Presented at the **WBF** **North American Conference** **Atlanta, GA** **March 5-8, 2006**		**195 Wekiva Springs Road, Suite 200** **Longwood, FL 32779-2552** **+1.407.774.5764** **Fax: +1.407.774.6751** **E-mail: info@wbf.org** **www.wbf.org**

S88 Isn't Just For Batches Anymore

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KEY WORDS

Control Module, Make2Pack

ABSTRACT

Applying the ISA S88 standard to continuous and discrete applications can save time and money. The ISA S88 modular concepts that lead to a structured design approach have gained a lot of momentum by providing cost savings in the batch process and packaging industries. Are batch processing and packaging the only industries which can benefit from standards and models? This paper suggests that all control systems can benefit from the ISA S88 standard approach. System design and start-up time reduction, easier long term maintenance, and overall lower cost of ownership are benefits of a standard approach that apply to a wide variety of control applications. In conclusion, this paper illustrates the potential time and cost savings attributable to applying the ISA S88 standards and models beyond batch processing applications.

Introduction:

At the dawn of the S88 standard it was recognized that standard models and terminology were required before various batch control vendors and users could communicate. The lack of a standard resulted in many varied solutions to the batch control problem. These custom solutions were only understood by the individuals developing them. The S88 standard has provided a vehicle for uniformly implementing batch solutions on different processes, at different sites and even in different industries. By following the S88 standard models anyone familiar with the standard is able to look at any code and have a general idea how it is structured and how to modify it if necessary.

The same issues exist in the continuous and discrete manufacturing industries as well. The Make2Pack effort recognizes this fact and is well on its way to finalizing conceptual models and methodologies that apply to the total manufacturing process. In addition the S88 committee will be issuing part 5 with the goal of applying S88 to continuous and discrete processes as well. This paper will illustrate how applying S88 concepts can improve your discrete processes today.

How can a batch standard possibly work in a continuous or discrete application?

Whether one is looking at the physical model of batch, continuous, or discrete manufacturing, similar levels of equipment can be identified. At the lowest level there are simple devices such as valves, switches, etc. These simple devices typically group to perform a higher level of functionality, and this higher functionality will coordinate to ultimately produce a product. In the batch world, these are known as control modules, equipment modules, units, and process cells respectively. Similar divisions can be made in the continuous and discrete world as well.

The WBF Make2Pack effort has already begun to correlate terminology between batch, continuous, and discrete manufacturing. As seen in table #1 below, a slight change in the S88 terminology makes it transferable to these other realms of manufacturing.

S88 part 1 term	Make2Pack term	Make2Pack Description
Process Cell	Production Line	A collection of one or more machines, linked together, to perform one or multiple tasks of the process for one or more products in a defined sequence. • Continuous Process (e.g. forming line in the food industry) • Converting Line (e.g. paper, fibers) • Discrete Manufacturing (e.g. assembly) • Packaging Line (from filling to secondary and tertiary packaging) S88: *A process cell contains all of the units, equipment modules, and control modules required to make one or more batches/lots.*
Unit	Unit Machine	In packaging, the unit corresponds to the logical grouping of mechanical and electrical assemblies that historically have been called machines. The term unit may apply to single function machine (filler, capper) or a multifunctional machine (monoblock filler/capper or any other configuration that combines functions within a single machine frame and control system). A multifunctional machine/unit can perform some or all functions of a packaging line, corresponding to process cell, that perform some or all of the functions of primary, secondary and tertiary packaging. A multifunctional machine may be logically broken down into several units corresponding to the individual functions. S88: *A unit is made up of equipment modules and control modules. The modules that make up the unit may be configured as part of the unit or may be acquired temporarily to carry out specific tasks.*
Control Module	Control Module	A Control Module is the lowest module in a physical model breakdown of a unit. The term Control Module relates to the combination of (a) physical equipment and the lowest level control component that controls this equipment to carry out a physical process action. There may be control modules without directly associated physical equipment. These control modules coordinate/supervise/sequence other control modules. NOTE: The use of the term control module to describe the supervisory/sequencing/coordinating functions is proving confusing and difficult to convey the concepts. Needs further consideration. Make2Pack examples of Control Modules: • Servo • Conveyor • Pneumatic Cylinder with feed-back S88: *A control module is typically a collection of sensors, actuators, other control modules, and associated processing equipment that, from the point of view of control, is operated as a single entity. A control module can also be made up of other control modules. For example, a header control module could be defined as a combination of several on/off automatic block valve control modules.*

Table #1

Why use a modular and structured programming approach with common definitions?

Using common definitions and methodology across the batch, continuous, and discrete operations required to make a product eliminates confusion when translating meaning from one application to the next.

