Error Proofing Plant Processes

Submitted by

John Piatek
Vice President of Technologies
Freedom Technologies Corporation

Manufacturers in the supply chain in the Automobile Industry today face unprecedented pressures: Cost reduction demands from customers, intense competition from offshore competitors and zero-defect quality expectations from customers. Customers in the supply chain expect nothing less than 100% quality in parts placed in containers, labeled correctly and delivered just-in-time. On top of this, new government mandates are forcing manufacturers to maintain complete recall traceability systems for their products and OEM customers are forcing warranty costs back to their suppliers. In short, the cost of quality non-conformance is going up. Poorly performing suppliers are more likely to lose business to other suppliers. Customers in the supply chain are now charging incurred costs for non-conforming shipments back to their suppliers. Furthermore, non-conforming suppliers can now face 100% sorting requirements from their customers after just one “quality incident,” until they prove to their customers that they have improved quality conformance.

How can the manufacturing community change its practices to conform to supply chain customers’ standards and still maintain profitability? This is a key challenge today faced by all suppliers. Through Error Proofing systems, manufacturers are trying to manage, and control production line operations, which can ensure the correctness of the manufacturing and shipping procedures and still cut costs. Error Proofing systems typically contain a robust set of verification and validation functions that can be used to perform component part verifications, transaction verifications, capture testing data, track part component genealogies (serial and lot traceability tied to each part), produce serialized part labels or direct part markings, interface with the programmable logic controllers (PLC’s), count to container verification and “earning labels” for shipping.

By electronically controlling shop floor, inventory movement and shipping processes, Error Proofing systems can eliminate the possibility of human error throughout the entire plant or, if desired, just in specific areas of the plant that are prone to quality issues caused by human error. This solves the problem of today’s companies who must re-engineer their plant and warehouse workflows to streamline, reduce labor, increase inventory turns, lower inventory levels, maximize data accuracy and timeliness as well as conform to customer quality mandates. Using practices borrowed from Shingeo Shingo’s “Poka-Yoke” writings, Error Proofing provides three functions to warn users against defects, via shutdown, control or warning throughout any part of the manufacturing process, regardless of whether quality defect is about to occur (prediction) or if it has already occurred (detection).

Traditional Methods

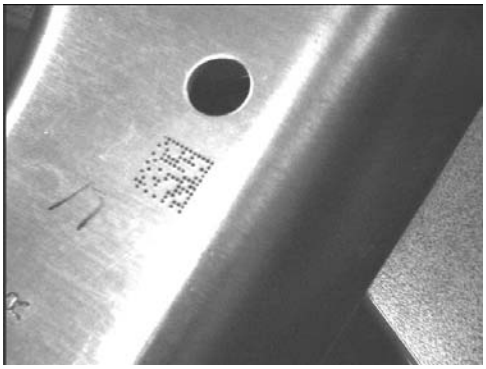
Many of today's manufacturers in the auto industry typically rely on some automatic identification methods to collect tracking and inventory data, but they miss the opportunity to finitely track parts and products in the manufacturing and packing processes because they have no way to automate their data collection processes on the assembly line. Why? Part of the answer is because the parts themselves are not bar coded. Part of the answer also is they do not uniquely serialize their internal labels. Many also rely on manual data collection methods by workers to collect information or make decisions.

Let's look at an example of a typical assembly line that manufactures products for a customer and the typical system that is used to pack and label the finished product container. At the start of the line, someone places a base part on the line to start the assembly process. As the part moves down the line, various other parts and processes are added to construct the finished product. At certain times in the process, quality checks are performed. Once the product reaches the end of the line, it is placed in a container. Once the container is filled, it is sealed and a preprinted label is placed on the box to identify what the contents are and what the quantity is. Perhaps a serialized control number is assigned to the carton. The carton is then removed and placed in a warehouse or similar holding area.

There are a number of missed opportunities and places for errors to occur in this type of system. First and foremost, the system relies on human decisions to guarantee things such as making sure the right products are being placed in the right container. It relies on human decisions to make sure that the product count is correct in the finished goods container. And it relies on the ability of the packer to correctly select the proper label from a stack of preprinted labels and place it on the finished goods container. If there is any information that needs to be collected for quality or lot traceability, it is usually collected manually if there is no automatic identification method to collect it. The key to the success of this method is the ability of the human information gatherers to accurately and consistently provide information, make intelligent decisions on count and labeling and to generally carry out information-gathering tasks without errors. That is a pretty tall order to ask of any of your people, yet it happens every day, resulting in errors and missed opportunities to collect valuable information.

