The ISA S88 Standard A Roadmap for Automation A Powerful Management Tool

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– A Powerful Management Tool

ABSTRACT

This paper explains the purpose and benefits of ISA's S88 standard and its role as both an engineering guideline and an often overlooked management tool. Because detailed description of the standard's underlying technology frequently obscures the intrinsic value of the standard itself, this paper is not intended to be a tutorial on S88 technology. Rather, the intent is to help the reader understand what S88 is and where it is useful or, perhaps, essential. The focus is on how it can be used to reduce cost and improve the way a manufacturing process operates. Why S88 is important is emphasized along with how it can serve as a common language for better communication about automation opportunities and manufacturing requirements. It includes ways this modular and internally consistent standard can help reduce engineering cost and serve as a management tool, ways it can be used to help control capital expenditure, enable more precise definition of operational requirements, identify what should and should not be automated and aid in definition of optimum levels of automation.

Lastly, it discusses the compatibility of S88 concepts with the new ANSI/ISA S95 standard for Enterprise - Control System Integration and how the two standards complement each other. It explains why the S88 approach enables much more predictable manufacturing activities and correspondingly better scheduling and why that and other S88 benefits are enhanced by better connectivity with manufacturing IT and corporate business systems.

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The author of this whitepaper is an independent industry consultant with many years of experience in batch processing. The author is familiar with the industry efforts for defining batch control standards and has participated in these international efforts for a number of years.

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INTRODUCTION

The ISA[1]-88.01-1995 Batch Control standard (commonly known as S88) has had a major impact on the way batch process automation is done today. It has influenced everything from the way control systems are built to the way project requirements are written and has simplified and reduced the cost of batch control automation along the way. As an engineering guideline, it has been broadly accepted. However it is often overlooked as a management tool.

A road map for automation

Because it addresses the entire scope of manufacturing activities, including procedure and coordination as well as more traditional single point control (local to the process equipment), it deals with essentially all of the functionality required in a batch processing plant. It also provides tools to help define the way the processing equipment should work with manual control, automatic control or some mixture of both. Whether the challenge is improvement to an existing process or a major new installation, the standard is a reliable guide for automation.

A basis for management control of automation scope

Batch manufacturing processes have traditionally relied heavily on manual control and are unlikely to be comprehensively automated even today. At the same time, automatic control is becoming crucial in modern competitive manufacturing. Arriving at the optimum mixture of manual and automatic control is difficult, often because of the disparity between engineering and management understanding of requirements and implementation options. Defining what should be automated is both a production management opportunity and responsibility. However, if the definition of what needs to be done is defined in terms of control technology, the functionality and benefit is often obscured by complexity and terminology of the technology that is being described. If the definition is only in terms of perceived production requirements, conversion to technical solutions is less than precise and, at best, an art form. In either case, a gap exists.

Standard terminology and intuitive models

S88 provides standard terminology and intuitive models that are relatively easy to learn and are an enormous help in closing the communications gap between control professionals, process specialists, IT specialists and production management. The models and terminology provide an essential link between the functionality needed to make a product and the technical options (manual, as compared to control system and associated instrumentation and) that can be used to implement those functions.

Management participation in automation decisions

With easily understood models and common terminology, as the working tools, a production manager and other stakeholders can participate fully in the definition of the

[1] ISA, the Instrument, Systems and Automation society sponsored the creation of the S88 and S95 standards and supports the expansion and development of industrial instrumentation and control expertise for process and other industries.

optimum level of automation. With management involvement in the process, what needs to be automated is much more likely to be established precisely. A good decision about whether automation should be an immediate priority or should be deferred for future consideration is also more likely. It is especially helpful with one of the most difficult judgments in any automation assessment — exact determination of what *doesn't* need to be automated at all.

An optimum level of automation can only be realized by clearly identifying the functions a person does best, the functions automation does best and the relative benefit of automating a given function. That is best achieved with the participation of the managers and supervisors responsible for operating the process. It is unusual for an independent engineering viewpoint or operations viewpoint alone to settle on the optimum. Together, they can do a better job, but they have to communicate clearly. Engineering technical language (sometimes called “geek speak”) and management generalities (sometimes called “big picture” or “bottom line focus”) are barriers to this kind of interaction and too often have resulted in vague requirements being “tossed over the transom” followed by dismay about how much the whole thing (projects, operations, and maintenance) is costing without ever dealing with fundamental factors that affect cost and benefits.