A good example of the benefit of common definitions can be found in the following military example. If one branch of the Norwegian Military were to pass the command "secure the building" onto another branch they would each interpret that command differently. The Army would surround it, provide cover fire by snipers and heavy machine guns, and then clear the building room by room. The Air Force would make sure the windows were closed, the lights turned off and the doors properly locked at the end of the day. The Navy would sign a ten-year-lease contract, with options to buy it after five years. (Source www.geocities.com/militaryhumour/norway/secure.html) Each of these actions are appropriate and meet the needs of the individual branches of the military, but could bring disastrous results if the command was given from one branch to another.

The same is true for the steps in a manufacturing process. To improve manufacturing output as product is passed from one production step to the next, information must flow faster and transition times be reduced. As companies continue to connect the top floor to the shop floor, "secure the product" will need to mean the same thing in every step of the process. When the business management system sends a command to the manufacturing floor all processes and machines must have the same understanding of that command to insure the command is executed properly and safely.

What demands are placed on today's manufacturing facilities? The same as have always been; to provide an ever increasing return on investment for the products manufactured at that facility. To achieve this end, the team is challenged to continually make product faster, better and cheaper. How does following the S88 standard models help reach these goals? Let's examine each individually:

Faster:

- *Reduced Design and Startup Time:* By reusing modules of code, design time is reduced as well as the time required to startup and troubleshoot a new machine.
- *Greater Process/Machine Uptime:* When consistent code is used throughout the manufacturing processes, operations and maintenance workers can more easily find and understand the root cause of a maintenance issue.

Better:

- *Improved Quality:* Using standard terminology to define the components and processes involved in manufacturing, quality is able to define consistent metrics for continuously improving the quality of the product.
- *Improved Validation:* Common code reduces the time required to validate changes as a change can be validated once and used in many different places.

Cheaper:

- *Less Initial Capital Investment:* Common code modules allow manufacturers to reuse code, enabling shorter design cycles and start-up time, and ultimately less up front investment
- *Less Training:* Since the same concepts and code are used, operators and maintenance personnel do not need to be retrained every time a new process or machine is installed in their plant.
- *Improved Efficiency:* Consistently defined states throughout all modules of equipment allow for quick identification of which modules are not being fully utilized.

Applying S88 principles can help achieve the continuous improvement goals that all manufacturing facilities must reach. The next section illustrates such savings when applying S88 standards to non-batch operations.

Real world example of discrete system using S88 standards

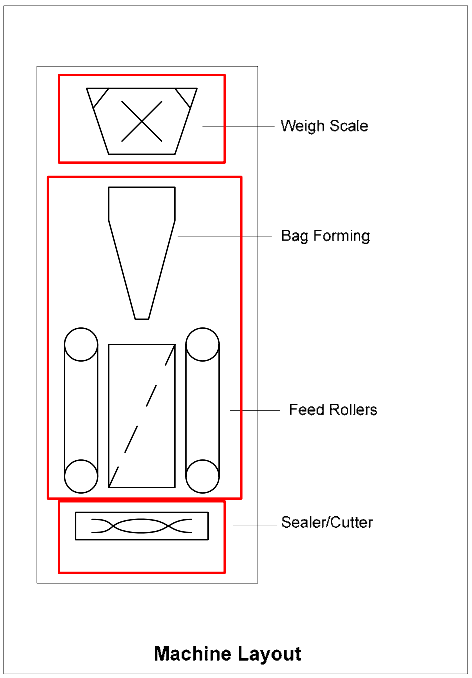
The following is an example of implementing a discrete machine using the S88 standards and concepts. The application is from the packaging industry and is known as a 'Vertical Form Fill and Seal (VFFS)' machine illustrated in Figure 1. The machine consists of four main operations: weigh, bag form, feed roll, and seal and cut. In other words, the machine weighs out some product, forms a bag or package around the product, feeds it through and cuts and seals the package.