Enter 2D Symbologies

2D symbologies (barcodes) can contain vast amounts of information that suppliers can use to further benefit the automatic data collection processes not only in shipping but also throughout manufacturing, warehousing and distribution. The Auto Industry recommends the 2D symbologies, Data matrix and QR Code, for individual parts marking. Because 2D codes can contain vast amounts of information in very little space and can be damaged and still be readable, these codes are ideal for the Auto Industry. Each individual part can be labeled with its own serialized 2D barcode. Today's printing technologies allow virtually any type of part surface to be marked with one of these 2D barcodes. The Auto Industry's direct parts marking initiative opens up many opportunities for error proofing operations and labeling. To meet the minimum requirements of the OEMs of just placing a correct 2D label on parts or packages is a waste of the potential this technology has to further internal operations and much more. The ability to serialize every part with a 2D code allows the opportunity to error proof each plant labeling and data reporting operation.



Individual Part Marked with

Error Proofing

"Error"-- the failure of planned actions to achieve their desired goal. The execution of a prohibited action, the failure to correctly perform a required action or the misinterpretation of information essential to the correct execution of an action.

In the Automotive world, the number one cause of quality related issues identified in studies done by the AIAG (Automotive Industry Action Group) and the OEM's (Ford, GM and DCX) is "Mislabeling of Product". Indeed this is the primary motivator for most suppliers to institute label Error Proofing systems. Frequently this is done because suppliers do not want to endure the pain associated with having a customer placing them on containment for a mislabeled product. From a supplier standpoint, it can be very expensive to have a sorting house come in and verify 100% of your product labeling. While this certainly is a good reason to institute a good label Error Proofing system, there are also many other opportunities for Error Proofing other processes that can add dollars to the companies bottom line.

Many of today's suppliers are simply focused on easing the pain of dissatisfying their customers, while they miss the opportunity to improve their own performance and quality and thus their own profitability.

Error Proofing should not stop at label Error Proofing. Each and every operation in the supplier community could likely benefit from some type of Error Proofed process. The ability to serialize both containers and individual parts opens up the possibility for many Error Proofing opportunities. Because most suppliers have the ability to at least print 1D or 2D codes on shipping labels, and most will have the ability to read them, the natural progression of improving business processes for managing inventory and shipments can now move to the next level of control and exploit the benefits of automatic identification. The new GM parts marking initiative, the AIAG B4 and B17 Guidelines with Data Matrix or QR Code being used to mark individual parts really is the key to a whole new avenue of opportunities to gather information, error proof your processes and disseminate information beyond the manufacturing facility to the end user or customer. By using a 2D Code or serialized individual part labels to mark individual parts, the individual part now becomes capable of retaining a database of information about each part and can be used for any automatic data collection, error proofing or verification process. Each part now can have its own identity and traceable history. Parts marking provides for functionality to serialize all production parts. This can be by using direct part marking methodologies such as labeling, dot peen, laser etching, ink jet and many others. Each individual part label is typically scanned to produce a container label with genealogy retention. This assures only correct parts are being packaged and eliminates scrap and foreign parts from finding their way into shipping containers. Error Proofing methods can also use a sophisticated Work-In-Process (WIP) label to track work-in-process. Much like the item labels described above, the WIP label can be produced at the part or at the container level thus providing a tracking and Error Proofing mechanism throughout the production process. This label is unique in that it combines both the bill and router with the label to be used for additional error proofing processes.

Another important Error Proofing process for labeling is its capability to serialize all incoming shipments of components during the receiving process. This can be via scanning or the incoming ASN process.

Combined with WIP label error proofing, production error proofing validates the manufacturing process contained in the routing, the product structure including any bill of material component, the correct container, attributes and features of products, and lastly, retains validated production information.

