

ISA-TR88.0.03-1996

Possible Recipe Procedure Presentation Formats

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Foreword

The IEC (International Electrotechnical Commission) SC65A/WG11 and ISA SP88 batch standards groups have defined the required functionality for recipes used in the automation of batch processing plants. Those standards groups, however, have not yet defined a format or graphical representation for those recipes. It is neither possible nor appropriate to predict exactly what the committees will recommend, but it is useful to begin consideration of options that will undoubtedly be reviewed.

This document gives examples of possible formats for recipes as they have been defined in part 1 of the IEC SC65A/WG11 (IEC 65A/186) and ISA SP88 (ANSI/ISA-S88.01-1995) standards. This document uses terminology and models defined in ANSI/ISA-S88.01-1995, *Batch Control Part 1: Models and Terminology*, but it does not presume work to be done in the area of data modeling, language description, or any other work that is included in part 2 of the IEC/ISA standard. It is the intent of this document to illustrate by example rather than to propose specific implementation options or to indicate preference for specific solutions. The following recipe procedure presentation formats are discussed in this document: list, sequential function chart, and modified Gantt chart.

Abstract

This Technical Report gives examples of possible formats, such as textual list, sequential function chart, and modified Gantt chart, for recipe procedures as they have been defined in ANSI/ISA-S88.01-1995 and IEC 65A/186/CDV, *Batch Control Part 1: Models and Terminology*.

Key words

list format, modified Gantt chart format, operation procedure, recipe presentation format, recipe procedure, sequential function chart format, unit procedure

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1 Scope

ISA-TR88.0.03 defines a format or graphical representation for recipes used in the automation of batch processing plants as defined in part one of the IEC SC65A / ISA SP88 standard. ([See Annex A — References.](#)) The following are possible recipe procedure presentation formats discussed in this document:

- a) List
- b) Sequential function chart (SFC)
- c) Modified Gantt chart — horizontal orientation
- d) Modified Gantt chart — vertical orientation

2 Purpose

It is the intent of this Technical Report to illustrate by example (rather than to propose specific implementation options or indicate preference for specific solutions) possible formats for recipe procedures as they have been defined in ANSI/ISA-S88.01-1995 and IEC 65A/186/CDV, *Batch Control Part 1: Models and Terminology*.

3 Multiple use requirements

However depicted, recipe information is not confined to a single use. The recipe depictions discussed in this document may be used for the following purposes:

- a) In the specification of general, site, and master recipes, including the specification of library recipe procedural elements
- b) For the use of recipe information in scheduling
- c) For the control recipe in the operating environment — which may include display of current batch status
- d) For batch history — as may be applicable for reporting and referencing batch information.

4 Hierarchical requirements

The primary challenge in choosing a recipe presentation format is crisp depiction of the procedure. All other categories of recipe information can be related to the procedure or to the overall recipe. The procedure, on the other hand, must clearly portray sequencing of procedural ele-

ments (such as phases or operations) in such a way that the sequence, as well as other relationships of procedural elements, to each other is clearly defined.

A recipe presentation format must also deal with the various levels in the procedural element hierarchy. Recipes do not depict elements below the level of the phase. Operations, however, are an ordered set of phases that may be detailed in the recipe. It must be possible, therefore, to define an operation in the recipe procedure. The definition must contain both the phase identities and the ordering logic that specifies the order in which they are to be executed.

The next higher level procedural element is the unit procedure. Because no more than one operation is presumed to be active at a given time in a single unit, a unit procedure can usually be represented as a simple sequence of operations, one following the other.

The highest level procedural element is the recipe procedure itself. It consists of all required unit procedures along with information that defines the order in which they may be initiated.

Because of the differences in functionality from one level to the next, the ideal recipe presentation format for portraying a recipe procedure may vary from level to level.

5 Recipe presentation formats at the operation and unit procedure levels

Operations are made up of phases that may run concurrently and have either complex or product-specific interrelationships, or both. A list format is possible for simple (serial) cases, while a method that allows depiction of a range of sequential relationships, such as a sequential function chart format, is useful in more intricate (concurrent) cases.

Unit procedures are made up of operations that are usually executed sequentially. Therefore, either the list format or sequential function charts may be used to represent the operations in a unit procedure.