Vertical Form Filler and Seal - Intermittent Motion

Page 1 of 2

System Capabilities

- ❑Weigh Scale
- ❑Film Feed
- ❑Crimp and Cut
- ❑Date Code Printer



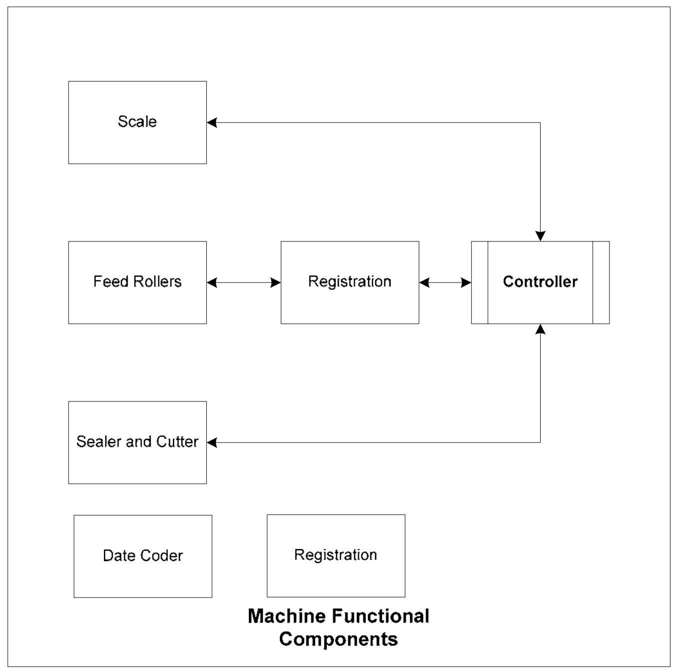


Figure #1

The Original Equipment Manufacturer (OEM) broke the machine down into equipment modules and control modules as suggested by the S88 standard. As illustrated in Figure #2 each of the four main operations of the machine was configured as an equipment module. The elements and devices within each equipment module were defined as control modules. The entire machine was defined as a unit.

By defining the machine in this way, the OEM was able to create modular code that could be reused within this machine and also on other applications.

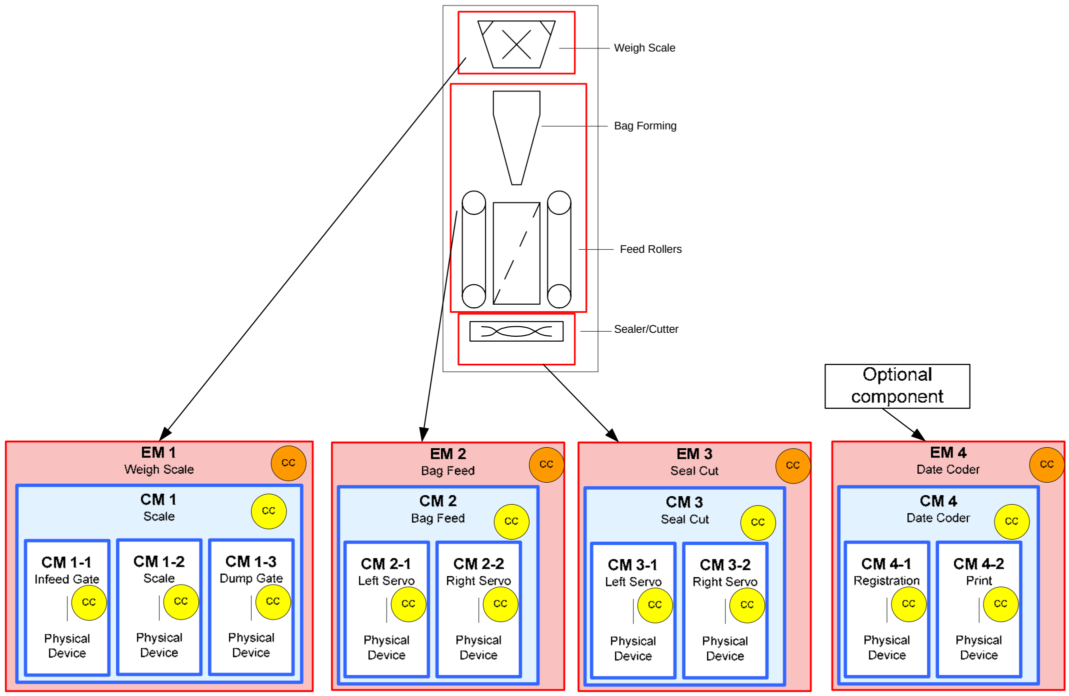


Figure #2

The OEM was then able to structure the code into modules which could utilize a modified S88 state model as the foundation. This made the code easier to write and understand because there was a model to follow. The unit (machine) program will transition according to rules set forth by the state model. The state model can be used to develop a functional specification, programming document, training document, user document and HMI.

The OEM employed the following methodology when designing the VFFS machine.

Program design methodology

- Define Physical Model
  - Break the unit (machine) into Functional Components and Sub Components (Equipment Modules and Control Modules).
- Define Equipment Procedural Model
  - Procedural model
  - Drive the complexity as low as possible into the Control Modules
  - Make interface to Control Modules as simple as possible

- Populate Program

Program the Control Modules and Equipment Modules:

With the Physical and Procedural Model defined the OEM programmed nine control modules for this machine. Five of the modules were Servo Devices so he was able to duplicate the code for these, which simplified the program structure. By following this structure, the OEM and the end user only needed to understand one ‘servo device’ module as opposed to five modules (each coded slightly differently because they did not share common states and functionality as defined by S88).

The OEM used a specific algorithm to start, stop, reset, gear, and cam his servos. With one control module being defined for ‘Servo Devices’ the OEM was able to consistently apply this algorithm to all of the servos.