Opportunities Start with Serialization
Certainly with the advent of the serialized labeling of containers and parts (the GM and other individual parts marking initiatives) it becomes apparent that, since things can be identified with serialized barcodes, the ability to collect information using automatic identification in all information-gathering tasks not only becomes feasible but also is executed easily. This also means that the tasks usually performed by human decision makers can now be shifted to computer-controlled mechanisms. In layman's terms, this can mean shifting the decision making from humans to computers and computer controlled devices (Error Proofing), while at the same time saving time and improving accuracy. Any data input sent to the host software should be by at least bar code scanning to minimize the human error factor. The key to most error proofing processes lies in the ability to utilize serialization in identifying a container or individual part. When products are identified with just a part barcode on a label or a part number in a bumpy barcode on an individual part, you lose the ability fully error proof your processes. While scanning a part number barcode does have some benefit for error proofing, the full benefit for error proofing processes are missed.

Some benefits of serialized bar coding are shown below:

- Provides ability to accurately report production in real time by scanning.
- Provides ability to automatically time study manufacturing times and efficiencies.
- Provides for the capability to relieve raw materials quantities via discreet method (actual) versus standard (calculated).
- Provides for automatic cycle counting and error proofing of each transaction.
- Enables Lot Traceability – Links Raw to Finished.
- Provides ability to identify the current location of each tote or container in the plant and
  warehouses in real time.
- Provides ability to provide a real time update of what is available to ship and where it is located.
- Provides ability to verify correct Customer Labels are applied to each container as they are packed for shipment.
- Provides for an audit trail of each container’s location, movement, process, disposition, quality tests or results, operation, or operator.
- Provides ability to place product on hold by serial number to prevent shipping non conforming parts.
- Provides ability to link raw material used to actual containers for lot trace ability.
- Provides ability to link serial number with operator and machine.

Automated Receiving
The first place, and maybe the most important place, where an error could occur is in the plant receiving processes. Errors made here frequently affect other plant processes and cost the company money in terms of expediting costs or extra production time. Many companies today are streamlining and error proofing their receiving processes. A good way to reduce labor, reduce recording errors, and utilize supplier labels for traceability in receiving is to utilize ASN (Advance Ship Notice) receiving methods. Most suppliers today are familiar with shipping to their customers and sending ASN’s, but very few are requiring their suppliers to utilize ASN’s when shipping to them. By utilizing ASN receiving, companies are able to reduce the amount of labor in their receiving areas, while at the same time improving data input accuracy and providing labeling on received products that can be used for error proofing and traceability throughout all plant processes. In the process of ASN receiving, the supplier sends an ASN to their customer.

Each incoming container is then labeled with a serialized AIAG label. The serial number on this label may be also be referenced in the ASN. Upon receiving the product from a supplier, the receiving department scans the shipping label or scans a barcode on the shipping document that references the ASN. The host system, already being updated with ASN's from suppliers, references the scanned data with the ASN, and automatically receives the shipment. Since the ASN already contains the information needed to receive, there is no need for manual entry into the company's ERP system. Added benefits of ASN receiving are the ability to utilize the supplier AIAG label for traceability and tracking inventory movement in your plant. Figure 1 below shows the typical ASN Receiving process.

