Integrating ISA-88 and ISA-95

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ABSTRACT

ISA-95 is the international standard for the integration of enterprise and control systems. Many of the SP95 committee members have also been active in developing the older ISA-88 standard for batch control. So it's no wonder that the models and terminology in the two standards closely mesh. ISA-88 contains models and terminology for controlling batch processes. The models provide a hierarchical and modular categorization for the machines and devices that carry out the process, and for the recipes that describe how to manufacture the product. They form the basis for managing the production process and thus ensure standardization within batch process automation.

The standards differ in terms of their purpose, which means manufacturing companies will increasingly make use of both standards. They will use ISA-88 for automating the control of machines and devices, and ISA-95 for the exchange of information between ERP and MES systems.

MES software users and developers in particular must choose when to use the ISA-88 models and when to use the ISA-95 models. This paper aims on offering more clarity on the situations for which each standard is most suitable. It is based on the experience of the ISA-95 competence centre of Ordina, in applying the ISA-88 and ISA-95 models for specification of user requirements, functional requirements and for development of a software layer between batch oriented MES solutions and ERP systems, in order to reach 100 percent of integration.

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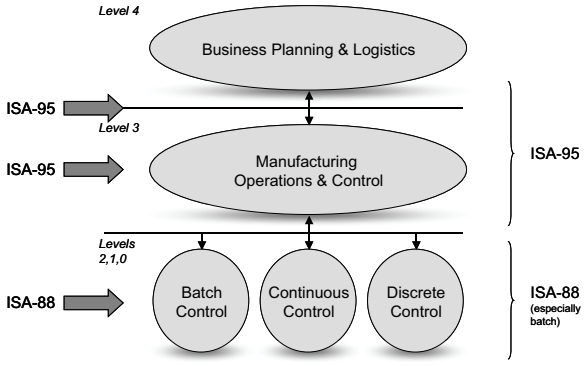

Figure 1: Comparison of the scope and focus of ISA-88 and ISA-95

Introduction

Many of the SP95 committee members have also been active in developing the older ISA-88 standard for batch control. So it's no wonder that the models and terminology in the two standards closely mesh. The standards differ in terms of their purpose. ISA-88 was developed for the control of batch processes (and it is often used for the control of discrete, continuous, hybrid and storage processes as well). The first two parts of ISA-88 completely focus on the level of the Process Cell and lower (see figure 1 & 2). Note that a manufacturing company that applies ISA-88 could also apply ISA-95 at the same time. ISA-95 focuses on the exchange of information between level 4 (Enterprise, Site) and level 3 (Area). In other words: ISA-95 is a standard for the integration of enterprise and control systems. It standardizes the information that is exchanged between ERP systems and MES systems.

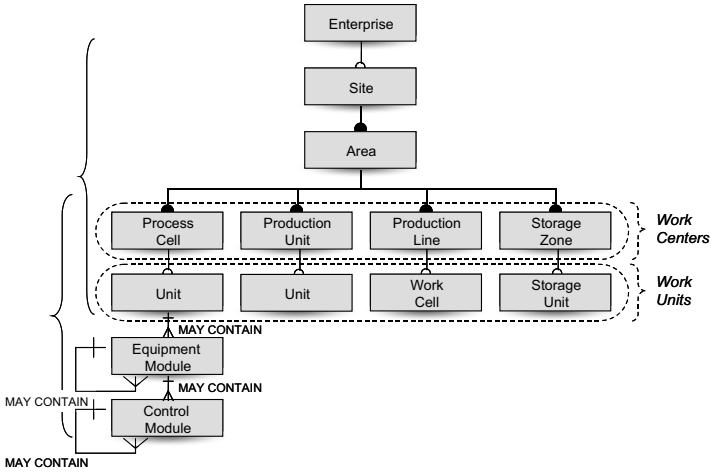

Figure 2: Integrated view of ISA-95 and ISA-88 equipment hierarchy models

For the first two parts of ISA-88 the Process Cell is the *highest* level of interest, whereas for ISA-95 the Process Cell and Unit are the *lowest* levels of interest. So there is an overlap between the two standards, which suggests that there will be collision points in the use of ISA-88 together with ISA-95.

One example of a collision point is the following: Both standards pay attention to the information that defines how to produce a product. ISA-88 defines a Recipe Management activity and it defines General, Site, Master and Control recipes. ISA-95 defines a Product Definition Management activity on level 3 and it states that Product Definition Information is exchanged with level 4. What is the difference between the ISA-88 concept of Recipes and the ISA-95 concept op Product Definitions? In which situation is one standard more appropriate than the other?