Focused on Batch – but concepts apply to most manufacturing processes
S88 focuses on automation of batch processes – one of the more difficult manufacturing automation challenges. To accomplish this, it had to deal with the way real-life production processes actually operate. Since batch processes require nearly all of the fundamental types of control needed in almost any manufacturing process, it is not surprising that the general principles apply not just to batch, but also to a significant number of other manufacturing processes. This is especially helpful where batch manufacturing interacts with other types of manufacturing processes, a common occurrence.

S88 - WHAT IS IT?

Given that it is the major focus here, what precisely is S88? As mentioned before, S88 is a combination of five documents, only three of which have been published. Of the three in publication, the first part entitled *Models and Terminology* defines most of the important concepts the standard contributes to manufacturing automation. The technical content of part one is not particularly difficult to understand, but it is more extensive than can fit the scope of this paper. Rather than a tutorial on S88 technology, the focus here will be on what S88 is and where it is useful or, perhaps, essential.

The committee that wrote the standard realized that a common set of terms would be needed to even start work on the standard, so terminology was addressed first. However, names can only be applied to things, methods, functions or concepts that are understood. At that time, much if not most accepted terminology was related in some way to commercial products, most of which differed significantly from supplier to supplier. The converse was also true. Features or functions common to multiple suppliers had often been assigned unique proprietary names. To make matters worse, many of the concepts the committee found important had no accepted name at all.

To solve that problem, several conceptual or functional models were created. The models are general so that they can be used to represent almost any batch manufacturing process and are intended to be valid no matter how control is actually implemented. Terms were then matched up with elements of the models. This might sound terribly abstract and a little inaccessible, but neither is true. Once the basis is understood, the models are intuitive and the terminology is easy to apply to any physical process.

Terminology

The purpose of the standard terminology was to provide a common language free of techno babble. Where words in common use could be applied, they were. Where more than one word in common use meant the same thing in the context of the standard, either one of the words was chosen or a more appropriate term was found. A difficult part of the exercise was finding the best term to use when naming a concept that had never had a name. The goal was to arrive at a common language that would allow people to communicate clearly and unambiguously with each other — engineers with other engineers and specialists, engineers with suppliers, managers with both, etc. The committee came pretty close. The terminology provides an adequate way to communicate concepts as well as references to tangible components of control, automation and process elements.

Models

The models are intended to provide a generalized view of the manufacturing process. To be useful, they have to be abstract enough and flexible enough to fit essentially any batch process and still be detailed enough to represent reality. Given the diversity in batch processes, this resulted in models that fortuitously also fit most other manufacturing processes regardless of type. The models that resulted serve their purpose well. They are able to establish a basis for modularization and allow unsynchronized activities in a manufacturing facility to be visualized and understood. They represent required functions in each part of the process and identify the relationship between the various parts.

Structure and understanding

It seemed fairly simple to begin with. Draw up some models, plug in some terms and go on to the important stuff. However, something awkward happened on the way to the models. In order to create them, it was necessary to really understand and properly represent almost everything that goes on to make a product in a batch process. That ended up requiring five years in which up to 50 batch manufacturing experts met for several days every month or two to define a much more perceptive view of the organization of manufacturing equipment and the hierarchy of control functions needed to cause that equipment to make product. The committee ended up with a structured view of manufacturing function that is much more complete than many expected. Concepts like the need for modular groupings of equipment and control, the meaning of recipe, the importance of the schedule, the inherent layering of control functionality, etc.

were fitted together to create an internally consistent and structured view of essentially any batch manufacturing process. It became the accepted road map for batch automation.

Other parts of the standard

Models and Terminology was the seminal work of the committee, but other parts have followed. Each has its own purpose and focus. They are outlined below:

Part 2 - Data structures and guidelines for language

Once the structure of manufacturing equipment was understood and the control functionality required for each was defined, the movement of data from one module to another and the relationship of the data generating functions had to be defined in detail. This part of the standard is generally of minor interest to engineers implementing manufacturing automation and of no interest at all to production managers. It is, though, of interest to suppliers who need to provide systems with the required functionality. It had to be done to close the loop.

