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The clear path to operational excellence

Automation of batch and procedural control through standards based design

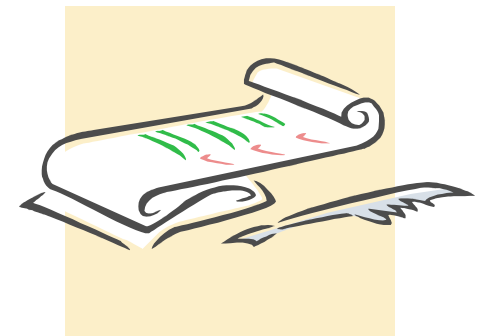


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Yokogawa Corporation**

Automation of Batch and Procedural Control Processes through Standards Based Design

Batch processes are built to achieve very flexible manufacturing requirements. Often, it has been difficult to automate a batch process and to keep its flexibility. Developed and refined for the past 20 years, the ISA Batch Standard (ISA 88) has become a commonly understood approach to communicate batch system requirements across R&D, process engineering and control disciplines, and has enabled manufactures to build flexible and highly automated batch systems. This presentation will outline the basics of the ISA-88 standard and overview how it has helped many different companies to achieve agile and flexible manufacturing in automated batch systems. It will also show how the standard is now being applied to continuous and discrete applications.

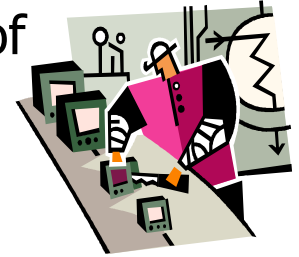
- Overview of Batch process vs discrete and continuous
- Challenges of Automating a Batch process
- Overview of the ISA-88 standard
- Business Benefits
- Applicability of ISA-88 for continuous & discrete processes



Processing Overview

❖ A Discrete Process produces things- a part or a specific group of parts moving from one workstation to another

- Automobiles, dishwashers, circuit boards & packaging products
- PLC developed to address



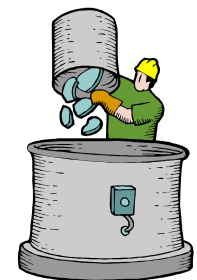
❖ A Continuous Process makes stuff - involve the continuous flow of materials through a various processing equipment

- Oil refining, bulk chemicals & paper production.
- DCS developed to address



❖ A Batch Process is the production of finite quantities of material by subjecting quantities of input materials to an ordered set of processing activities over a finite period of time using one or more pieces of equipment.

- Discrete quantities of stuff
- Personal care products, food & beverages, pharmaceuticals, & many specialty chemical products



No Universal
Model for
Batch Control

Difficult for Users
to Communicate
Requirements

ISA 88 Batch
Control
Standard

Integration of
Different Vendors
Is Difficult

Batch Control
Systems
Difficult to
Configure

- These issues lead to expensive batch control systems that did not meet all the needs of users, were inflexible and difficult to maintain
- In 1988 the ISA (International Society of Automation) formed the SP-88 committee to address batch control

- ❖ ISA 88.01 Batch control Part 1: Models and Terminology approved 1995
- ❖ Other sections approved
 - ISA 88.02- Data structures and guidelines for batch control languages(2001)
 - ISA 88.03- General and site recipes(2003)
 - ISA 88.04-Batch production records(2006)
- ❖ Other sections still in Draft
 - ISA 88.05 Implementation Models & Terminology for Modular Equipment Control
- ❖ Technical Reports issued:
 - TR88.95.01 Using ISA-88 and ISA-95 together(2008)
 - TR88.00.02 Machine and unit states: An implementation example of ISA-88(2008)
 - TR88.0.03 Possible recipe procedure presentation formats(1996)

This discussion will focus on Part 1

- ❖ Terminology and models
 - to make functional requirements understandable
 - apply to all types of control systems
 - applies manually-controlled batches

- ❖ Applies equally well to simple batch processes as it does to complex batch processes
 - Expandable if additional levels are needed
 - Collapsible if all the levels described are not needed

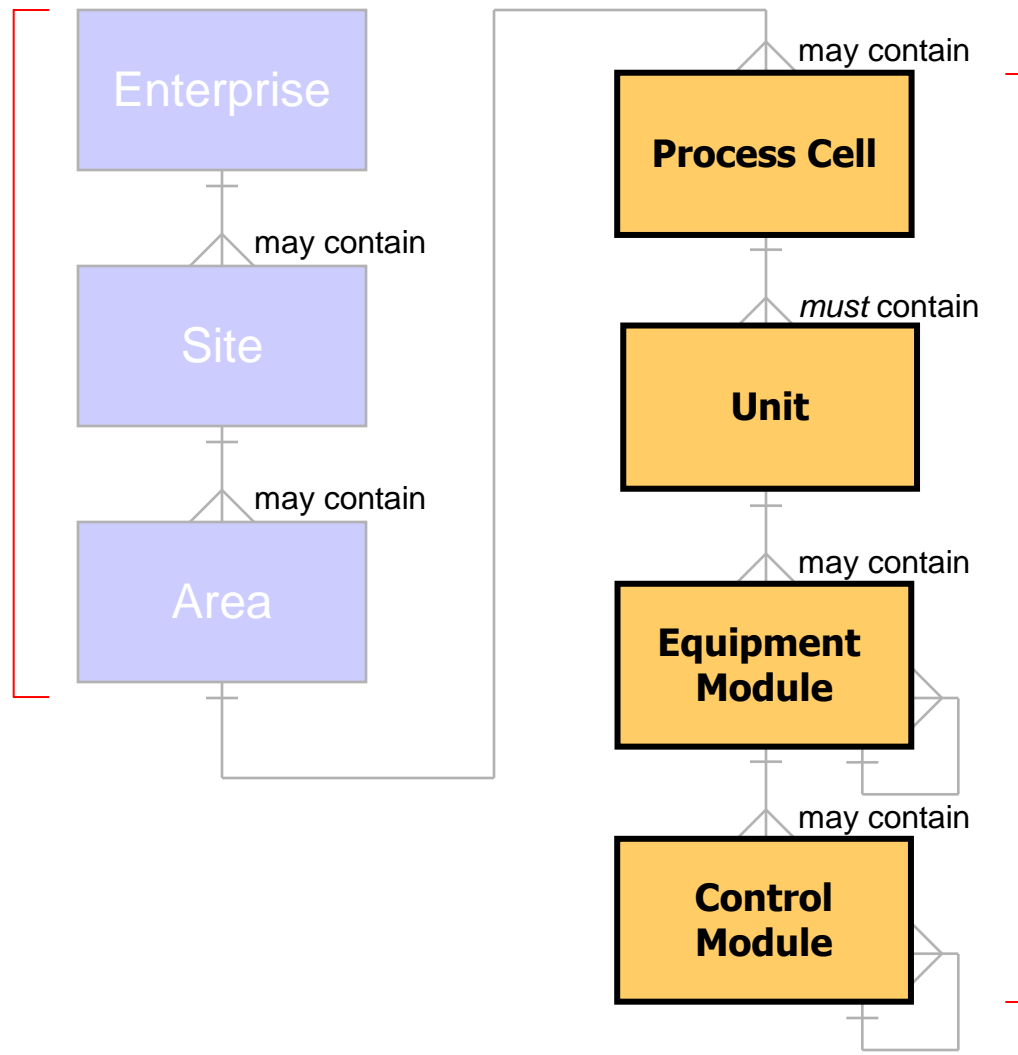
- ❖ A concept that separates the recipe that describes how the batch is to be made from the equipment that is actually used to make the batch
 - Improves recipe transportability
 - Makes recipes more flexible
 - Simplifies recipe validation
- ❖ A modular structure that promotes reuse of previous work

- ❖ Equipment model
- ❖ Recipe definitions
- ❖ Procedural model
- ❖ Linking the models