Both standards also pay attention to the information that reports what happened during the production process. Part 4 of ISA-88 defines Batch Production Records. Batch Production Records contain information about the production of a batch. ISA-95 defines Production Performance Information, which may also contain information about the production of batches. This leads to the same basic question again: What is the difference between ISA-88 and ISA-95 and in which situation is one standard more appropriate than the other?

Comparison of models

Before taking a look at the every day work of end users, consultants and software developers, in which they encounter challenges in the use of ISA-88 and ISA-95 together, let's first compare some of the standards' models on an 'academic' level. The collision points described in the introduction become clear when comparing the following models and concepts of both standards:

ISA-88 model / concept	**ISA-95 model / concept**
Physical model	Equipment Hierarchy model
Control Activity model	Activity model of Production Operations Management
General, Site, Master & Control Recipes	Product Definition Information & Product Definition Management
Batch Production Records	Production Performance Information & Production Data Collection & Tracking

Table 1: ISA-88 models and concepts compared to ISA-95 models and concepts

88's Physical model compared to 95's Equipment Hierarchy model

Both standards contain a model that can be used to structure the physical assets of an industrial company and its organizational or geographical parts into hierarchical levels. As said before, the first parts of ISA-88 focus on the control of the process that takes place within a Process Cell. Process Cells, Units, Equipment Modules and Control Modules are essential concepts for realizing this control. The ISA-88 Physical model only contains the Enterprise, Site and Area level to properly identify the Process Cell and the lower levels.

The SP95 committee decided to take 88's Physical model as a basis and to extend it with terminology for discrete processes, continuous processes and storage. For ISA-95 the levels of the Equipment Module

and Control Module are out of scope. That is because ISA-95 focuses on the exchange of information between ERP systems and MES systems. An ERP system may, for example, provide a production schedule. If this schedules the activities within Process Cells and Units, then it would be an extremely detailed schedule for an ERP system. ERP systems will never schedule the even more detailed level of Equipment Modules or Control Modules. The same is true for the reporting functionality of MES systems. MES systems may provide information to ERP systems about the activities that took place within a Process Cell, or even within a Unit. But information about the activities of an Equipment Module or a Control Module will be too detailed for ERP systems. ERP systems are looking for aggregated information, not for a flow measure every second. That's why the Equipment Hierarchy model of ISA-95 does not explicitly mention the Equipment Modules or Control Modules defined in the Physical model of ISA-88.

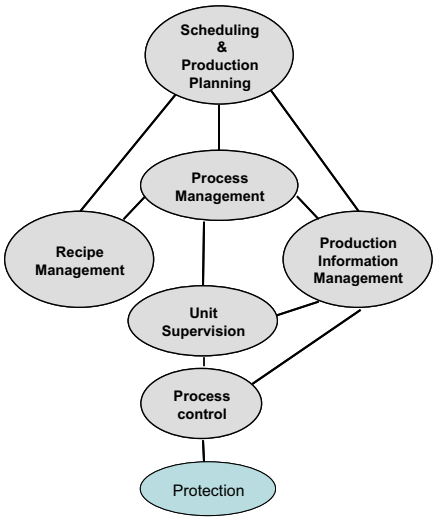

Figure 3: Activities in the ISA-88 Control Activity model

88's Control Activity model compared to 95's Activity model of Production Operations management

Part 1 of ISA-88 contains the Control Activity model (see figure 3). It defines the activities that have to be done in order to prepare for batch processes, execute batch processes and report about batch processes. Parts 1 and 2 of the standard focus on the activities called Process Management, Unit Supervision and Process Control. Part 3 of the standard focuses on the General and Site Recipe part of the Recipe Management activity and part 4 of the standard focuses on the Production Information Management activity by defining the standard structure and attributes of Batch Production Records. The Production Planning and Scheduling activity of this model is not addressed by a part of ISA-88 nor will it be in the future.

Note that this activity model of ISA-88 was made before the existence of the ISA-95 standard. At the time when the SP88 committee developed this Control Activity model, they considered the Recipe Management activity, the Production Planning and Scheduling activity and the Production Information Management activity to be out of scope. They focused on the control of batch processes and only later did they decide to develop part 3 and 4. In the mean time ISA-95 got developed. ISA-95 part 3 defines activities (see figure 4) that can be compared to the activities in the Control Activity model of ISA-88 but '95 describes them in more detail. That is logical, because ISA-95 part 3 focuses on the definition of models and terminology for manufacturing operations management and does not consider these kinds of activities to be out of its scope, as the SP88 committee did when they developed the Control Activity model.