Part 3 - General recipe structure

Part one of the standard defined the concept of a “General Recipe” that could be used to specify how a product is to be made, but in a form that is totally equipment independent and will allow a single recipe to apply across multiple manufacturing plants, each with different equipment and equipment arrangements. Part three of the standard further defines the general recipe and the methods needed to convert it to a form that can be used in a specific control system in a specific plant. This part, also, has been published and is in limited use in a few installations. Its use is expected to increase significantly as integration of control and business systems becomes more common.

Part 4 - Batch Record

This work is not yet finished as of this writing, but is intended to define the relationships of historical data elements in a way that will facilitate verifiable long term storage and retrieval of data generated during the execution of individual batches. It should be applicable to any batch process and will have immediate applications in pharmaceutical and other regulated industries.

Part 5 - Application of S88 Principles to include and connect with other types of manufacturing processes

Part five of the standard is also under way. It is of particular interest because the team includes packaging machinery experts from the Make2Pack effort to standardize packaging machinery control and the application of S88 principles to entire packing lines. It is intended to define the interconnection of control entities such as a batch control system with packaged third party equipment. One of the important issues is the extent to which S88 principles can be applied to other types of manufacturing.

WHY IS S88 IMPORTANT?

S88 is important for several reasons but is best known because it has been proven to deliver measurable benefits when properly applied to define and implement batch process automation. Those and many other benefits are the subject of this and following sections. Naturally all benefits come with some cost and the use of S88 is no exception. The primary cost in the case of S88 is the time that needs to be dedicated to learning what the standard teaches and how to use it. In the case of a production manager, the time required to start participating may be no more than an hour or two. Others, who must learn the technology as well as the principles, will spend more time, perhaps a week or more. The time spent is definitely worth the effort, but it is necessary to invest that time in order to derive the benefits that are there for the taking.

The fundamental difference between traditional control and control as outlined in S88 is that S88 adds control of procedure and a level of coordination control necessary to keep multiple procedures sorted out. The concepts that are spelled out in terms of a batch manufacturing environment are consistent regardless of whether the control is provided manually or automatically. It treats control as a function that causes equipment to do the things necessary to make a product – no matter how that control is achieved. Manual control is best or quite appropriate in many cases; automatic control is better in others. S88 works with either case, or both. It is based on the premise that whether a function is controlled manually or automatically it is the function that is important. This is particularly important in modern manufacturing approaches where there is usually the need for smooth integration of manual and automatic control activities. Few plants actually run all night with the lights out and people are a long way from being obsolete.

More traditional control systems usually deal mostly with basic single point control that sets and maintains process conditions like a flow rate or the position of a valve. Human operators set the control of individual items to the proper condition. In that case the people are providing procedural control manually. There is nothing wrong with this and it has worked well for many years. However, there are usually benefits to be gained by automating at least some of the procedural control in a manufacturing facility. Unlike earlier approaches to automated procedures, the S88 concepts remain the same whether they are automated or not and even define some of the functions a person needs to provide when they are providing the needed procedural control.

Recognizes all types of control

Manual or automatic, there are three specific kinds of control needed to make most products – basic control, procedural control and coordination control. S88 recognizes all three. Some of them may be hidden, but they are always there; they just need to be recognized. In a manually controlled plant, people just intuitively take care of whatever needs to be done. The complexities that need to be recognized for manual and automatic control to coexist are of little concern. For example, if a schedule is not provided to a human operator, he or she will scout around or call someone or run him or her down in the break room and get what is needed. An automation system can’t do that so providing a schedule becomes a higher priority in an automated environment.

Has models and descriptive means to help design jobs & responsibilities

Coordination is a less obvious type of control that is, again, intuitively obvious to a person but important to recognize in an automated system. A modern automation system is a form of tame computer and no computer has a sense of humor or intuition. People have both. The sense of humor may not be terribly important to a process but the intuition, as the commercial says, " … is priceless". To a human operator, coordination of a procedure is so natural they seldom think of it as coordination or control. People are a lot smarter and a lot more intuitive than a computer and they generally won't initiate two conflicting control activities at the same time because they inherently know better. Automating that same activity requires specific coordination that must be included in the control to guard against the difficulties that humans automatically avoid. That becomes particularly interesting when manual and automated control coexist. At any given time for any specific activity, either the operator is in charge or the control system is in charge and both need to be quite certain about which is which.