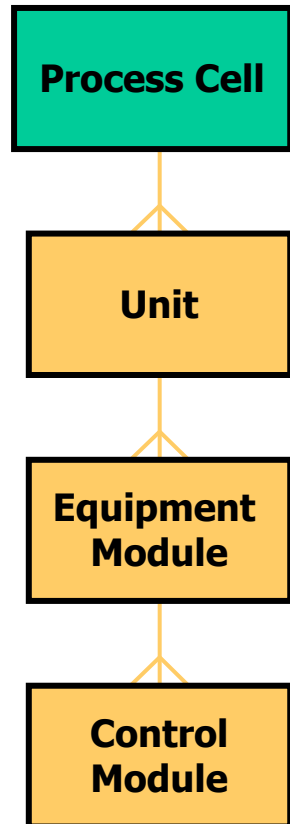


The ISA-88 Equipment Model

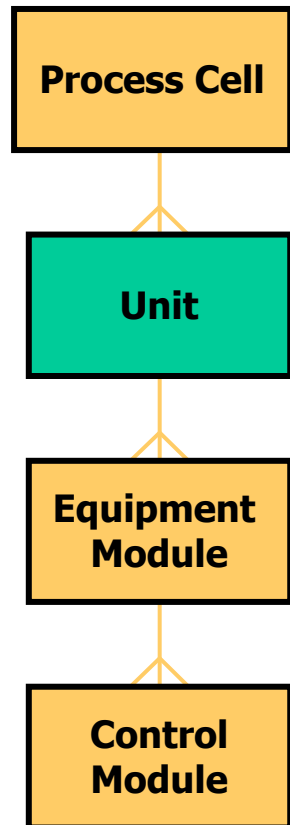
Defined in
ISA 88-
Discussed
in detail in
ISA-95



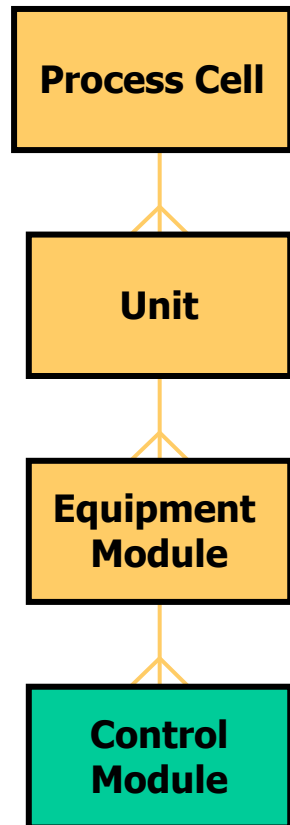
Primary ISA-
88 levels



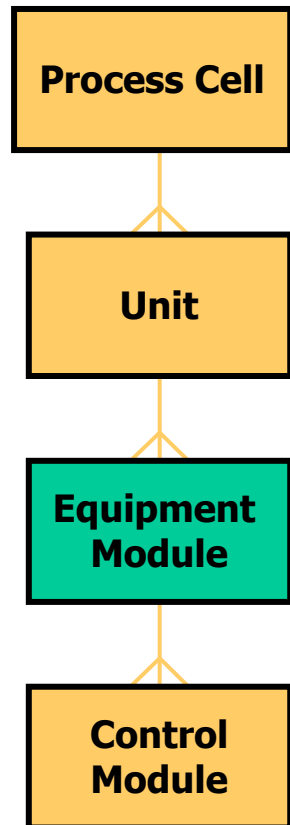
- A logical grouping of equipment that includes all the equipment to produce one or more batches
- Each batch produced does not need to use all the equipment in a process cell nor does it need to follow the same *path* of equipment as other batches
- The level responsible for coordinating resources and activities of equipment



- ⇨ A collection of one or more modules that performs one or more major processing activities
- ⇨ A unit is centered around a major piece of processing equipment, such as a mixing tank or reactor
- ⇨ Example major processing activities:
 - Adding and mixing materials
 - Performing a reaction
 - Crystallization
- ⇨ A unit cannot operate on more than one batch at any given time

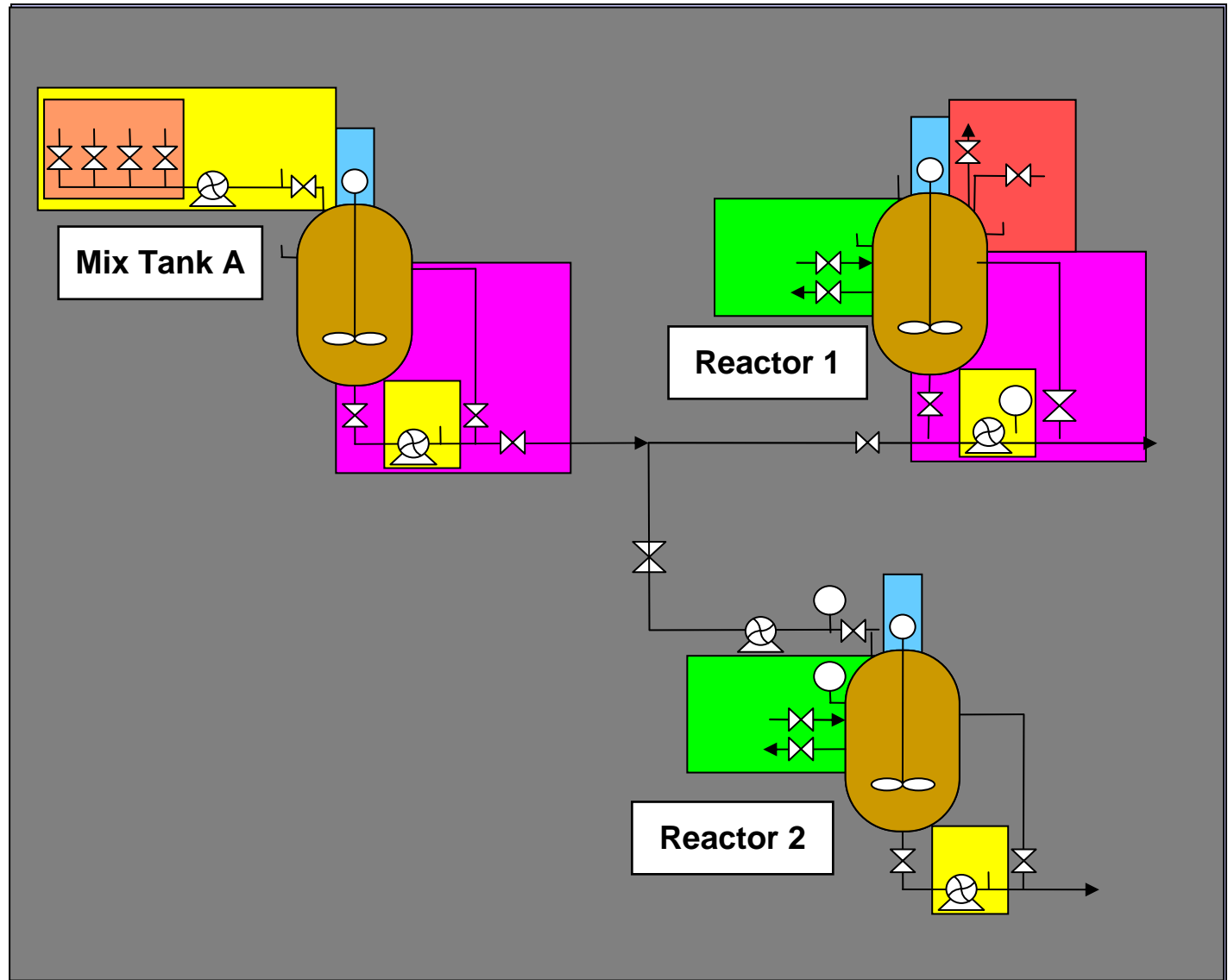
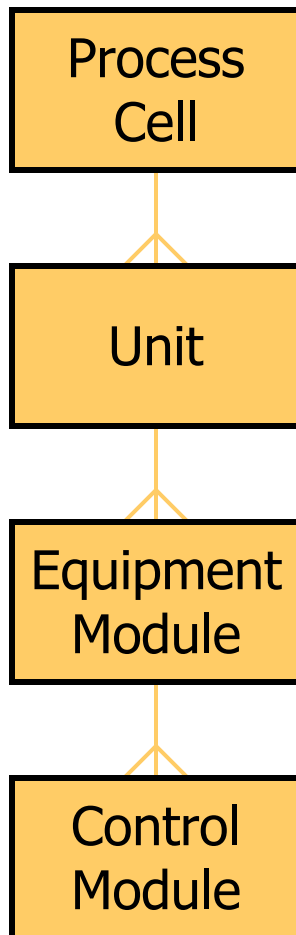


- ❖ Lowest level grouping of equipment in the equipment model
- ❖ Direct “connections” to the process through actuators and sensors
- ❖ Every physical piece of equipment should be controlled by one (and only one) control module
- ❖ More than one event can trigger the control module to manipulate a piece of equipment