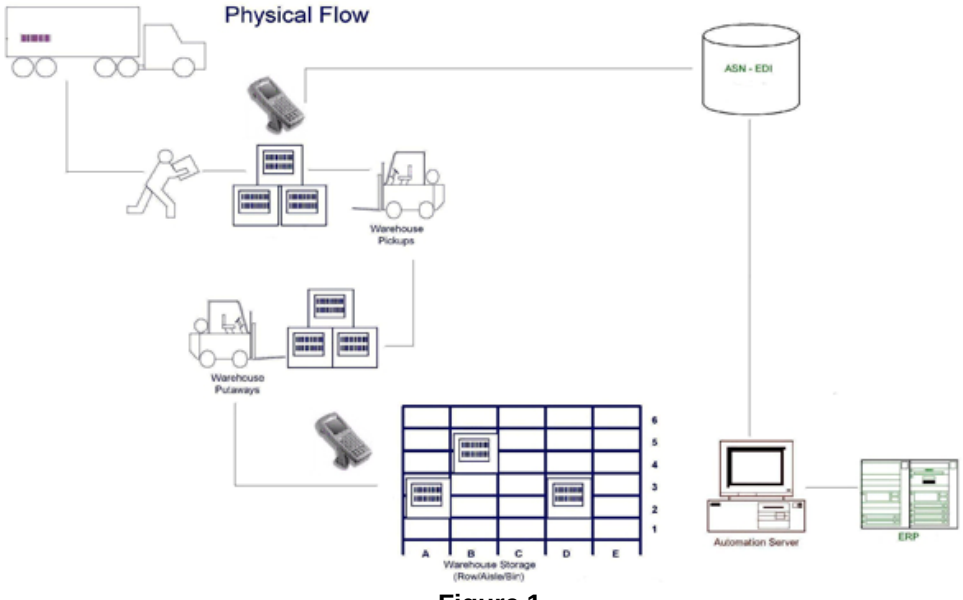


Figure 1

Production Error Proofing

Production Error Proofing can eliminate the possibility of introducing errors anywhere in your plant during the manufacturing process. By validating processes in your plant using automatic data collection technology, serialized labeling or direct parts marking and integration to shop floor devices, such as PLC's, scales, direct part marking systems, scales, vision systems, you can provide some the following Error Proofing capabilities:

Production Process Authentication-verifying that each process in the manufacturing procedure has been performed and verification of quality requirements is achieved.

- Correct Containerization
- Validation of Product Structure Authentication
- Correct Assembly Sequence Validation
- Accurate Production Counts
- Attribute/Feature Authentication
- Schedule Attainment (no over or under runs)

An example of how the Production Error Proofing process works for an injection molding operation is shown below.

1. Operator selects intended part number to run from a computer screen at set up time
2. Operator selects “ship to” destination or internal label for determining correct labeling from computer screen at set up time
3. Parts are ejected from Injection Molding Machine.
4. Serialized bar coded label or direct part marking is applied on each part
5. Operator places part on assembly station or table
6. Fixed Mount Bar code reader reads bar code label on part. Host software assigns part ID and attributes, (left, right, etc) to Serial #.

7. Color sensor determines color of part. Records color value to serial number. (traceability and proof to each individual part)
8. Operator applies clips or tapes to part
9. Sensors detect presence of clips and tape. Records presence or absence to serial #. (traceability and proof to each individual part)
10. Operator visually inspects part. Records operator ID that inspected to serial # (accountability to operator).
11. If part is “Bad”, operator scans bar code label to reject or place part on hold. Part cannot be shipped!
12. If part is “Good”, operator scans part bar code when placing into container.

Error Proofing software then validates all of the following:

   i. Verify part number is correct for the intended container.
   ii. Verify color is correct
   iii. Verify clips and tape were correctly applied
   iv. Verifies that the serial number is not a duplicate.
   v. Verifies that the part is not already assigned to another finished container.
   vi. Verifies that the part has not been placed on hold, been scrapped or voided.

- If any of these criteria are not met, an error message will display on the workstation with a corresponding error.
- Processes will need to be put in place for corresponding errors.

13. If there are no errors, the quantity in the container is incremented when operator scans label with a handheld scanner prior to placing in container.
14. Process is continued until container quantity is met.
15. Weigh Count scale quantity is then verified against counted to container quantity from scans
16. When container quantity is met, Error Proofing software prints out correct customer specific or internal container label and count is reset to zero.

17. Operator places correct customer label or correct internal label on container
18. Error Proofing software records all transactions and links them to each part serial number for future reference
19. Production reporting data from line production is sent to host ERP system

Error Proofing the Production Line - Work-in-Process Tracking

By labeling products with a Data Matrix code or a serialized barcode label at the beginning of an assembly line as shown in Figure 2 below, you are able to track each component while it is a work in process (WIP) using automatic identification. As each component moves from station to station, the serialized barcode can be read automatically, and this information can be fed into an enterprise resource planning (ERP) system to provide real-time WIP tracking and verification of all processes performed.

In addition, if raw materials are marked with serialized labels, the actual staging areas of the line for raw materials can be used as an extension of your raw materials warehouse, with the new location being a location on the line.

As each piece is added to the main component of the assembly, the bar code on the raw material can be read automatically to reduce your "warehouse" inventory by one piece each time it is consumed. This process can also automatically trigger a reorder from the raw materials warehouse once the "warehouse" location quantity on the line falls below a minimum threshold.