Automation, by its nature, defines the role and job of each operator. To that person a change in responsibility can be a wrenching experience so it is good to make sure we know what we are doing to the people at the same time we are deciding what the people ought to do to the equipment. The last thing we want to do without careful consideration is to change a job so that it is harder to do right or more stressful after automation is added than it was before the change. S88 makes such a situation easier to spot with guidelines that stay consistent for both manual and automatic control. Considering the possibility of automating any function obliges the person, who is doing the considering, to think through exactly what has to happen in exactly the right order and then think through what could go awry at any step in the procedure. Of course, exactly the same considerations are, or should be, of concern with manual control. We generally let the operator work those things out, but S88 helps identify what must happen so it is easier to determine what the operator's job is and how much (if any) of it needs to be spelled out to him or her and how much the person's current job description is affected. Dealing with the human aspects of automation is only one of the reasons that determining the optimum level of automation is not purely an engineering effort.

What to automate - What NOT to automate

When it comes to a decision about what to automate, S88 provides some important help. We know that a human being with intuition is better at any activity that requires unscripted evaluation. In a manual plant, they may also have to do things that they might not do nearly as well. Whatever the task, people usually try to do a good job and actually achieve that 98% or more of the time. Logically that also means they are wrong up to 2% of the time, which is not usually a good thing. None of us mean to be wrong, that is just the way people are built. We also take more than two or three microseconds to recognize that something needs to be done and then do something about it. For those kinds of control tasks, an automation system might well do a better job. To make an informed decision about whether automation is indicated or not depends on what the task is and where it takes place. The modular S88 structure helps to understand it.

By its nature, procedural control requires modules of equipment tightly tied to the control that gives it life. This is true whether the equipment is a simple on-off valve or a complex assembly made up of smaller modules of equipment. A system or person executing a procedure needs to "know" what he, she or it is controlling, what needs to be done and which subordinate modules are theirs to command. This modularity, with associated control, forms a basis for determining what should be automated. Since each module has a function or functions, the decision can be made on the basis of whether manual or automatic control will be better in that module, what the automation would need to accomplish in each case and if the activity happens often enough or is important enough for automation to be warranted. Breaking the tasks into "S88 modules" simplifies that decision making process enormously. The consideration may also make obvious what procedures a human operator should follow if the module is not automated. Some of those manual procedures can be critical and may need to be well documented.

Separates product specific procedures from equipment tasks

Many approaches to procedural control have been implemented over the last many years with varying degrees of success. One example is a large drum-like machine that was common many years ago that rotates in steps, tripping multiple switches at each step that activate pumps and motors and valves as the sequence progresses. More recently there have been computer-based systems that mimic the drum programmer. Even more recently, programmable controllers that sequence a process using ladder logic or sequential function charts have been popular. All do a job and some are quite satisfactory, but most have the same constraint – the procedure is fixed and hard to change.

A fixed procedure works fine when there is only one and it never changes. The problem is that most processes do change, either frequently as new products are added or more slowly as process improvements are identified and implemented. Since most of the early efforts tended to put all control in one pot, it led to a condition called "spaghetti code" where changes to the changes that had already been changed left control code that not even a mother could love. They were difficult to maintain and were necessarily redone or modified any time a new product was added or an old one was changed. This resulted in significant downtime and disruption. It also required long lead-time. It is not surprising that many of these "automated" facilities ended up being run in manual mode.

Manufacturing process changes are necessary

Whether it is a tweak to the way a product is made or the addition of an entirely new product, change is frequent and is daunting when it is necessary to get a control engineer involved any time there is a product-oriented change. At the same time, there are many aspects of a manufacturing process that seldom change – the process-oriented tasks that remain the same no matter what is being made. If a task is designed to charge material, for example, it is probably best to charge material the same way every time regardless of the product that is being made at the time.