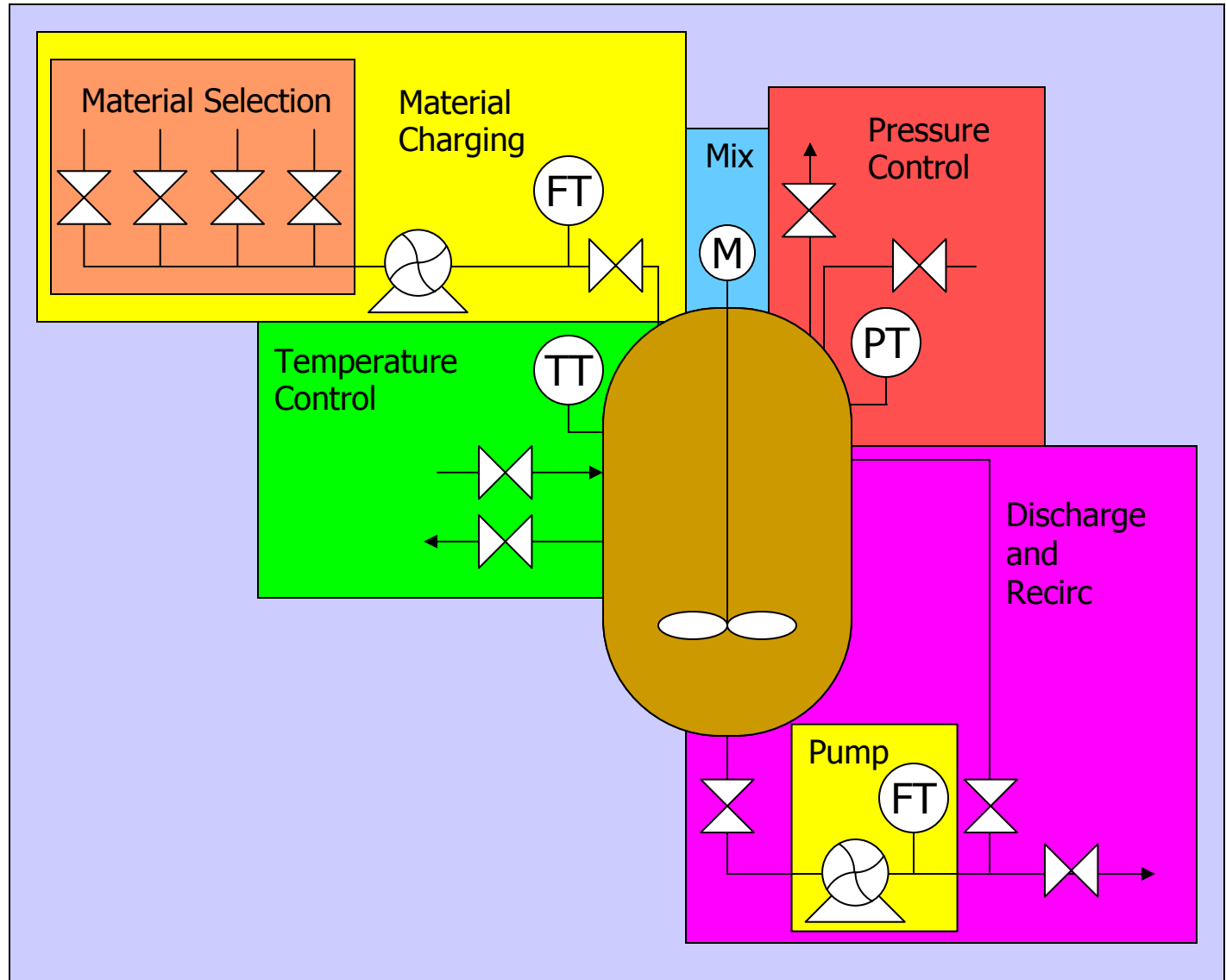
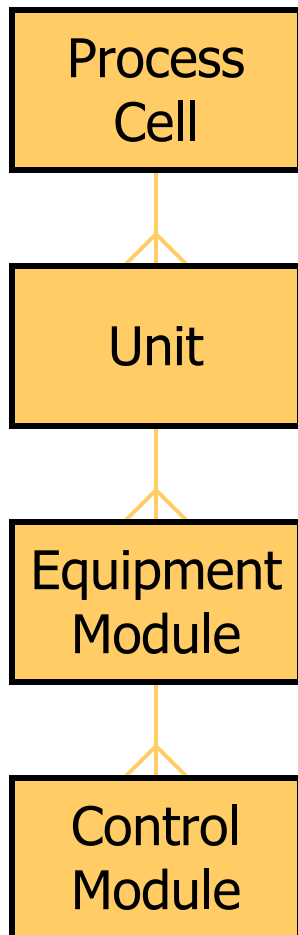


- ❖ Group devices for performing one or more specific processing activities
 - Add material A
 - Heat reactor to 120 F and hold
- ❖ May be made up of control modules or other equipment modules
 - Can be permanently attached to a unit
 - Or can be temporarily attached as a common or shared resource
- ❖ Equipment modules typically have sequencing in the execution of the activity.

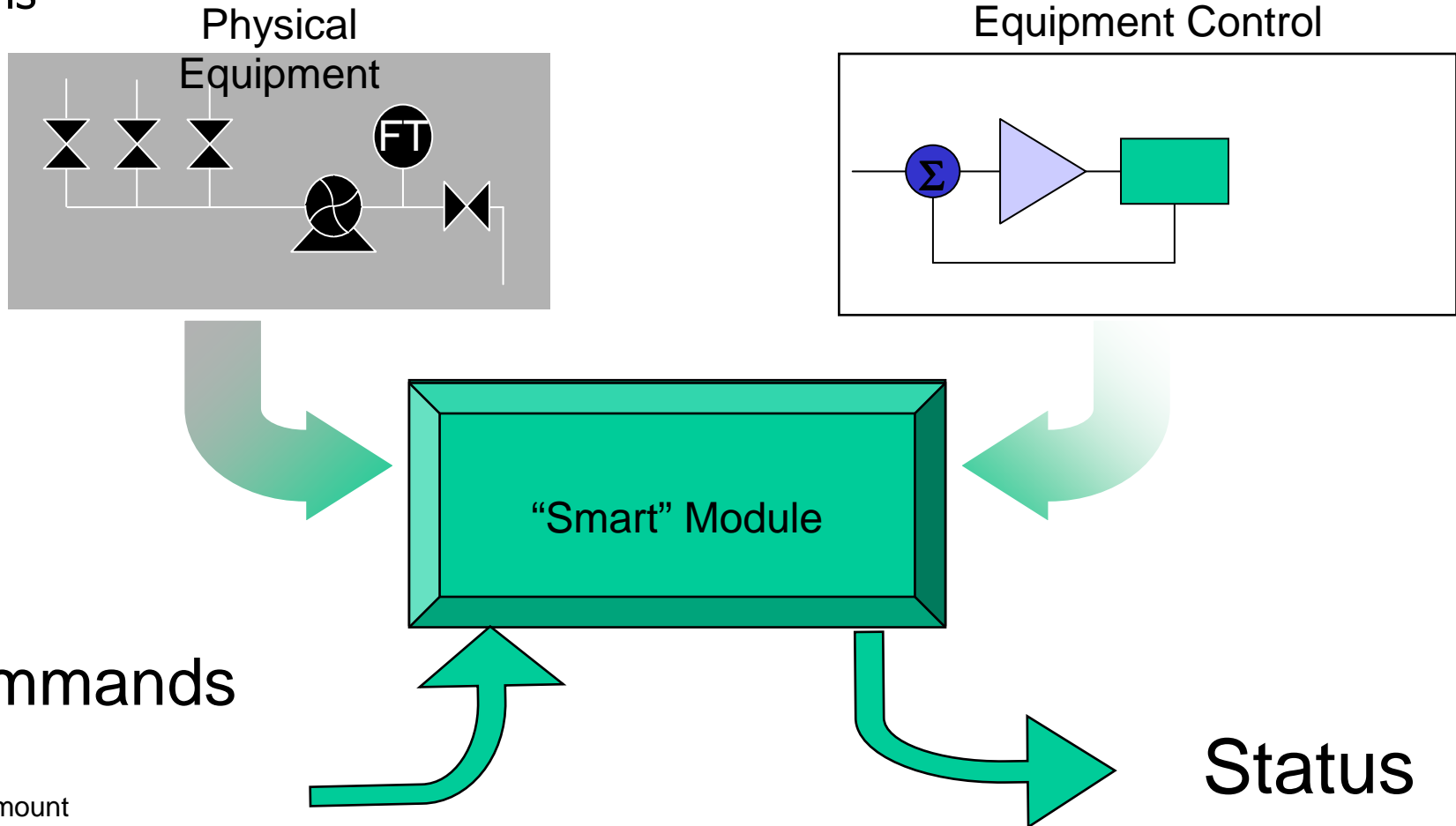
An Example Process Cell



An Example Process Cell



A collection of physical processing and control equipment and equipment control grouped together to perform a certain control function or set of control functions