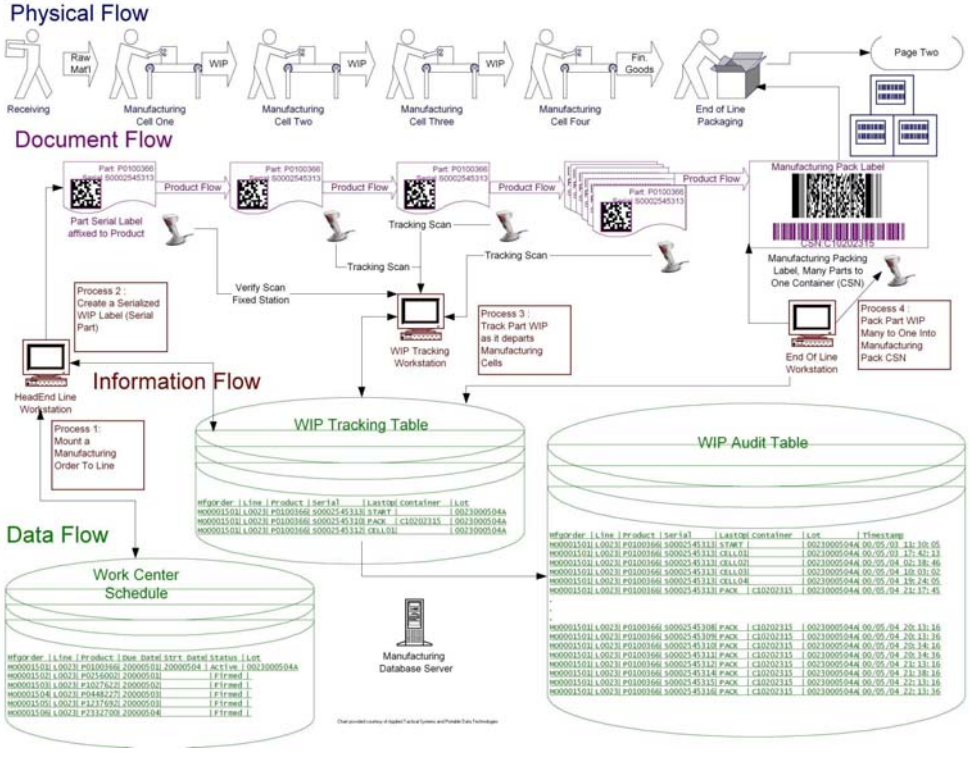


Figure 2

Lot Traceability and Quality Conveyance
By using a direct parts marking or serialized labeling to mark parts with a unique serial number, the user has the opportunity to automatically collect lot traceability information for each part or sub-assembly. This information can be easily collected by reading the symbol on the main component or casing at each assembly station and reading a raw material serialized label on components that are added to the assembly. This process links the main component serial number with each subcomponent added to the assembly. A record of what components go into making a particular assembly can then be maintained in a database. In addition, other information can also be added to the record automatically, such as which employee is assembling the product, time of assembly, temperature, etc. This type of traceability can be very useful is performing to the spirit of the government mandated TREAD act. This process, identified by the auto industry as "quality conveyance," provides a link between the subassembly and the quality checks or test results.

Error Proofing a Kanban System
Kanban or “pull systems” typically use a plastic Kanban signal card that is not uniquely serialized and is recycled throughout the system after being used. Typically the Kanban is placed on a visual scheduling board to show the user what to build. Once a container is built, the Kanban card is placed in the container for identification. Once the container is moved to the next process or shipped, the container is relabeled with a customer or internal label and the plastic Kanban is pulled and placed in a pile of Kanban’s ready to be resorted and distributed back into the system.

The shortcomings of this type of Kanban system are many. First, the Kanban itself is not uniquely serialized for traceability and error proofing. Because the Kanban’s are recycled back into the system, any bar coded identification placed on the Kanban is also reused over and over in the system. In the Auto industry, traceability is a fact of life. By reusing serial numbers or worse yet, not using them at all, you lose all traceability at the container level.

Secondly, Kanban’s are your scheduling tool. By recycling Kanban’s back into production, the Kanban’s must be collected at the last process by someone, sorted and re delivered back into the production areas. Frequently, Kanban’s are lost or misplaced during this process. Lost Kanban’s can result in missing signals to produce the correct quantities in the production areas. It also results in having someone go out each day and verify that the Kanban counts are correct in the system.

A disposable or replaceable Kanban system eliminates these types of errors while still utilizing the benefits of the traditional Kanban “pull signal”.