Recipes can be written by product experts

S88 leverages the infrequent changes to process-oriented tasks and separates them from product processing information. A recipe then contains all of the remaining information needed to make a product. That recipe is used to orchestrate the sequence in which process-oriented tasks are executed and provide the values they will use for such things as amount, rate, pressure, etc. Most process changes can be made in recipes that can be written by product experts who understand the process but are not necessarily expert in control. This allows control experts to design and execute the process-oriented tasks and for the equipment control to be effectively locked away in a controller while the robust and much less complex recipe can be executed in another part of the system. It is a powerful concept that definitely helps keep an automated plant running in automatic (at least the parts that ought to be automatic). As technology has advanced, the level of control that can be accomplished has shifted more power toward the controller. What will be done in the controller in the future remains to be seen.

Direct benefits are significant

Not only can process experts make changes without having to filter what they need through a control expert, new product introduction is smoother. It gets around another issue we don't like to talk about. Direct equipment control is complex and unforgiving. Any change to control at that level provides an opportunity for a control expert to leave a bug that may not be obvious until much later – usually at the worst possible time. Being able to make minor changes in the way the process operates without having to change control code that directly affects equipment is a big plus.

Secondary benefits may be even more noteworthy

Separating the recipe from equipment control requires that the recipe address specific modules of equipment that "know how to" carry out the processing tasks specified by the recipe. S88 recognizes that these major modules of equipment are made up of smaller functional modules that serve as building blocks. The concept of modules of equipment with dedicated control enhances the chances of identifying standard modules. Standard modules pay off, especially when designing new systems because they can be reused and don't have to be redefined, recoded and tested each time that kind of module is needed. They also pay off in production costs because modules that reliably do the same thing every time improve process reliability and reduce maintenance and training cost. More complex functions can also be built by combining basic "building blocks". This is a proven way to achieve a major reduction in engineering effort and cost for a project. It also contributes to more predictable project schedules and major reductions in lead-time.

Function definition is independent of technology of-the-day

With S88, the analysis and design of automation requirements are not specific to the control hardware and software to be used for implementation. This is particularly important in a world where rapid advances in computer and control technology can make today's best system obsolete in a few years. S88 focuses on the manufacturing process and its requirements rather than on the implementation technology. Manufacturing process requirements are usually constrained by the capability of the process equipment and seldom change while control and electronic technology changes frequently. Work based on manufacturing process function is highly reusable and allows upgrade to new control technology without having to redesign the way the manufacturing process works. The detailed coding of a new control system may need to be redone, but there is no need to start again from scratch. The control system industry is making code generation easier and easier as long as what that code needs to accomplish is precisely defined. The most vital issue in the implementation of any control system is not the detailed coding but the clear definition of process requirements. Such definitions fit quite nicely in "S88 aware" control products.

Integration with business and other electronic data systems

A standard approach helps ease another perennial automation problem – the integration of a control system with other control and business systems. If control is defined in a reasonably standard way, then the context of the data that must be exchanged with other systems is reasonably consistent. This is important because moving data is not difficult – moving information is. Without structure, the data becomes an increasingly deep pool of numbers without a central thread to tie it together. One can extract information from this pool of numbers but without structure that process is difficult and usually requires custom software.

Buying software is usually preferable to writing your own

With a standard approach, it becomes possible to more easily create software that can be applied across many different applications. That makes it attractive for suppliers to market standard software that can be purchased and configured without the need for custom programming. This can make a big difference in the cost to implement and maintain data exchange or acquisition software. Since the S95 Enterprise-Control System Integration standard will provide an interface to S88 structured control systems, integration of S88 structured control systems will be greatly simplified.

Integration of control system components

It is also much easier to integrate auxiliary control systems and equipment if all of the systems are using the same standard approach. Commands and expected responses from system to system are more likely to connect without extensive interface software or confusion about meaning. The WBF work with Make2Pack on the integration of packaging machinery is addressing this issue based on S88 modularity guidelines.

S88 principles and benefits can be broader than batch

There is something to be gained by addressing control uniformly across a plant or a company. It is not only possible but has advantages. It reduces training and makes maintenance of systems more consistent. It allows the same sort of modules that work in a batch process to be used in other applications. For example, the same modules of equipment used in a batch process to move material are likely to be used elsewhere in the plant to move material from place to place and, perhaps, to store material. Any time the same equipment and associated control can be reused there is a saving. Clearly, the best way to save engineering cost is to not have to do the engineering – just reuse something that we already know will work. There are other obvious savings in training, spare parts and maintenance.