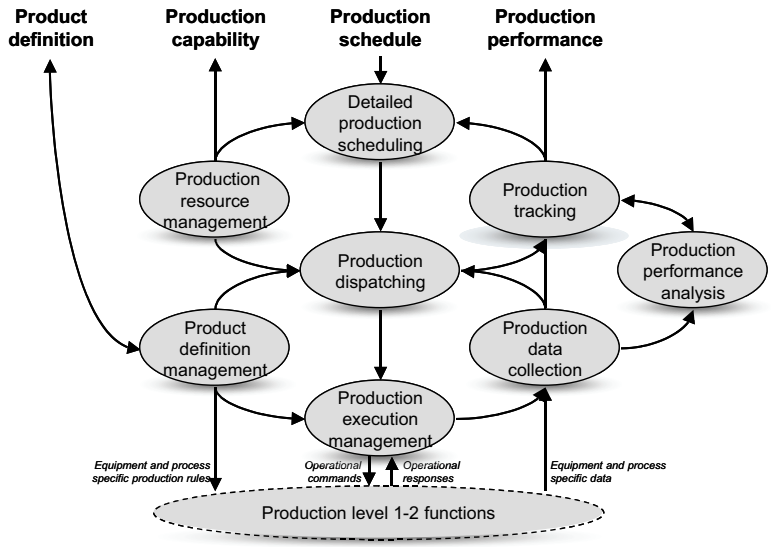

Figure 4: ISA-95 Activity model for Production Operations Management

When the SP95 committee developed the Activity model of Production Operations Management (see figure 4) they were well aware of the existence of the ISA-88 Control Activity model. But because of its scope, ISA-95 had to use terminology that was not typical for batch processes. The terminology should be more general, so it could be used for non-batch processes as well. Therefore this model does not speak of Recipe Management. In stead it uses the term Product Definition Management. Recipes are examples of Product Definitions, but so are SOPs and Assembly Instructions, which are not specific for batch processes. In other words: ISA-88 Recipe Management is a batch specific example of ISA-95 Product Definition Management.

All ISA-88 activities in the Control Activity model can easily be translated into the ISA-95 activities in the Activity model of Production Operations Management. The table below compares both models.

ISA-88 Control Activity model	**ISA-95 Activity model of Production Operations Management**
Recipe Management	Product Definition Management
Production Planning and Scheduling	Detailed Production Scheduling
	Production Dispatching
	Production Resource Management
Production Execution Management	Process Management
Production Information Management	Production Data Collection
	Production Tracking
	Production Performance Analysis

Table 2: ISA-88 activity model compared to ISA-95 activity model

Note: The ISA-88 activities called Unit Supervision and Process Control are out of scope of the ISA-95 standard

88's Recipe concepts compared to 95's Product Definition concepts

As said before, ISA-88 provides terminology for batch processes whereas ISA-95 terminology is more abstract and developed for use in all kinds of processes. Both standards provide concepts which address the information that defines how a product should be produced. The ISA-95 models make clear that there are several functions and activities within manufacturing enterprises that generate or exchange such information. For example there is a Research & Development and Engineering function. In batch environments R&D departments would typically develop ISA-88 General and Site Recipes and provide this information to Production and Engineering. This information will then have to be translated into ISA-88 Master Recipes which are equipment specific recipes. Such information exchange and translation is what ISA-95 calls Product Information (Management) in its Production Operations Management model, where the arrow makes clear that this information is exchanged with a higher level (for example the R&D department). Another arrow points downwards. In case of batch processes this could be the translation (copying) of a Master Recipe into a Control Recipes that is used during execution for the production of a single, unique batch.

In short, ISA-95 provides abstract models and terminology and the ISA-88 concepts and terminology can be regarded as batch specific examples of the 95 models and terminology.

Note that ISA-95 in general is focused on the exchange of information between level 4 and level 3. So its concept of Product Definitions, including Product Segments, was developed for the exchange of information between these higher levels. The ISA-88 concept of different kinds of Recipes with a standard structure was developed to simplify the translation of higher level Product Definitions (General and Site recipes) to lower level Product Definitions (Master and Control recipes). In the end the goal of ISA-88 is the control of the (batch) process whereas the final goal of ISA-95 is the exchange of information between level 4 and level 3.