Error Proofed Kanban systems are “disposable” meaning it is replaced when its useful life is over rather than recycled. Each Kanban is printed on card stock by a printer with a unique serial number attached to it. The Kanban can also become the container label, which can be used for location, error proofing and the automatic reporting of production. Each Kanban is automatically printed in the production area as an old Kanban is retired. This means that when a Kanban is removed from the container for the purpose of returning to a production area, it is automatically “retired” and replaced by printing a new one with a new unique serial number back in the production areas. This means that Kanban’s are never sorted or lost. A current inventory of each Kanban type can be computerized and automatically tallied.

Each Kanban has a unique serial number on it that can never be duplicated. This unique serial number provides the ability to track each container as it goes through the production process, report production by scanning, error proof all processes and provide complete cradle to grave lot traceability for each container.

Error Proofing Data Reporting

Most plant processes rely on some form of data collection, either manual or automated, (i.e. Barcode scanning) to report production or inventory movements in the plant or warehouse. Frequently errors are made in the reporting process because someone failed or forgot to report something, mistyped a data entry or didn't scan a barcode when required. Because of these types of errors, inventory accuracy suffers. A good example of where an error frequently occurs is in the reporting of production once a part is made. Many facilities today use a manual form of production reporting, that is, once parts are made, the operator writes down on a slip of paper what was produced for the day and forwards that paper to someone who keys in the information to the company's host database. There are several opportunities for errors in this type of system. First, the operator easily can miscount the quantities produced and give a false number for production.

Secondly, the operator may have correct count but may write down the number wrong, make it illegible or transpose the figure on the slip of paper. Thirdly, the person who keys this information into the database can make a mistake by typing in the information incorrectly. These types of errors can result in expedited freight costs, unplanned overtime, or worse yet, a customer stock out.

Fortunately, these types of problems are easily fixed when you incorporate serialized bar-coded identification labels on your products for automated reporting and by using these serialized labels to error proof all of your reporting processes. Let's take a look at the same production reporting process using error proofed methods.

Each part or container is labeled with a serialized bar code label when produced. Each serialized label is identified in the database for part number and quantity. By scanning the serial number of the label, the error proofed system knows what the part number and quantity is. These labels can be printed automatically upon filling a container or printed ahead of time if you are using standard package quantities. Once each container is produced and labeled the operator scans the serialized bar code label to report production automatically to the host system in real time. With each scan, the operator number and time and date of the transaction are also recorded in the database. This process not only automates the recording of production, but also provides other information for accountability (the producing operator name) and traceability.

But what happens if the operator fails to scan the container to record production? By using error proofing methods in your reporting processes farther down stream, you can also guarantee that production is reported accurately and timely, even if the operator forgot to scan to report production. This is easily accomplished if you also error proof the next reporting process. Let say that the operator failed to scan to report production and the product now goes to the warehouse or shipping to be shipped. If you require that the product be scanned to be put away in the warehouse or scanned to be shipped, you can guarantee that the production is reported correctly. Once a serial number is scanned at the next operation, you can error proof all processes by checking to see if the previous process has been reported or completed automatically. So in this example, where the product was not reported as produced, the next time the serial number is scanned, your software will check to see if that serial number has been reported as produced. If it has

not, you can either report it automatically at that time; send an error message or hard stop to the person trying to scan the label informing them of the error. You can even check to see if that serialized label has been placed on hold, rejected or has skipped a process.

In summary, by serializing labels and using real time bar coded data reporting, you can easily error proof any process by validating that prior processes are completed before moving on to the next process.

Packaging and Label Verification

You can utilize parts marking to automatically print carton labels to guarantee that the right amount of parts, the right parts and quality parts are being placed in the package. As each part is produced and packed at the end of the assembly process, its individual serialized bar code is read with a bar code reader to identify to host system that the part is being placed in a box or package. The host system will then verify that the correct part is being packed in the box, that each part has passed all quality and verification tests, and that the serial number has not been scanned previously for packing. If the part is correct, the host system increments the box counts by one. If the part is not the type of part that is to be packed in the box, the system will alert the operator that the part is incorrect. The system verifies the part has passed all quality checks and is okay to pack. Once the correct box count has been reached and all the packed parts have been verified as belonging to that box, the host system automatically produces the correct label for the box. This label can then be immediately applied to the box by an operator or by an automatic labeling device. The host system will record the availability and existence of the box in its tables. Once done, the system resets the counter for the next box to zero and the process repeats itself.