Although the standard was intended for the batch industries and is written in specific batch oriented terms, the principles it espouses have been applied in other types of manufacturing. The Make2Pack work mentioned above focuses on discrete packaging machinery. Other applications of those principles in continuous processes have been described in WBF conference papers. A continuous process, after all, looks very much like a batch process during startup, shutdown and other production shifts like grade changes. Since S88 batch control is built on the foundation laid by the continuous and discrete control communities, a batch approach is not alien. However, traditional continuous control functionality is usually not complete enough for batch or for automatic control of startup and shutdown. Controlling such activities automatically requires control functions that many continuous and discrete processes often get along without. Automating that kind of activity requires the ability to deal with a sequence of procedures – just like batch.

Procedural control activities in a continuous process take place when operating conditions are being changed. The rest of the time the goal of a continuous process control system is to keep any changes from occurring. Whether it is worthwhile to consider automating startup or shutdown of a continuous process depends totally on the process in question. However, it is true that many of the problems that occur in complex continuous processes surface during startup or some other change in the operating target. Does this mean that older continuous control systems should be replaced? If they are doing the job, of course not, but it is good to remember that S88 may well provide the conceptual tools and management mind-set if a higher level of automation is a consideration.

BUSINESS RISK

ISA S88 is not a new adventure. It is a well-grounded and consistent roadmap based on internally consistent models and a common vocabulary for unambiguous communication. It is broadly and actively in use in industry with all of the support that brings. It now has more than a ten-year track record and is recognized & well accepted in the control community. Most of the batch control systems available today are based on the standard and ISA, WBF and others offer training programs.

WBF is of particular interest because it was founded as a professional society specifically to support S88. In addition to S88, it now supports the exchange of information about related standards and issues such as S95 and S99. It provides an open forum where manufacturing and automation professionals can network with people who have "done it" and discuss what has worked for them and what was a problem. There are active groups in many countries – France, Japan, Hungary, Netherlands, South Africa and other countries. ISA is another resource. It is the organization that sponsored the standard and it also provides support including training courses for both engineers and technicians. In addition, there are books, case studies, tutorial papers, and supplier sponsored training available. A company undertaking a program of S88 based control in today's world is not alone.

BUSINESS BENEFIT

Because the S88 methodology allows production management to have a much more interactive role in defining what needs to be automated and, very importantly, what doesn't need to be automated, it enhances management control of capital investment. It simplifies engineering design and allows an overall automation plan that can be implemented in stages. Whether Automation follows an 80/20 rule or a 70/30 rule in a given instance, the standard's modular structure lends itself to modular projects when time, capital or need does not support larger projects.

A working understanding of the S88 models is, by itself, a useful management tool, providing an approach to conceptualizing a dynamic manufacturing operation and understanding its inner workings independent of the details of equipment or staffing. The standard has also been proven to facilitate clear definition and communication of requirements and to save money in control execution. More importantly, it provides a guide for automation that reduces variability in the manufacturing process and greatly enhances predictability. The improvement in predictability is a prime requirement of better scheduling. Coupled with the better integration that S95 will bring to compatible systems, the better scheduling and better response to demand can very pragmatically have a significant impact on inventory levels and inventory turns and the potential for reducing working capital. Of course, S88 doesn't do scheduling but it definitely increases the precision and accuracy with which schedules can be created.

CONCLUSION

The ISA S88 Batch Control Standard is a recognized, accepted engineering guideline and a frequently overlooked management tool.

It can serve as a common language for engineering and operations management to better understand and manage manufacturing automation requirements and benefits.

It is an internally consistent standard for automation that reduces the engineering cost for automation.

It is a tool that can be used to identify the appropriate level of automation and to control capital investment.

It is a powerful tool for operations managers and engineers with many benefits, but there is a learning curve: short for managers; longer for engineers — a low risk investment with an immediate payback. This can be witnessed from its extensive application in the field.

It is compatible with the ISA S95 standard and through it will be able to interface with manufacturing IT and corporate business systems providing better manufacturing data, faster response to business needs, better scheduling for faster inventory turns and a consequent reduction of working capital.