Commands

- Start
- Add X amount

Status

- I have completed
- I have added X amount

❖ Equipment model

❖ Recipe definitions

❖ Procedural model

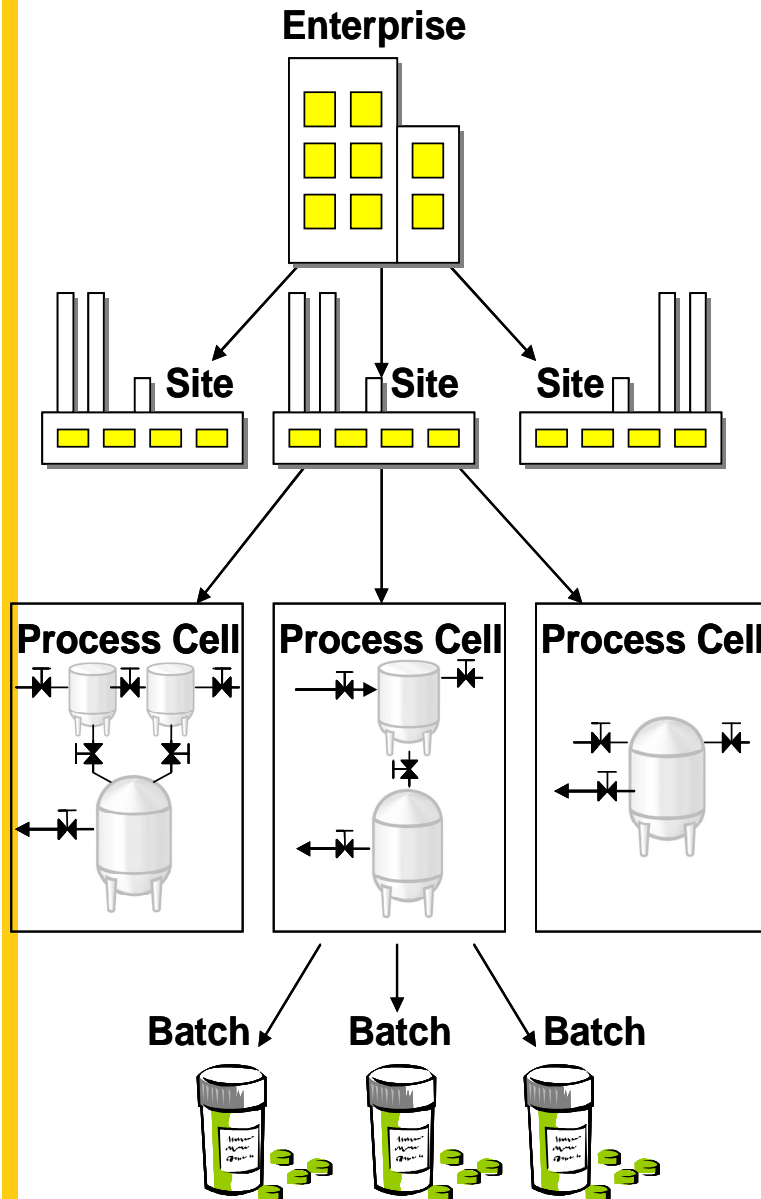
❖ Linking the models



Recipe definition: The necessary set of information that uniquely defines the production requirements for a specific product

- Different parts of the organization need information about products in varying degrees of specificity
- ISA 88 defined four types of recipes
- Not all types have to be used

Four Levels of Recipes



General Recipe

- Maintained at the enterprise level
- Describes relative material amounts and general processing requirements

Site Recipe

- Describes recipe using local materials, language, or segment of production

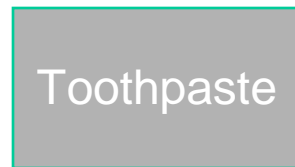
Master Recipe - Is targeted to a process cell

- Details specific Equipment & Raw materials to be used
- Used for detailed scheduling

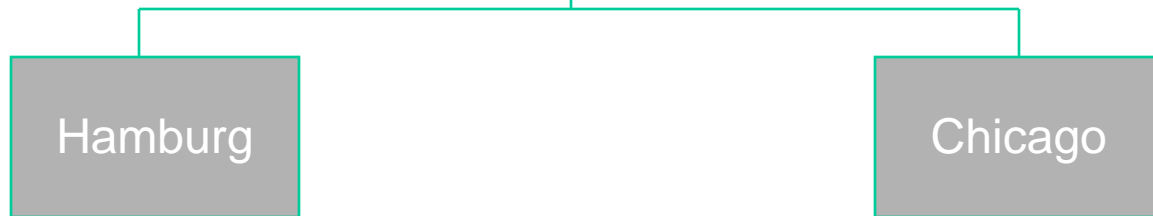
Control Recipe is used to create a single specific batch of product

- Starts life as a copy of a master recipe
- Assigned a Lot ID
- May change as the batch progresses

General
Recipe



Site
Recipe



Master
Recipe

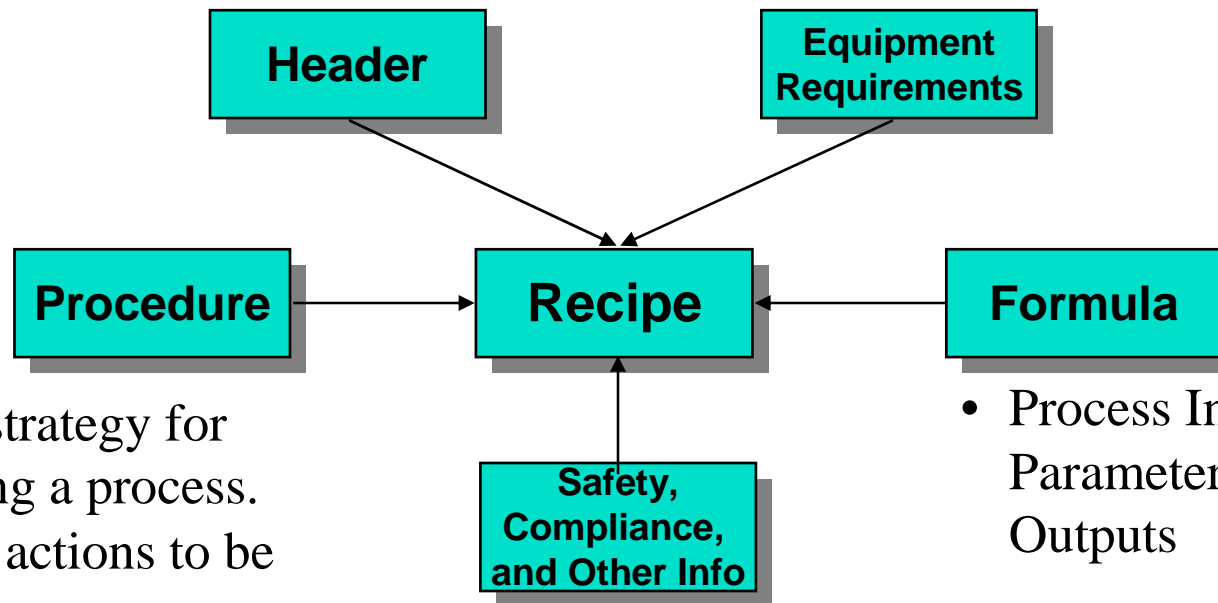


Control
Recipe



- List header information (product ID, author, version # , date)

- Specify type and size of equipment needed



- Defines the strategy for accomplishing a process. (the order of actions to be performed.)