88's Batch Production Records compared to 95's Production Performance Information

ISA-95 calls the information that is sent back to level 4 to report about production 'Production Performance Information'. This could be information about the production of a car, the production of drinking water, the production of pills, the production of steel, etc. Typically this information is reported to level 4 systems in order for the ERP system to adjust the amounts of raw materials, finished products, to account for labor hours, etc. It especially focuses on logistics, cost accounting, etc. The purpose of the ISA-88 Batch Production Record is different. It focuses on providing reports about a specific batch. FDA requirements were taken into account when this part of ISA-88 was developed. So the Batch Production Record model of ISA-88 is aiming at the development of reports about specific batches, whereas the Production Performance Information of ISA-95 defines the information that the interface between a level 3 and a level 4 system should contain. ISA-95 Production Performance Information could be information about more than one batch, or about a part of a batch, or it could be a report that does not focus on a batch but on a day of production, or on a shift. On the contrary, ISA-88 batch production records explicitly centre information around the production of a specific batch.

So much for the academic comparison of both standards. Much more could be said about that, but now let's focus on the every day life of end users, consultants, software developer and other people who are confronted with the choice between ISA-95 and ISA-88. What are specific issues that they encounter? From an academic point of view many differences and collision points can be pointed out. But which ones are the real issues?

Writing a URS

One of the purposes for which standards like ISA-88 and ISA-95 are used in practice is the writing of documents, like a URS (User Requirement Specification). The URS defines the requirements of the user for a new system. The concepts and terminology of standards help to write very well structured documents, in a 'standard' language. When writing a URS, the question comes to mind if the ISA-95 concepts and terminology provide the best fit for describing the requirements, or should that be the ISA-88 concepts and terminology?

Writing a URS for an MES system

When an end user (or a consultant) writes a URS for an MES system, this document should provide some background information about the company's processes and machines, in order to inform future vendors. As described earlier, both ISA-88 and ISA-95 provide models and concepts for the structured description of the equipment hierarchy and processes of industrial enterprises. The ISA-88 model provides more detailed levels (Equipment Modules, Control Modules) whereas the ISA-95 model provides extended terminology for continuous, discrete and storage processes.

From my own experience I learned that for a URS for an MES system the level of Equipment Modules and Control Modules is much too detailed. It may even be too detailed to describe every single Unit and every single Process Cell. When keeping in mind the purpose of this description (provide a basic impression of the company's processes and machines) usually a more general description is detailed enough. The table below shows the relevant levels for this description.

Enterprise	**Site**	**Area**	***Process Segment***	***Examples of* Units**
ABC Pharma	Baltimore	Liquids	Formulation	Reactors
				Weighers
			Packaging	Etc.

Table 3: The use of equipment hierarchy levels within a URS

Note that this table does not describe every specific Work Center (e.g. Formulation Process Cell 1, Formulation Process Cell 2, Packaging Line 1, etc). In stead it uses the ISA-95 concept or Process Segments. This way the processes can be described in general, without having to list every single piece of equipment or every single production line.

The level of detail will always depend on the purpose of the URS. If it is a URS for an APS (advanced planning and scheduling system) then you may want to go into more detail. But when it is a system for recipe management, then the amount of detail described above will be sufficient. When the URS does not specify MES functionality but Process Control functionality, then of course you should go into much more detail. In that case, the ISA-88 concept of Equipment Modules and Control Modules becomes highly relevant.

Writing a URS for a flowchart management system

Recently I had to write a URS for a system that (among others) generates and archives flow charts. Here I encountered a challenge in choosing between ISA-95 Product Definitions and ISA-88 Recipes. Although the functionality of flow chart generation and archiving can be considered MES functionality, it soon became clear that ISA-88 provided better concepts and terminology for this matter. The examples in the tables below make clear what is the advantage of the ISA-88 models in this case.

Product Segment	**Product Segment**	**Product Segment**	**Product Segment**
Make CMOS			
	Interconnect		
		Sputter Aluminum	
			Sputter Etch
			Sputter Aliminum
		Litho IN	
			Coat
			Prebake

Table 4: A flow chart structured based on ISA-95 Product Segments

Procedure	**Unit Procedure**	**Operation**	**Phase**
Make CMOS			
	Interconnect		
		Sputter Aluminum	
			Sputter Etch
			Sputter Aliminum
		Litho IN	
			Coat
			Prebake

Table 5: A flow chart structured based on the ISA-88 Procedural model

When describing the contents of flow charts using the ISA-95 concept of Product Segments (parts of Product Definition Information) then it is possible to define Product Segments that contain other Product Segments. The disadvantage is that this concept does not explain the level of each segment within a segment. Every level has the same name: Product Segment.