5.1 List format

A simple way of representing a linear sequence is a list. A list has the advantage of being easy to visualize and unmistakably precise. However, a list is useful only in simple situations because parallelism and complex sequences are very difficult to depict clearly in this format. In spite of difficulties with the list format when dealing with complex processes, this format is adequate when the recipe procedure is simple or has been simplified by engineering effort.

The list format for an operation specifies what phases are to be executed and in which sequence. The list of phases may be displayed in a tabular form where the phases are listed together with associated key information, including some or all parameters. ([See Figure 1.](#)) The same type of representation can be used for the operations in a unit procedure.

The list format is most often used to display a linear sequence of phases or a linear sequence of

operations. Through parameter control of the phases or operations, a limited amount of concurrency may be described, such as a parameter indicating heating with or without agitation.

ID	Phase	Phase parameters		
		Ingredient	Set point	Other parameters
1	Fill	Water	1000 kg	
2	Add manually	Salt	50 kg	
3	Heat	Steam	50°C	
4	Add manually	Sugar	30 kg	

Figure 1 — List format for phases in a tabular form

5.2 Sequential function chart (SFC) format

More complex recipe sequences require a recipe presentation format that can clearly depict a variety of ordering logic. One accepted methodology is the function chart that is defined in IEC 848, *Preparation of Function Chart for Control Systems*. ([See Annex A — References.](#)) This presentation format, commonly known as sequential function chart (SFC), has the following advantages:

- a) Quite flexible
- b) Broadly understood
- c) Well documented

If a 1:1 relationship is imposed between a step in the SFC and a recipe phase, the recipe creator and other recipe users have an overview of the phases involved and their interaction. During execution, such a depiction can be used to give the operator an overview of the current status of the operation.

A simplified SFC may also be developed in which the actual activation of the equipment phase and the transfer of parameters are implicit (i.e., the format in [Figure 2](#) without the more rigorous expansion shown in the inset). Display techniques may be applied to give access to additional information such as associated formula and other information.

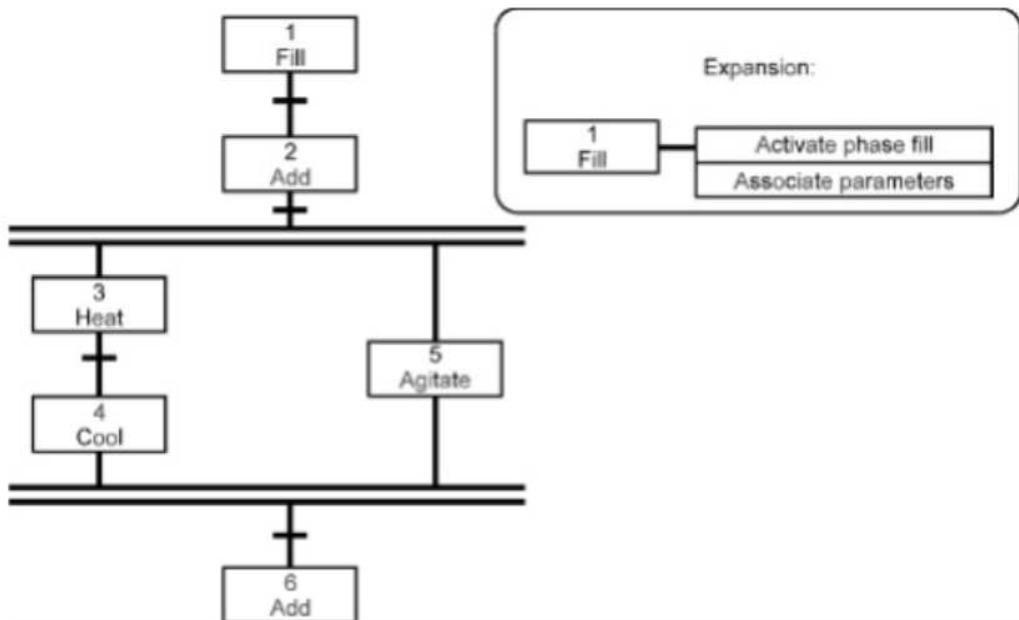


Figure 2 — Phases in a sequential function chart format

6 Recipe presentation formats at the procedure level

The recipe procedure consists of recipe unit procedures that may run in parallel. Each unit procedure is presumed to be a linear sequence of operations, some of which interact with operations in other unit procedures. In situations where the interaction between parallel unit procedures is limited or not important, either a list format or a sequential function chart is adequate. Without extensions, these formats do not lend themselves to easy visualization of relationships between concurrent unit procedures.