If the box is to be packaged as part of a larger box or pallet, each box is scanned as it is being placed into the larger container. The host system will again verify that the correct box of parts is being packed to the correct container and keep a current content count.

The box or pallet can then be relocated to a warehouse or shipping area by bar code scan which will automatically update the host system. Once done, the system resets the counter for the next box to zero and the process repeats itself. If the box is to be packaged as part of a larger box or pallet, each box is scanned as it is being placed into the larger container. The host system will again verify that the correct box of parts is being packed to the correct container and keep a current content count. The box or pallet can then be relocated to a warehouse or shipping area by bar code scan which will automatically update the host system.

Shipping Label Verification

With the advent of the new GM and Ford shipping label standards utilizing PDF417, suppliers should no longer effectively print shipping labels in batches prior to shipments because some of the information that is required on the shipping label is not known until just before the time of shipment. Traditionally, many suppliers have relied on printing batches of labels and labeling cartons by removing the correct label from a preprinted stack. This method has caused both the OEMs and suppliers problems because the system relies on the ability of the person to choose the correct label from the correct pile and place it on the correct pallet.

With a real-time verification system (see Figure 3 below), shipping labels are never preprinted but rather are printed only when the process that is being performed is verified by a host system to be absolutely correct. By using this real-time verification system, the

human factor for error is minimized or removed. Designing a system that relies solely on the host system to provide shipping labels automatically once a predetermined set of conditions are achieved guarantees shipping labeling accuracy.

With this type of system, labels are only printed when the host system determines the reported information has been verified as correct. If it is not, a shipping label is not printed. Relying upon the host software to assign specific pallets to be shipped to a customer against a shipping order based upon available product on hand is mandatory. The operator should be instructed via a real time wireless RF terminal to pull and scan specific boxes by serial number.

If the correct serial numbers are scanned, the data collection device will verify the correctness of the boxes loaded for this shipment. Software will verify the pallet serial numbers are correct and generate a pallet label immediately from a portable printer or mobile wireless print stand possessed by the person who scanned the pallet. The label will be immediately affixed to that pallet by the operator. The host software will then assign this serial number the status of being ready for shipment. This process is repeated until the order for the customer is fulfilled.

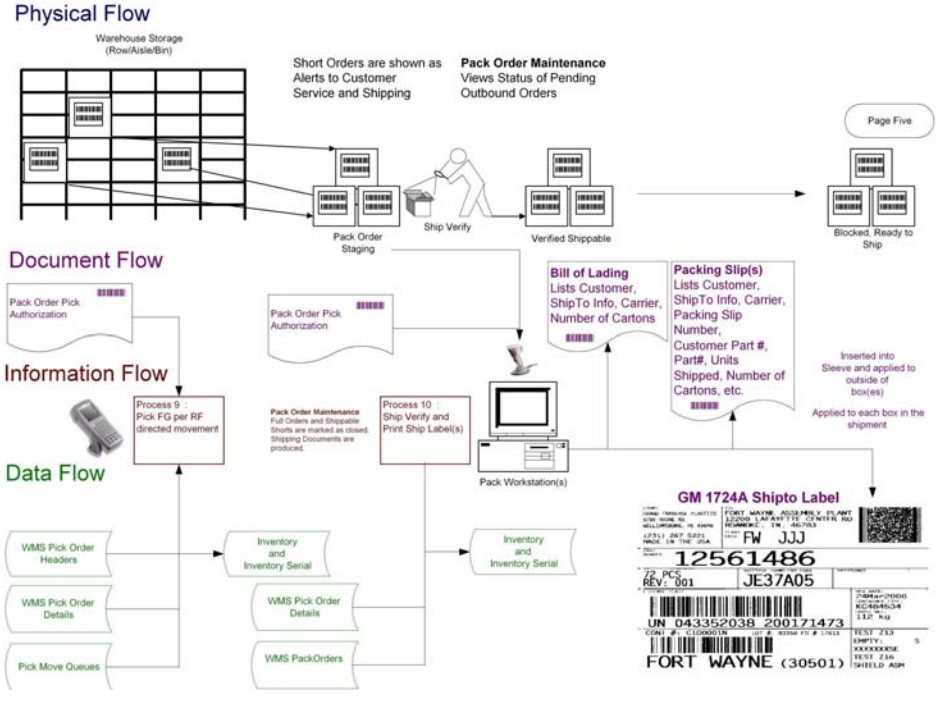


Figure 3

Upon filling the order, software may generate a master pallet label if necessary. Software will continuously monitor the scanning process to verify that proper labels have been scanned. Upon completion of an order, the same verification process used for packing may be applied to loading the truck (fig. 4)