In addition the scale vendor provided some basic control code was designed to S88 principles (the scale vendor also supplies the batch industry). This code easily ‘plugged into’ the code and design philosophy of the machine as an equipment module with three control modules. The scale vendor defined the functions of the scale system with the complexity of its function buried in the details of the “black box” control code. The interface is easily understood and clearly defined as inputs, outputs, status etc. The OEM felt the scale was easy to add to his machine. In reality the scale may be extremely complex, with multiple scales and an averaging algorithm. All of this was transparent to the OEM.

The OEM designed the date coder section of the code from scratch. This code included control for one servo for registration correction and a printer. The printer was defined as the final control module with logic for the basic control of the printer and sending ASCII string commands for the codes that were printed on the product.

Define Linkages Between Modules:

The OEM next considered the linkages between the base control modules and their respective equipment modules. In the ‘servo devices’ control module there is interlocking for electronic camming and other servo-only level functions that are in the control module code but not exposed to the end user. The cam timing and parameter values can be accessed but access to the algorithms for starting and stopping is of no value to the end user. The end user of the machine may only care about the system starting and stopping smoothly, and cycle time. The OEM can do his magic by delivering a machine that performs optimally within the user guidelines. By creating cam profiles that maximize the acceleration and deceleration within the required product cycle time value may be added to the machine by delivering smoother operation and lower shock on the machine and product.

The OEM considered how the control modules would be accessed, and what data would be transferred in and out of the module. In this way the interface to the control module was as clean and intuitive as possible.

This effort made ‘plugging’ the control module code into the equipment module simple because the interface points were clearly defined. By coding this module and testing it in one application the OEM was comfortable the code would work when ‘plugged’ into other parts of the machine or into other machines.

Programming the operation of the machine:

At this point the code was set up to represent the physical structure of the machine. Next the OEM looked at the operations the VFFS needed to perform.

In this case the machine needed to do the following:

- Thread up the machine with packaging materials
- Start up production of the machine
- Empty out the machine
- Manually jog one section

When designing the control code for a machine using S88 concepts and methodologies, at the highest level of machine control one considers the physical and procedural models and how they interact together in a machine to provide useful functions. From an S88 perspective these functions correspond to Unit Procedures or operations for the machine. The OEM set up the functions of a machine as phases. From this level the OEM considered which phases of the machine to invoke. An individual phase, such as threadup, or many phases may run simultaneously (or as a recipe) in the case of making product.

Benefits derived by using the S88 standard

By following the S88 standard the OEM would be able to reuse this code for next generation machines or other packaging applications. For example, the OEM was able to use the weigh scale equipment module 'as is' for a different machine that also included a weigh scale. Likewise the OEM would be able to reuse the 'servo devices' control module and printer control module when appropriate. Part of the power of code structured to fit the models of S88 is that it can be separated at different levels (i.e. unit, equipment module, and control module) and 'plugged into' other applications as appropriate because of the common definition and structure.

The OEM has also found that their field support personnel are now able to quickly understand the machine code and have expressed appreciation as the modules have found their ways onto other machines. The field support personnel no longer have to understand how control engineer Frank programs versus control engineer Ted. Now Frank and Ted use the same structure by following the S88 principles. If Frank and Ted were authors, one would request that their books have the following structural components: Title, Table of Contents, Chapters, Paragraphs, Sentences, possibly even an index and a glossary.

From maintenance perspective there is a benefit for both the OEM and the end user. By following the standard the customer is able to easily understand the structure of the code eliminating the time required to trouble shoot issues when they arise. In addition if the customer performs batching operations they may have other S88 based installations within their facility. Since the code is easy to understand the customer is less likely to make a mistake when modifying (tweaking) the code which minimizes the support costs for the OEM. If there is an issue it should be easy to locate as the module of code associated with the device in question is defined as a specific control module.

In an ideal world the end user would never need to tweak code once a machine is delivered, however in the real world one must be prepared for such an event Using models and terminology as defined as defined by S88 was key in helping this OEM successfully manage change.

As this OEM continues to roll the S88 standard into other applications they believe they will reduce design time, startup time, installation time, support trips, and end user training time. All of these savings will significantly reduce their overall cost of designing a machine while improving the quality of the end product. This standard allows them and their end users to meet the goal of making the product faster, better and cheaper.

Conclusion:

The above examples illustrate real savings to a discrete manufacturing process by implementing S88 principles. In addition to the immediate efficiency gains on the manufacturing floor, a consistent and commonly defined programming structure enables a connection to business level systems by enforcing the use of common definitions and methodologies.

One can see S88 standard ‘isn’t just for batches anymore’. S88 concepts can be applied and have the same value for continuous and discrete processes as well. Future efforts from the Make2Pack and S88 committees will continue to evolve and improve the ability to implement structured programming concepts and methodologies. These efforts will provide a standard and consistent programming structure across automation at the process, site, and enterprise levels.