A pure Gantt chart cannot be used because a recipe does not contain scheduling information. A modified Gantt chart may be used at this level to allow relationships between asynchronous procedural elements to be shown graphically and to illustrate the sequence and relative relationships without adding an actual time dimension.

6.1 List format

A list format specifies what unit procedures are contained or referenced and the sequence in which they are to be activated. The list format of unit procedures may be displayed in a tabular form with the unit procedure IDs listed together with associated key information. (See Figure 3.)

ID	Unit procedure	(Reference to) other recipe information
React 1	Reaction	
Filtration 1	Filtration	
React 2	Reaction	
Separation	Separation	

Figure 3 — List format of unit procedures in a tabular form

Concurrency cannot be easily expressed in the list format. As soon as multiple unit procedures and/or multiple units with material transfers are involved, some concurrence becomes inevitable. In this case, a more sophisticated representation should be considered. However, the execution of two consecutive unit procedures on the same unit should not be cause for abandoning the simple list format. In especially simple cases, it may be unnecessary to embed even concurrent sequences in the recipe (e.g., because transfers are handled by unit-specific equipment control, and scheduling is not important). In such cases, a simple list format may still be usable.

6.2 Modified Gantt chart at the procedure level

Unit procedures are largely asynchronous, and this presents many problems in representing the permissible order of initiation of each unit procedure and the relationships that exist between them. Asynchronous unit procedures result in lower level operations and phases that interact with operations and phases in other unit procedures. If these sequencing and relationship issues are to be easily visualized in a recipe, some method must be added to SFC depiction to clearly show both the permissible initiation sequence of unit procedures and the relationship between asynchronous but related unit procedures.

A scheduling activity may need more information, such as estimated execution times of unit procedures, points of transfer or other interaction between operations in unit procedures, or the time limitations on such activities as transfers. In some cases, there may be the need for synchronization in the middle of a unit procedure (e.g., if a reaction in unit A can take place only after B has reached a certain operation).

Note that not all of the information mentioned above can come from a recipe, because recipes may not contain information about real-time events such as actual execution times, paths actually chosen, and other complications. The form of the recipe, however, can be similar enough to a traditional Gantt chart to allow external information to be easily integrated for scheduling and other functions. In the absence of actual execution times, for example, relative time lengths can be used for each operation.

A proposed recipe presentation format for displaying this type of complexity at the procedure level would be a modified Gantt chart. (See Figure 4, horizontal orientation.) The dashed lines with arrows indicate synchronization between the unit procedures.

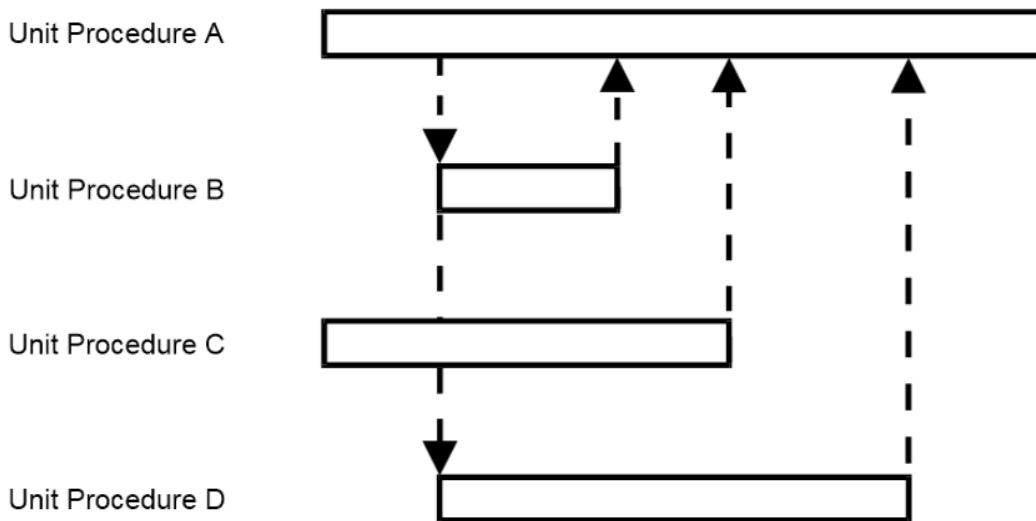


Figure 4 — Modified Gantt chart of unit procedures — horizontal orientation

The classic Gantt chart depiction is horizontal rather than the vertical format usually seen in tables or SFC types of sequence descriptions. A useful modified Gantt chart depiction can also be constructed in a vertical layout. While not traditional, many of the advantages of a traditional Gantt chart form are still available while making the methodology easier to merge with other vertically oriented sequence depictions. An example of such a vertical Gantt chart format is shown in [Figure 5](#).