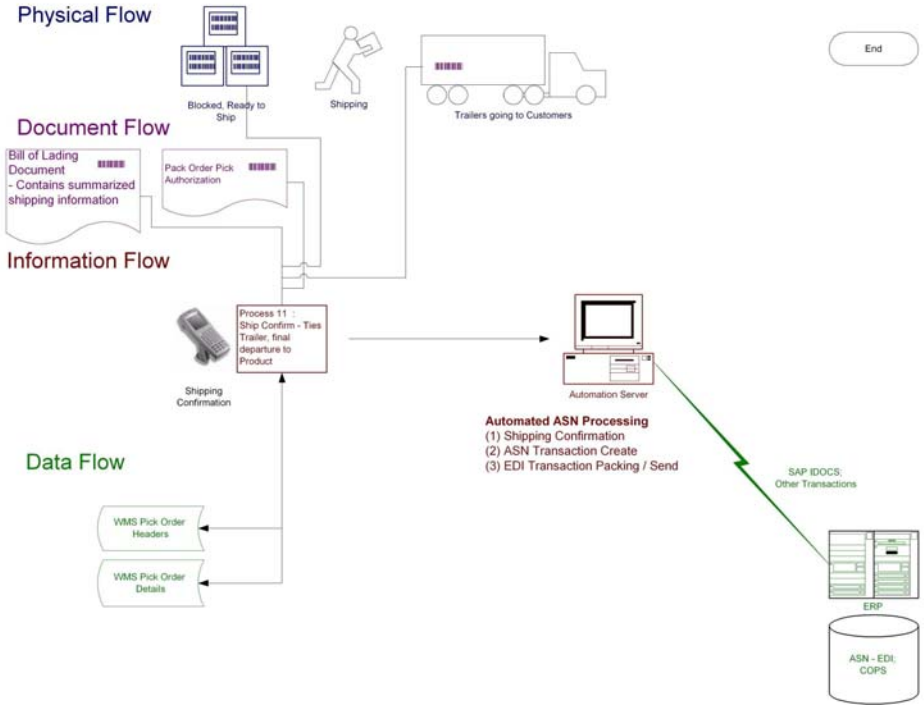


Figure 4

These are just some examples of how to maximize the error proofing technologies you are now putting in place. The potential is there. All it needs is application.

Summary of the Benefits of Error Proofing Your Processes

- Increased quality
- Improved supplier quality ratings
- Lower cost of maintaining quality and attaining Six Sigma initiatives
- Improved material accuracy and visibility
- Higher inventory turns
- Minimized scrap and rework due to increased control over manufacturing
- Lower warranty costs by having immediate traceability of shipped product
- Compliance with government mandates (TREAD Act)
- Increased efficiency with same number of workers
- Ensuring correct parts are shipped
- Ensuring compliance labeling
- Certified re-labeling of products
- Correct EDI data collected
- Automatic ASN generation
- Production Process Authentication
- Containerization Authentication
- Product Structure Authentication
- Correct Assembly Sequence Validation
- Accurate Production Counts
- Attribute/Feature Authentication

About the Author

John Piatek – Freedom Technologies Corporation

John is an internationally known expert on 2D bar coding, error proofing and Manufacturing Systems. John has been awarded several US Patents on bar coding and inventory systems and has several more pending. He also served as the co-chair of the Automotive Industry Action Group (AIAG) 2D Symbology committee from 1992-1993, a group that set the standards for two-dimensional bar code use in the auto industry.

Acknowledged as one of the world's leading experts on 2D bar coding and error proofing, John has been asked to present demonstrations to such entities as the US Department of Defense, FEMA, US Department of Energy, US Department of Treasury, the Bureau of Alcohol, Tobacco, and Firearms and various Foreign Government officials. John is also a frequent featured subject writer on Inventory Control, 2D bar coding and other applications and has been featured in over 100 magazines such as FrontLine Solutions, ID Systems, Automatic ID News, VAR Business, Assembly Magazine, Financial World, Newsday Magazine and others.