- Process Inputs, Process Parameters, and Process Outputs

- Provides information related to batch such as documentation required for government regulations

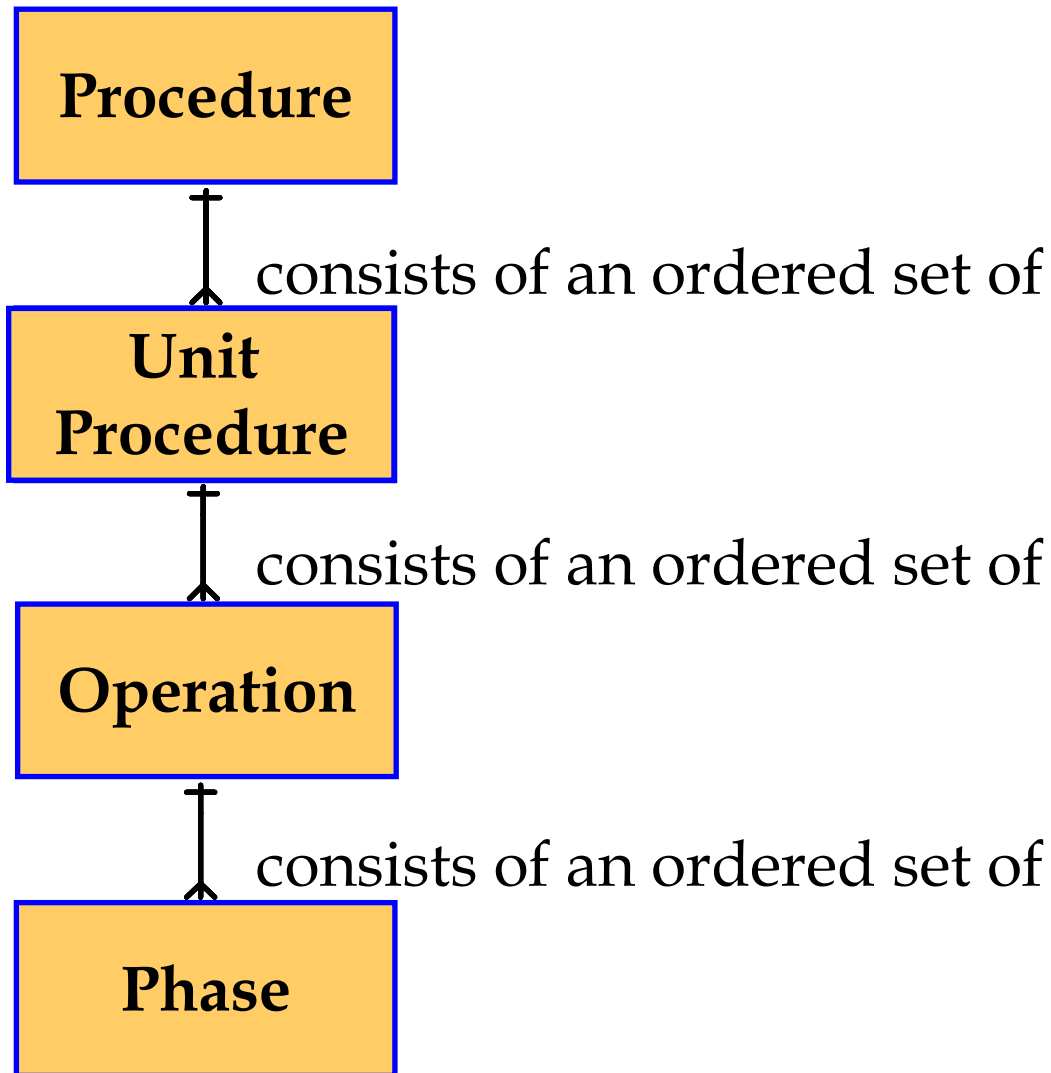
❖ Equipment model

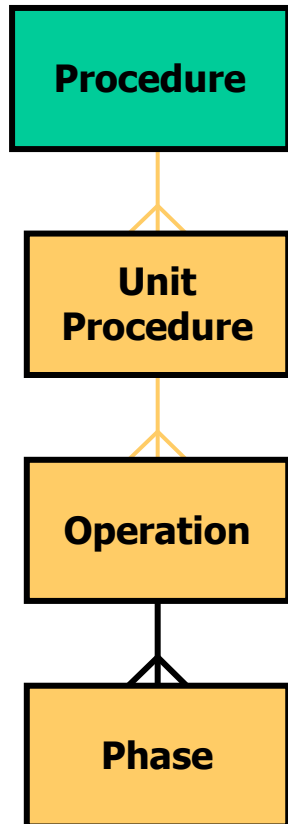
❖ Recipe definitions

❖ Procedural model

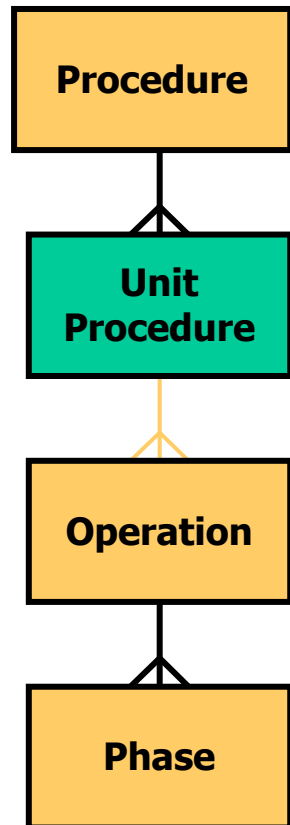
❖ Linking the models



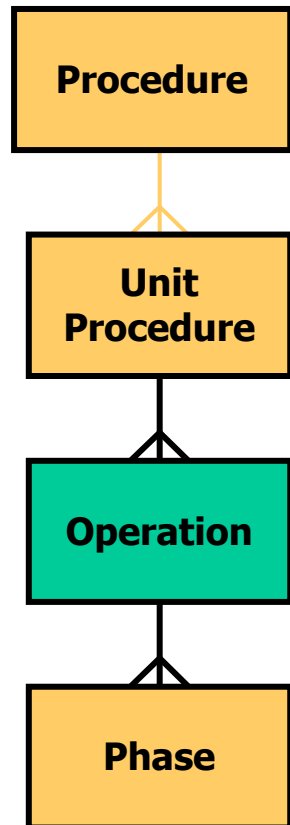




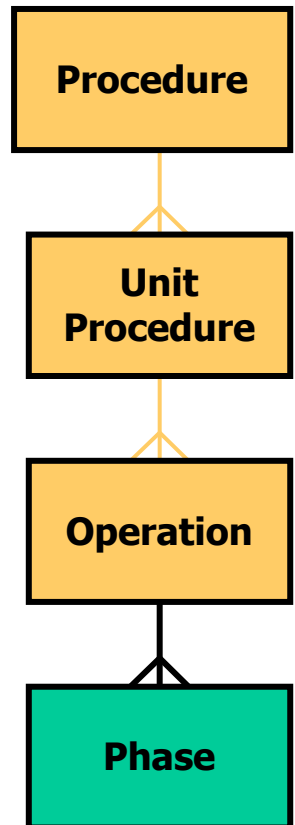
- The highest level in the hierarchy
- Defines the strategy for making a batch in a Process Cell
- Defined in terms of an ordered set of unit procedures



- ⇒ Consists of an ordered set of operations that cause a production sequence to take place within a unit
- ⇒ Only one unit procedure is presumed to be active in a unit at any time
- ⇒ A unit procedure is carried to completion in a single unit