Appendix

STANDARDS IN MANUFACTURING

Most people, if questioned, are at least vaguely in favor of standards and consider them generally beneficial. A person responding to this kind of casual question, though, seldom considers the number of standards we accept without conscious thought. Many of the real benefits of standards are often so obvious they are not even recognized. Law defines some standards; some are defined in the marketplace; others are generated by standards writing bodies; while others are "just there" and are seldom considered one way or the other. For example, were Beta or VHS tapes better? If that question even has an answer, it is no longer important. The public voted with their dollars, VHS won, defined the accepted standard and few worry about it. Also one can watch a long railroad train pass and never wonder how all those boxcars from different rail lines can hitch up and roll along without a problem. Likewise we seldom think about the fact that we can rent a car in any airport in the North American continent and find the pedals in relatively the same location even if we can't figure out how to turn on the headlights. Our thoughts are more likely to be "someone ought to do something about the headlight switch".

In most cases, there is little doubt that standards do some good. Just think how expensive it would be if we had to design a screw every time we needed a fastener. Most of us just use or specify something like a 6/32 screw without much thought about how that became a standard. That is a good example of an accepted standard. Once they are accepted, standards seem to disappear. They are just there like the brake pedal in a car. In the manufacturing industries, though, standardization usually has to be more overt.

Eli Whitney and musket manufacture

In 1798, Eli Whitney revolutionized the way muskets were made by making standard parts that were interchangeable and could be assembled without modification. The first 10,000 muskets he made defined the future of mass production. From that time forward, standards have been an important part of industrial life. So why is it difficult to implement them?

Standards often resisted initially

Standards are frequently resisted at first, sometimes for good reason. Standards generally define the right way to do something unless there is a compelling reason to do something else. New standards are often suspect and few people are so doctrinaire that they follow standards even if they think it means doing something dumb. Standards that are inherently bad or are improperly used obviously fit the definition of dumb. However, "good" standards may also be resisted. Even if a good standard is properly applied, is in place and is endorsed by whoever does endorsing, an additional forcing factor is frequently needed. A demonstrable and compelling reason to adopt a standard is often the kind of forcing factor needed to convince people to accept it. Without the forcing factor, some people will never adopt a standard and will find all sorts of reasons to go their own way. Most people are reluctant to accept constraint if they see it as reducing their options. Engineers tend to want to design the "perfect" application and a standard may well seem too constraining. Also, few really like to change the way they do things if past results seemed adequate. On top of that, many commercial interests strive for "differentiation" which can fly in the face of standard approaches. There are many barriers to standardization but, even if resistance is strong, the benefits usually outweigh the difficulties. Perseverance is necessary.

Acceptance rapid beyond the tipping point

In spite of initial reluctance, individual acceptance of a standard is usually quite rapid once the general level of acceptance reaches a tipping point. At least two factors drive acceptance toward that crucial point. A third makes it easier to accept once it is there.

A new standard has to be well understood. It is hard to endorse and believe in something you don't understand. In the case of a standard that covers as much ground and has as much depth as S88, that requires some study. The S88 models are intuitive and the terminology is not really all that hard to learn, but to get a full appreciation of the power of the approach requires that someone invest enough time to gain a fairly complete understanding of the letter and intent of the standard. If you remember learning to ride a bicycle, the first two or three turns around the block were not that easy but very shortly you were flying. Once someone in the team really understands the standard and the proper approach to its use, the rest of the team can quickly learn the rudiments and dive right into the hard part – in the case of S88, optimizing the manufacturing process. Climbing the learning curve of anything new is not cheap so, no matter what standard is being considered, it is best to make sure it provides benefits commensurate with the investment of time required to understand it.

The second factor of importance, then, is a clear understanding of the benefits to be gained from the adoption of a new standard. Not only do the benefits need to be clear, they need to be believable. That is difficult if a standard is new. After all, if you are the only one following a standard it is hardly a standard, so if it hasn't been adopted broadly you are flying on faith. It is much easier to identify and accept a good standard if it is in broad use and it is possible to see the benefits others have realized and the problems they have had. The third factor that provides comfort and believability then, is broad acceptance.

The primary benefits of any standard

The primary benefits of any good standard are manifest. It should reduce cost of something or the time it takes to do something or to design something or should improve some factor in manufacturing like quality or should otherwise make life less complex or should make it better. Since it began life as an engineering standard, for example, the primary benefits of a standard like S88 should be seen in reduced engineering costs, faster project execution and improved operating capability and costs. As it happens, those benefits exist.