The same description can be done using the ISA-88 Procedural Model which describes a Procedure, which contains a Unit Procedure, which contains an Operation, which contains a Phase. In that case it becomes clear which segment is the overall segment (Procedure), which segment groups the information into parts that are executed within one single Unit (Unit Procedure), which segment describes the physical or chemical change of the material (Operation) and which segment describes the steps that realize these changes (Phases). Another advantage of the ISA-88 concepts is that it provides a good method for the generation of new recipes. The concept of Master Recipes which are used as templates for Control Recipes appeared to be a good basis for this company's generation of new flow charts. Although ISA-95 defines functions within industrial enterprises that manage and exchange information about how a product is produced (e.g. R&D and Product Definition Management), it does not describe such a method in detail, so that is the disadvantage of ISA-95.

Of course we have to keep in mind that ISA-95 was developed for the exchange of information between level 4 and level 3 systems. So for that purpose, you'd better use the ISA-95 concept of Product Segments. In the future there will be more and more ISA-95 compliant ERP and MES systems, which will exchange Product Definition Information based on the ISA-95 standard. For example that could be an R&D system (level 4) that defines the assembly of a bike. Then segments of this Product Definition Information will be sent to different Work Centers. E.g. a Product Segment will contain information about how to make the wheels. Another Product Segment will contain information about how to make the paint. All these segments of information have to be sent to different Work Centers. For this interface ISA-95 provides the best solution. ISA-95 compliant ERP systems and MES systems understand the concept of segments and have interfaces for the exchange of information grouped into segments.

Developing software

When software vendors develop MES software for batch environments, then they have to choose between ISA-95 and ISA-88. ISA-95 can be considered the language that is spoken between ERP and MES systems. So that would be a reason to base the MES system on the ISA-95 data models. But on the other hand ISA-88 is the language that is spoken by many Batch Control systems. The MES system will have to take orders and material information from the ERP system through an ISA-95 interface, and then send segments of this information to the right Process Cells, using ISA-88 terminology. In this case, what is the best standard for the MES system?

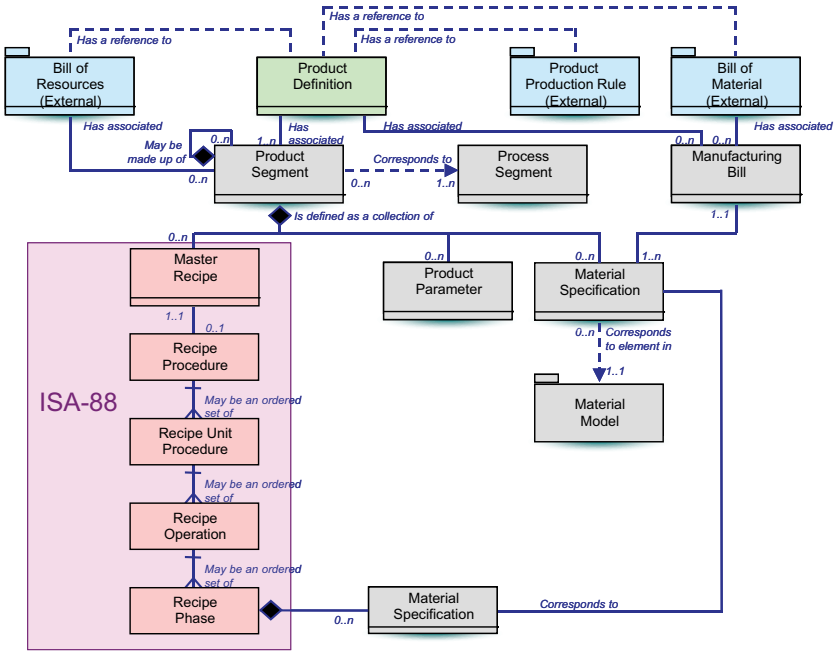

Figure 5: Integration example of ISA-95 data model with ISA-88 model

In our company we decided to use the best from both standards (see figure 5). The upper part of the data model shows the ISA-95 Product Definition model and the lower part shows the ISA-88 Master Recipe, with a Procedure, a Unit Procedure, an Operation and a Phase. This way the system is capable of speaking ISA-95 with the ERP system on the higher level and speaking ISA-88 with the lower level Batch Control system. The Product Definition Information received from level 4 is divided into ISA-95 Segments, which are related to an ISA-88 Master Recipe. The same was done for the ISA-95 models Production Schedule and Production Performance Information. (In that case ISA-95 Segments relate to ISA-88 Control Recipes).