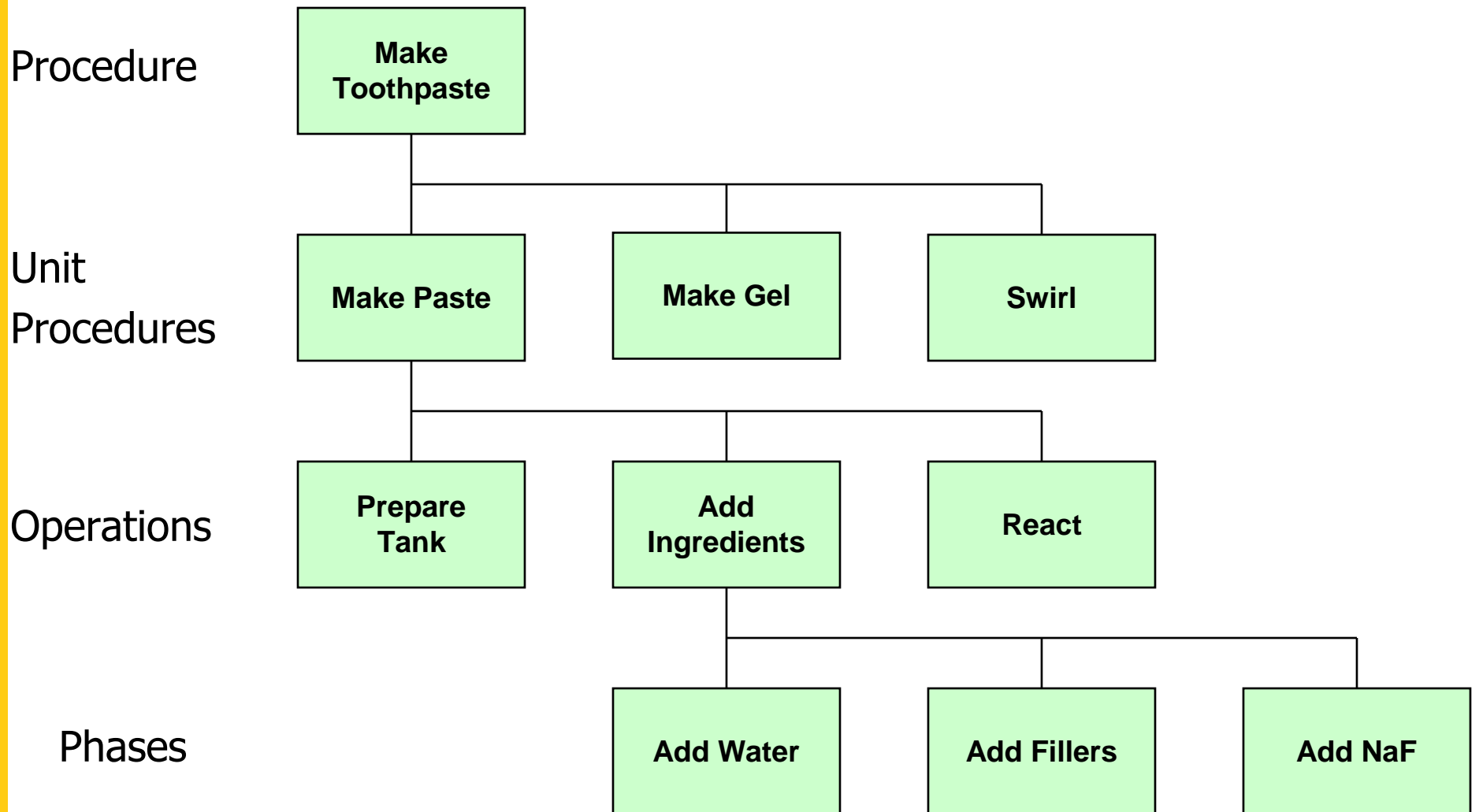


- An ordered set of phases that defines a major processing sequence
- Takes the material being processed from one state to another
- Usually involves a chemical or physical change
- Operation boundaries are often at points where normal processing can safely be suspended

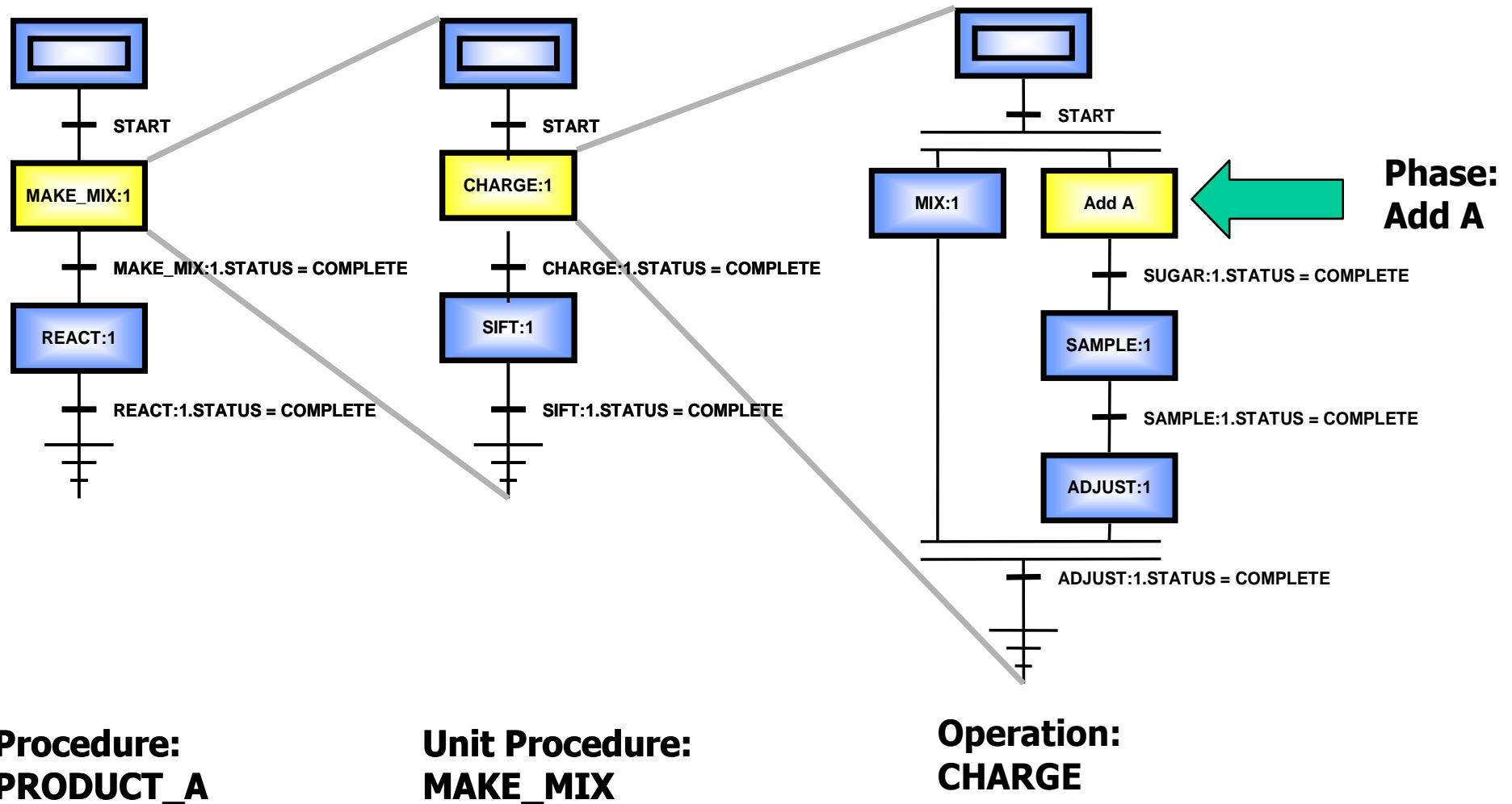


- ❖ The smallest element of procedural control that can accomplish a process-oriented task
- ❖ The logic or set of steps that make up a phase is equipment specific
- ❖ Are the workhorses of the recipes- the levels above organize, group and direct phases

