined frame gap at a transfer transition. Two standard-width conveyors butted side by side have a real gap between their frame edges. A small product traveling hard way across that gap will hang up. Measure it, compare it to the product, and specify a transition roller if needed. Do not assume the gap is acceptable.
- ! Relying on a tight PLC delay calculation to solve stopping position variation at a transfer. O-ring degradation, air pressure variation, and product weight variability all shift the stopping position over time. The correct design response is maximum carton length clearance that absorbs that variation, not a delay that is correct only when conditions are ideal.
- ! Feeding air-based accumulation conveyor directly into a merge without a positive-control belt section upstream of the merge point. Air is variable. A sluggish or failed air component at the merge feed will produce jams that cannot be resolved by adjusting PLC parameters alone.
- ! Treating the merge as free throughput in the capacity calculation. Lane switching creates dead time in the merged stream. The controls team's gap and timing requirements reduce effective throughput below the sum of the individual lane rates. Account for it explicitly.
- ! Selecting a sorter based on a previous project or on average throughput rather than on the specific inputs of the current application. Every application is different. The product mix, peak rate, and footprint must drive the selection. A sorter that was right-sized for one application is not automatically right-sized for another.

SECTION 10: FOREST THROUGH THE TREES

How Transfers, Merges and Sortation Connect to Everything That Follows

Module 8 is where the full system begins to take physical shape. The transfers, merges, and sortation points defined here are the highest-complexity nodes in the layout. Every rate calculation from Module 6 is tested against real physical constraints at these nodes. Every product handling decision from Module 2 produces a consequence at a transfer or a sorter. Every flow diagram decision from Module 5 about where to split and combine flows becomes a physical design challenge in this module.

The controls requirements introduced here, PLC delays, lane switching timing, merge sequencing, and identification system cycle time, are the inputs to Module 9 when the controls architecture is designed in full. An engineer who understands why those timing requirements exist, not just that they exist, will specify them correctly in the controls design and will be able to troubleshoot them intelligently when commissioning reveals discrepancies.

The sorter selection made in this module carries into Module 11 as one of the highest-cost line items in the project proposal. Right-sizing the sorter is not just a technical discipline. It is a commercial one. An overengineered sorter that was not needed wastes customer capital and reduces the competitiveness of the proposal. An underengineered sorter that cannot perform creates a performance failure that damages the customer relationship and requires expensive remediation. Getting it right in Module 8 has direct commercial consequences in Module 11.

SECTION 11: KEY TAKEAWAYS

KEY TAKEAWAYS | MODULE 8

After a 90-degree transfer, product travels hard way on the takeaway. The roller center on the takeaway must be selected based on the hard way dimension, not the easy way dimension used on the trunk line.

The combined frame gap between two butted conveyors at a transfer transition is real and must be measured and addressed. A transition roller bridges the gap for products that would otherwise hang up between the frame edges.

Photoeye placement upstream of a transfer creates a stopping position offset that requires a PLC delay. That delay drifts over time as O-rings degrade and slippage increases. Maximum carton length clearance is the design safeguard against that drift.

Air-based accumulation conveyor feeding directly into a merge is a reliability risk. Install a belted conveyor section at the end of the air accumulator, upstream of the merge point, to provide positive control.

Merge lane switching creates dead time in the merged stream. Account for it in the capacity calculation. The merge is not free throughput.

Right-size the sorter from the specific inputs of the application: the full MTBH product mix, the peak rate from the flow diagram, and the footprint constraint from the layout. Use the product handling matrix and throughput ranges as selection tools. Do not over-engineer or under-engineer.

Never select a sorter based on average throughput. The system must perform at peak. Use peak rate as the selection input.

SECTION 12: MODULE ASSESSMENT

Knowledge Check

Q1

A 14-inch by 8-inch carton is traveling easy way on a main trunk line with 3-inch roller centers. It is diverted at a 90-degree transfer onto a takeaway conveyor. Explain what orientation the carton is now in on the takeaway, what dimension is now in the direction of travel, and what roller center the takeaway conveyor must be designed to support. Then explain what happens if the engineer specifies the takeaway with the same 3-inch roller center used on the trunk line.

Q2

Describe the photoeye placement constraint at a 90-degree transfer and explain why a PLC delay is required. Then explain why that delay becomes less reliable over the life of the system and what the correct design safeguard is against that drift.

Q3

You are designing a merge that receives product from three lanes of ABEZ air accumulation conveyor. Identify the reliability risk this creates and specify the design change required before the merge point. Explain what the design change accomplishes and what happens without it.

Sorter Selection Exercise

Q1

A regional e commerce fulfillment center handles a product mix of 60 percent corrugated cartons, 25 percent plastic totes, and 15 percent bagged apparel. Peak throughput is 4,200 pieces per hour. The building has 8,000 square feet available for sortation and requires 12 sort destinations.

Using the Hytrol product handling matrix, identify which sorter technologies can handle the full product mix. Then determine which of those technologies fits the medium throughput range for this application. Finally, explain why bagged apparel must still be considered in the sorter selection even though it represents only 15 percent of the volume.

END OF MODULE 8

Next: Module 9 | Controls Integration and PLC Interface

Before continuing, review the PLC delay and lane switching timing requirements identified in this module. Those requirements are the inputs to the controls architecture in Module 9.

Confirm the sorter selection from the exercise is recorded alongside the speed outputs from Module 6. Module 9 will use both as inputs to the controls specification.

The Hytrol Sortation Technology white paper is a reference document for this program. Keep it accessible through Module 11 when sorter line items appear in the proposal.