Integrating ERP and MES systems

When an MES system is available, then companies may want to integrate this system with the ERP system on the higher level and with the Batch Control system on a lower level. This could for example mean that a batch is scheduled, starting from an ISA-95 schedule which schedules a specific ISA-88 Control Recipe.

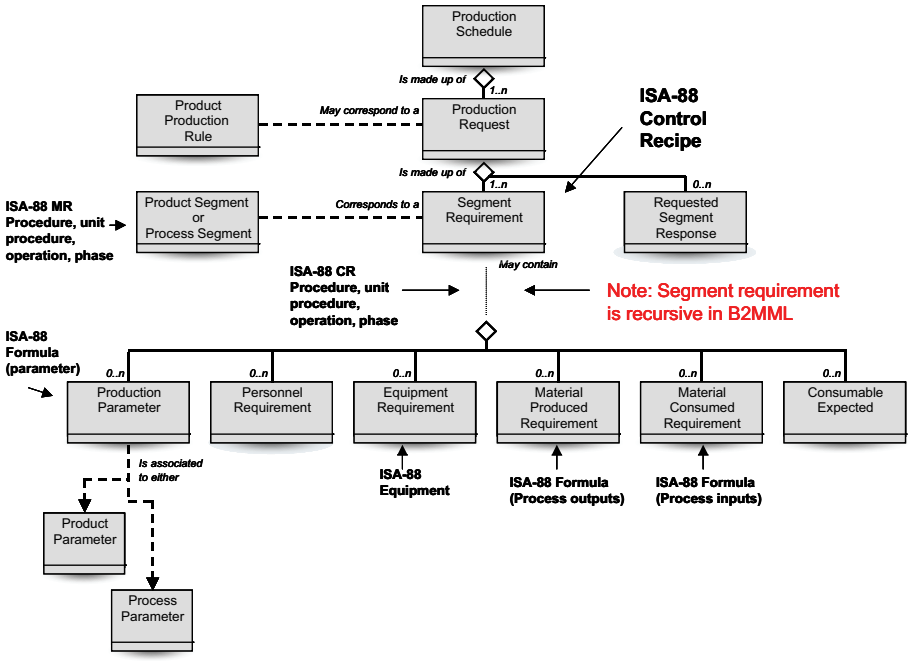

Figure 6: Comparison of the ISA-95 Schedule to ISA-88 concepts and terminology

Figure 6 makes clear how the ISA-88 information parts relate to the objects of the ISA-95 schedule. Note that, according to B2MML a Segment Requirement may contain other Segment Requirements. So one Segment Requirement could be a specific Control Recipe Procedure, which contains other Segment Requirements, namely the Control Recipe Unit Procedure, the Control Recipe Operation and the Control Recipe Phase. These parts of the Control Recipe correspond to Segments of the Product Definition, which in this case would be Segments of the ISA-88 Master Recipe. Other information in the Control Recipe, like Process Inputs, Process Outputs and Process Parameters can be put into the objects Material Consumed Requirement, Material Produced Requirement and Production Parameter. Typically the Material Produced Requirement information (Process Output) is put in the highest Segment (like the Control Recipe Procedure) whereas the Material Consumed Requirement information is put in the lowest Segment (e.g. the Control Recipe Phase). That is because at the lowest level it is known during which phase exactly a raw material is added, whereas the final product is only ready when all the lower level Segments have been executed.

So in short, ISA-88 control recipe elements can be instances of ISA-95 production schedule elements.

Conclusion

A joint working group of the SP88 and the SP95 committee is currently writing a technical report about how to use ISA-88 and ISA-95 together. That report goes into more detail. The report is planned to be available towards the end of 2007. Visit www.ISA.org to find information about the current status of this report.

About the Author

Bianca Scholten is the author of the book called “The Road to Integration: A Guide to Applying the ISA-95 Standard in Manufacturing”. She’s is a fellow at Ordina, one of the largest publicly traded consultancy service providers in the Netherlands and Belgium in the areas of information and communication technology and management. Ms. Scholten advises national and international industrial companies on how to determine their manufacturing automation strategies. Ms. Scholten is a voting member of the SP95 committee. She publishes regularly in trade journals and frequently speaks at conferences on subjects related to vertical integration and technical automation. She has trained hundreds of professionals in applying the ISA-88 and the ISA-95 standard.

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