Recipe Procedure Summary



Another View of the Procedure Hierarchy



Each procedural component is reusable

❖ Equipment model

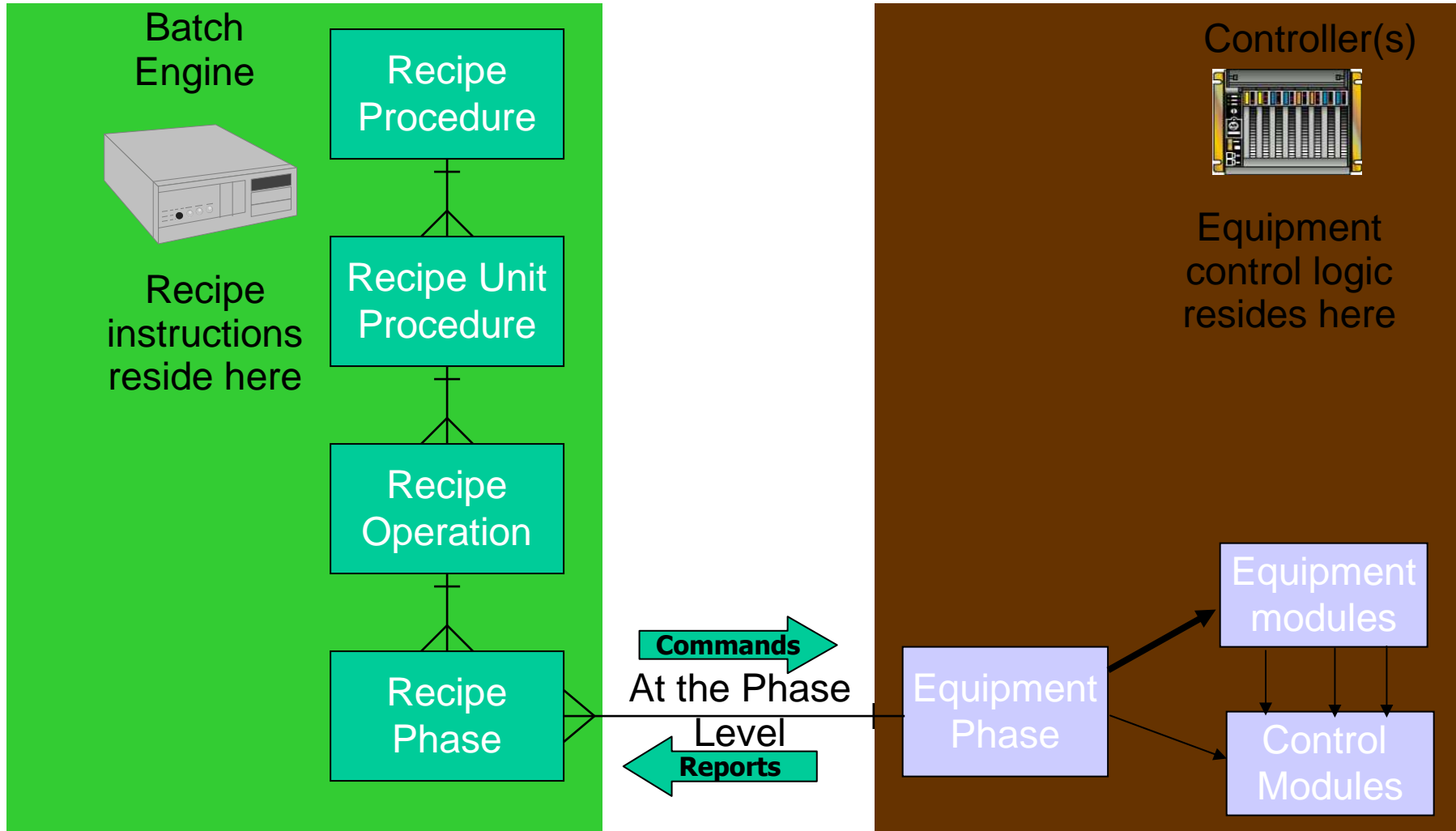
❖ Recipe definitions

❖ Procedural model

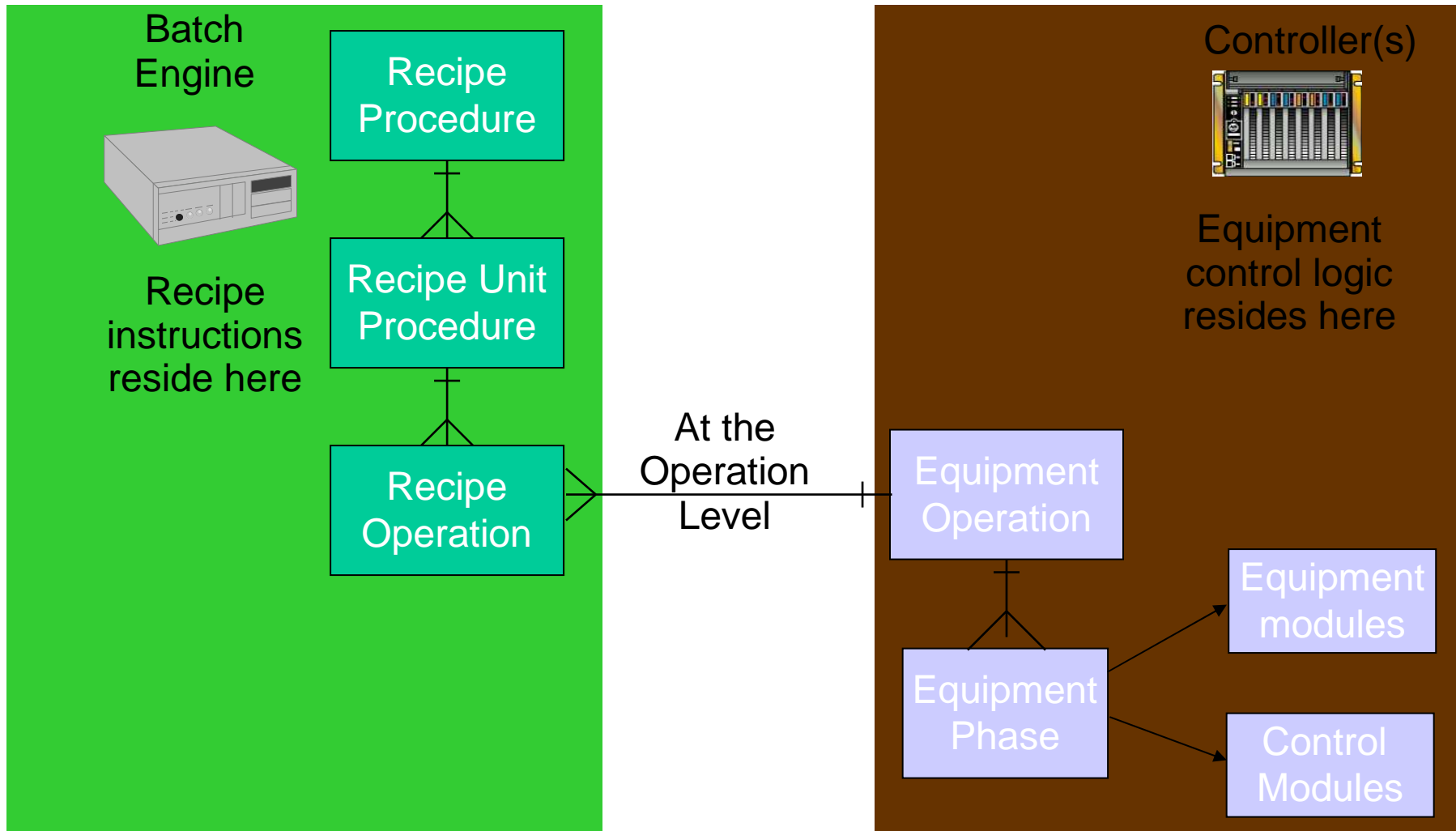
❖ Linking the models



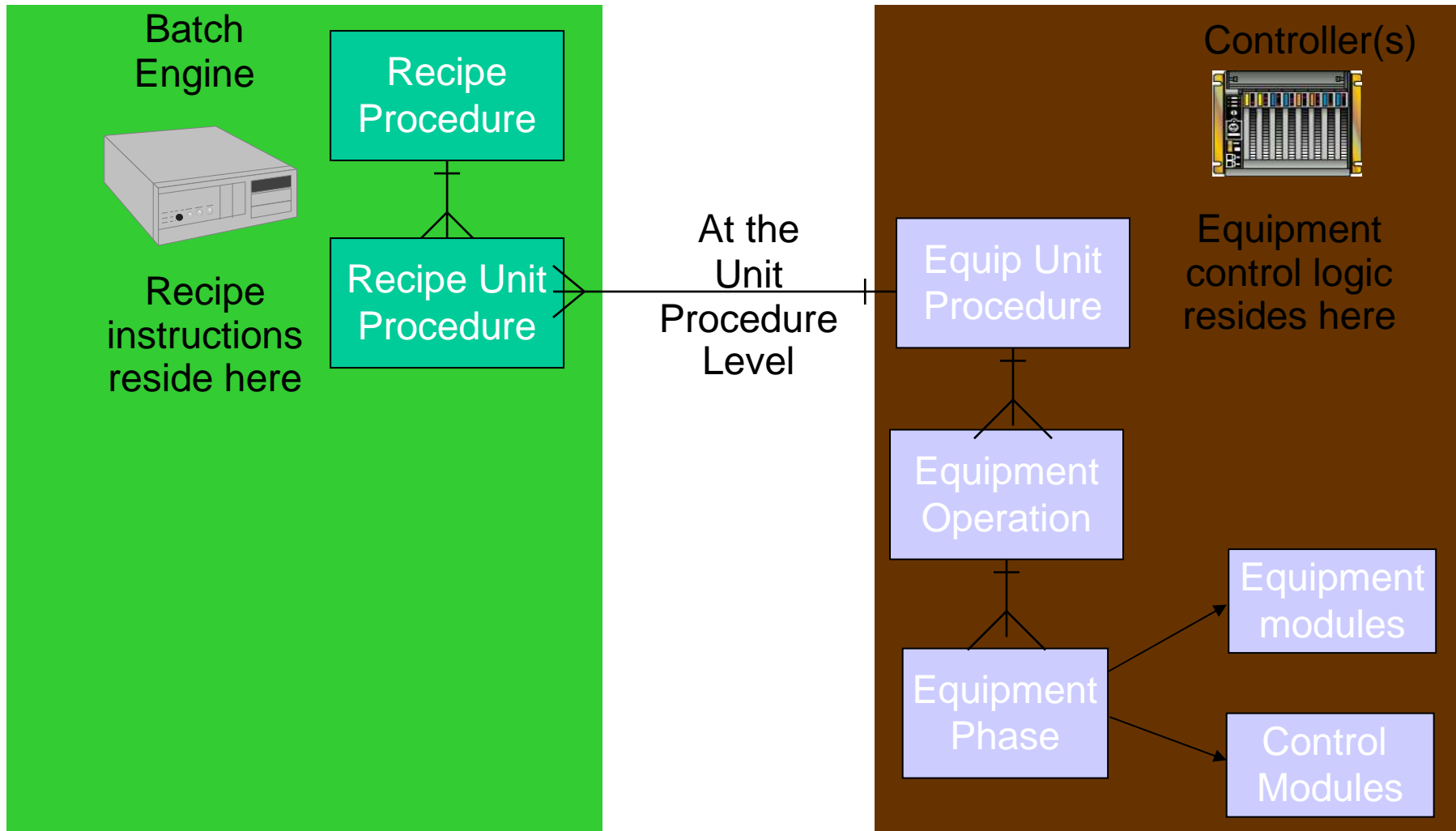
Link Procedure to Equipment Control



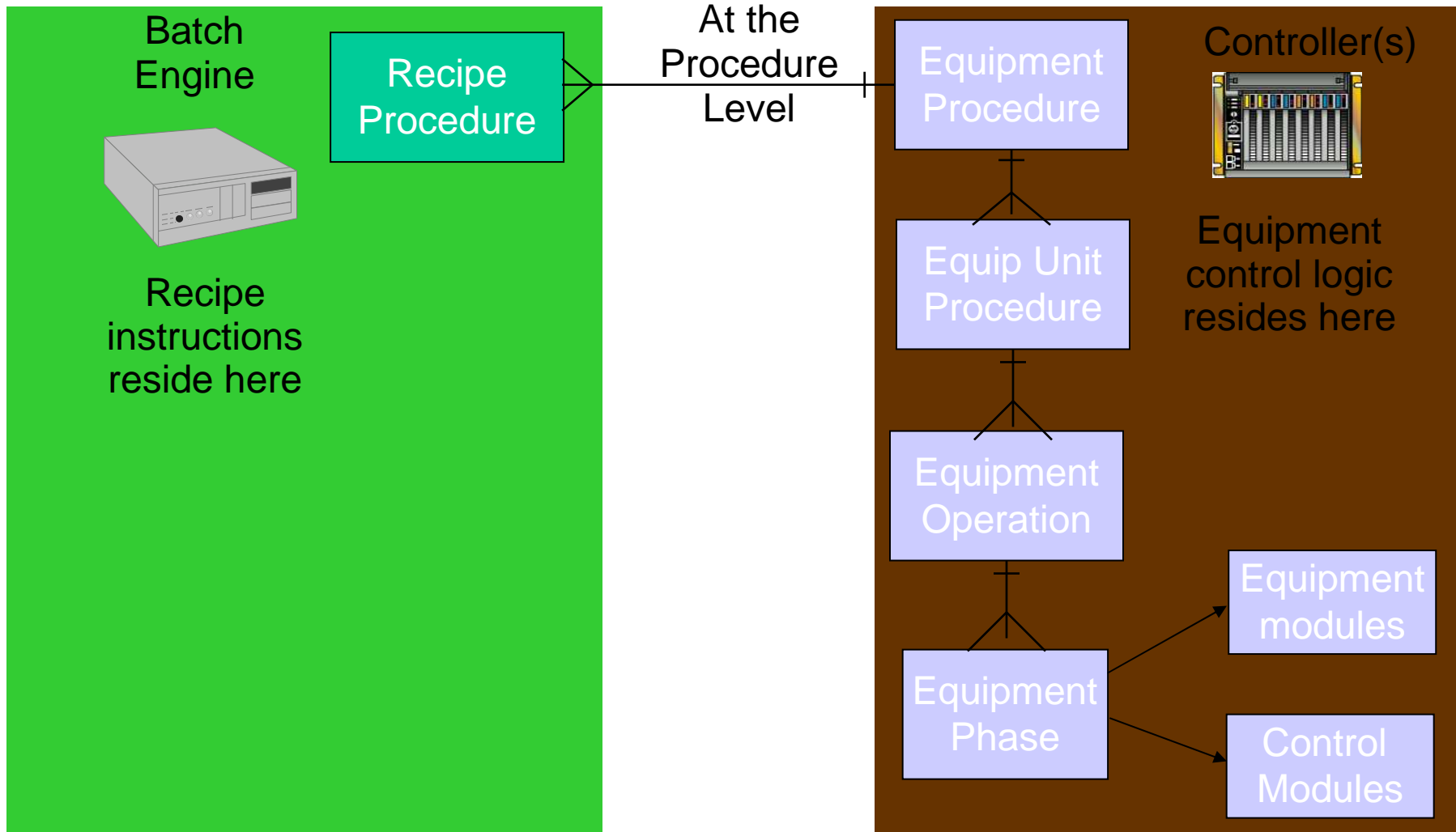
Link Procedure to Equipment Control



Link Procedure to Equipment Control



Link Procedure to Equipment Control



- ❖ Reusable engineering through modularization
- ❖ Recipe configuration much easier
- ❖ Detailed process information available

Throughput

- Faster process development
- Faster new product launches
- Reduced batch cycle time
- Faster changeover time
- Reduced downtime

Cost

- Lower engineering cost
- Improved batch consistency
- Better equipment utilization
- Less time to add or modify recipes

❖ Chevron Chemical

- 30% reduction in implementation cost
- 10% reduction in batch cycle times

❖ Eastman Chemical

- 20% reduction in batch cycle time
- Production yields increased by 5%
- Conformance to specification increased from 96% to 100%

❖ Cabot Corporation

- Increased throughput of treated silica unit by 30%
- Better production record information lead to additional process improvements

❖ DuPont

- Increased capacity of \$100 million/year fluorochemical operation by 50%

- ❖ Continuous processes have many procedural operations that could benefit from using ISA-88 principles
- ❖ Procedural control IS being used in continuous plants
- ❖ However the current applications are similar to batch applications prior to ISA-88
 - Custom code & manual procedures