Several less obvious benefits

In addition to the primary benefits, there are several less obvious benefits that can accrue from adopting any standard. Compared with one-of-a-kind items, standard items ought to cost less and be more reliable and, since they tend to be used over and over, by repeated use we should gain enough experience to know what to expect and how best to deal with them. In the real world of automation that often means the ability to reuse engineering or applications. That generates two subsidiary benefits – not only can the need to design the software again be avoided, we are also more likely to eventually get it right. The same engineering application gets used over and over gets refined to the point that it is virtually bulletproof and very reliable. In the case of standardized objects, the benefit can well be available, interchangeable and reliable spare parts. One would also expect a standard to reduce the number of trips through the learning cycle, not only for the adopter, but also for anyone using the standardized item or method.

STANDARDS FOR MANUFACTURING CONTROL AND AUTOMATION

There are many standards that are or can be associated with control and automation ranging from standard symbols for drawings to standard control languages such as Sequential Function Charts and function blocks. Within the world of manufacturing automation with its associated computer technology and requirements for interchange of data and other information, there are four relatively new standards of particular interest.

S84, officially ANSII ISA84.00.xx (IEC 61508)

This family of standards is mainly concerned with safety in control and auxiliary systems. It is primarily of interest to Control & Safety Engineers. The international (IEC[2]) version is written in 8 parts, all now complete or nearly so.

S88, officially ANSI/ISA88.00.xx (IEC61512)

This standards family is mainly concerned with procedural control, automation and associated issues for batch and related manufacturing processes. It is primarily of interest to Control Engineers, Production Managers and manufacturing specialists. Five parts are planned; three of them are complete.
The first two are published internationally, all three in the US. Most references in this paper are related to the first part entitled Models and Terminology.

S95, officially ANSI/ISA95.00.xx (IEC62264)

This standard is mainly concerned with definition of Manufacturing Operations Management functions and integration of control & operations information with business systems. It is primarily of interest to Control Engineers, Manufacturing IT practitioners & Production Managers. Five parts are planned; three are complete although only the first two have been published as of this writing.

[2] IEC is the International Electrotechnical Commission, an international standards writing and endorsing body.

S99, officially ANSI/ISA99.00.xx

This standard is mainly concerned with security of manufacturing operations, control systems and communications. It took on more importance in the wake of 9/11 terrorism threats. It is primarily of interest to Control Engineers, Safety Engineers and IT practitioners. Two technical reports have been issued as preliminary documents and full standards are in progress.

Why focus on S88?

All of the new standards are important and affect the implementation of control and automation, but S84 and S99 are specialized areas of engineering concern and are more or less separate considerations in that they do not deal directly with the determination and implementation of manufacturing functionality. It is important to recognize that both of these standards are important and are only of less interest in this paper because they do not significantly overlap with the S88 standard.

S95 models integrate with S88

S95 does overlap with S88 and must be considered, but as an additional issue and opportunity. It defines the connection between the S88 production equipment domain and the business enterprise. S95 is a very important step forward and likely will determine the future of manufacturing information integration. It will, by definition, be compatible with S88 and a major benefit when implemented, but it will not change the fundamental principles of the S88 standard or the topics covered herein. At the point where raw materials are changed into something else, S88 is the pertinent standard and the primary focus of this paper.

Broadly accepted in batch manufacturing

The first part of S88 was published in 1995 and is accepted to some degree in most batch manufacturing industries. The first adopters of S88 methodologies were in the specialty chemical and consumer products industries. The pharmaceutical industry began adoption of the methodologies a little later but has now almost universally adopted the standard. There is also considerable interest in the food and beverage industries.

The standard is unabashedly focused on batch manufacturing but clearly has potential benefits in discrete and continuous processes as well as material storage systems. There are many documented continuous process implementations in WBF[3] presentations and papers as well as proposed ways the standard can be interpreted for other types of manufacturing. The application of S88 principles to packaging machinery lines is the basis for the WBF/OMAC sponsored Make2Pack initiative.

[3] WBF, a contraction of the original name “World Batch Forum”, refers to a professional society dedicated to S88, S95 and the sharing of information about and application of these and other manufacturing standards to the benefit of manufacturing professionals and industries.