Either type of modified Gantt chart (i.e., horizontal or vertical orientation) can be expanded to take the specific relationships between operations into account or to use the boundaries between operations or phases to synchronize the initiation of unit procedures. ([See Figure 5.](#)) It may also be necessary to include additional specifications of recipe dependent synchronization and/or rules governing the execution.

The actual timing will be calculated in the Production Planning and Scheduling activity based on the interrelationships indicated in the master recipe, other recipe and production plan information (e.g., required materials and amounts), and separate historical or calculated data regarding execution times for phases, operations, and unit procedures. Augmentation of the modified Gantt chart with additional data from Production Information Management and Production Planning and Scheduling may then be used to indicate the actual execution of the control recipe. In effect, the combination of the modified Gantt chart recipe information with other information allows the construction of an actual Gantt chart illustrating actual execution and timing.

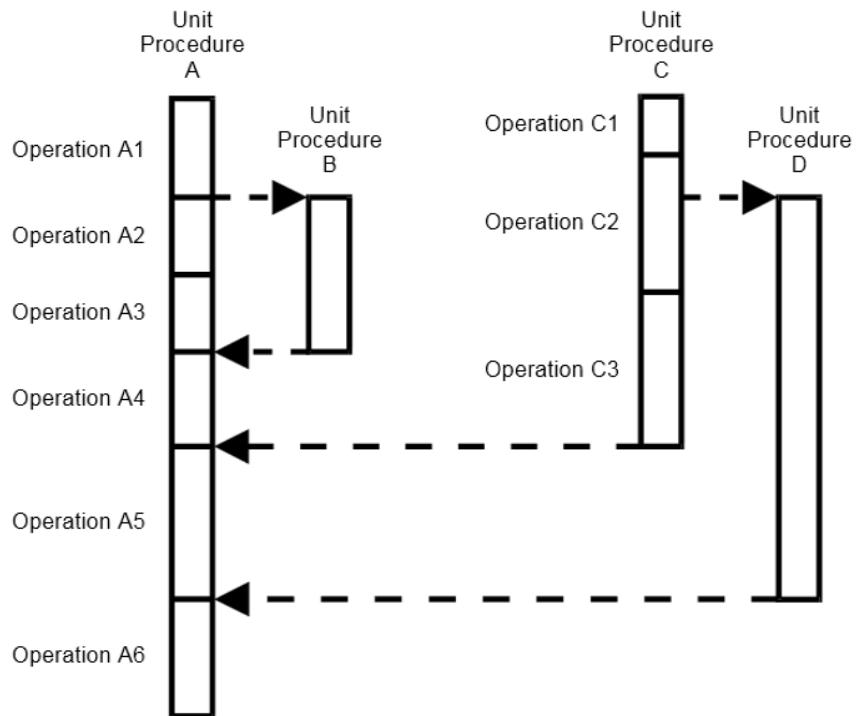


Figure 5 — Modified Gantt chart of unit procedures — vertical orientation

7 Summary

Each of the three recipe procedure presentation formats discussed in this document have their own set of advantages and disadvantages. The textual list format is simple, but it does not give timing nor conditional logic information. The modified Gantt chart displays timing information and some conditional logic, but it cannot display complex phase relationships. The sequential function chart provides complex conditional logic presentation, but it does not allow the user to easily visualize the relationships between unit procedures.

As stated earlier, the purpose of this Technical Report is not to declare the preferred or superior recipe procedure presentation formats. Its purpose is to provide further discussion regarding recipe procedure presentation formats. Hopefully, this document will initiate further discussion that will be input to Part 2 of ANSI/ISA-S88.01, *Batch Control Part 1: Models and Terminology*.

Annex A — References

INTERNATIONAL ELECTROTECHNICAL COMMISSION (IEC)

IEC 848: 1988 Preparation of Function Charts for Control Systems

IEC 65A/186/CDV Batch Control Part 1: Models and Terminology

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