 - Very little modularization

➤ Continuous Polymer Production Process:

- CST Reactor
- Reaction is exothermic
- Passes to a second vessel for residence time
- Product then goes to storage
- Two products with changes every 2-3 weeks

➤ Modularized program for each operation:

- Start-up, Shut-down, De-inventory, Restart, Reprocess, Cold Start
- Requested by operators

→ Polymer Process Benefits

- Enables a consistent product changeover time
 - Previously varied by 50%

- Improved safety
 - Safer start ups and shut downs
 - Procedure integration of an on line analyzer
 - On-line analyzer trips if:
 - Too cold – not reacting
 - Too hot – too much reactant
 - Normal operation
 - Procedural program goes into a “hold” state
 - Stays this way until operator intervention or abnormal state

- Reduced introduction time for a new 3rd product

ISA 88 Part 5

- ❖ Defines how modular automation concepts defined in Part 1 can be applied in different types of manufacturing environments

- ❖ Outgrowth of WBF-OMAC joint working group
 - Called Make2Pack
 - Use ISA-88 concepts for standardizing automation of packaging processes

- ❖ Draft -- currently undergoing major revision



→ For More Information

→ ISA site – Review the draft update standard

- www.isa88.org

→ Books

- Applying S88: Batch Control from a User's Perspective
 - Jim Parshall & Larry Lamb
- Batch Control Systems - Design, Application, and Implementation, 2nd Edition
 - William M. Hawkins and Thomas Fisher
- Design Patterns for Flexible Manufacturing
 - Dennis Brandl



→ Web site

- www.batchcontrol.com

→ WBF - The Organization for Production Technology

- Formally the World Batch Forum
- **www.WBF.org**