Application of the Process Safety Standards in the Batch Technology

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Batchcontrol

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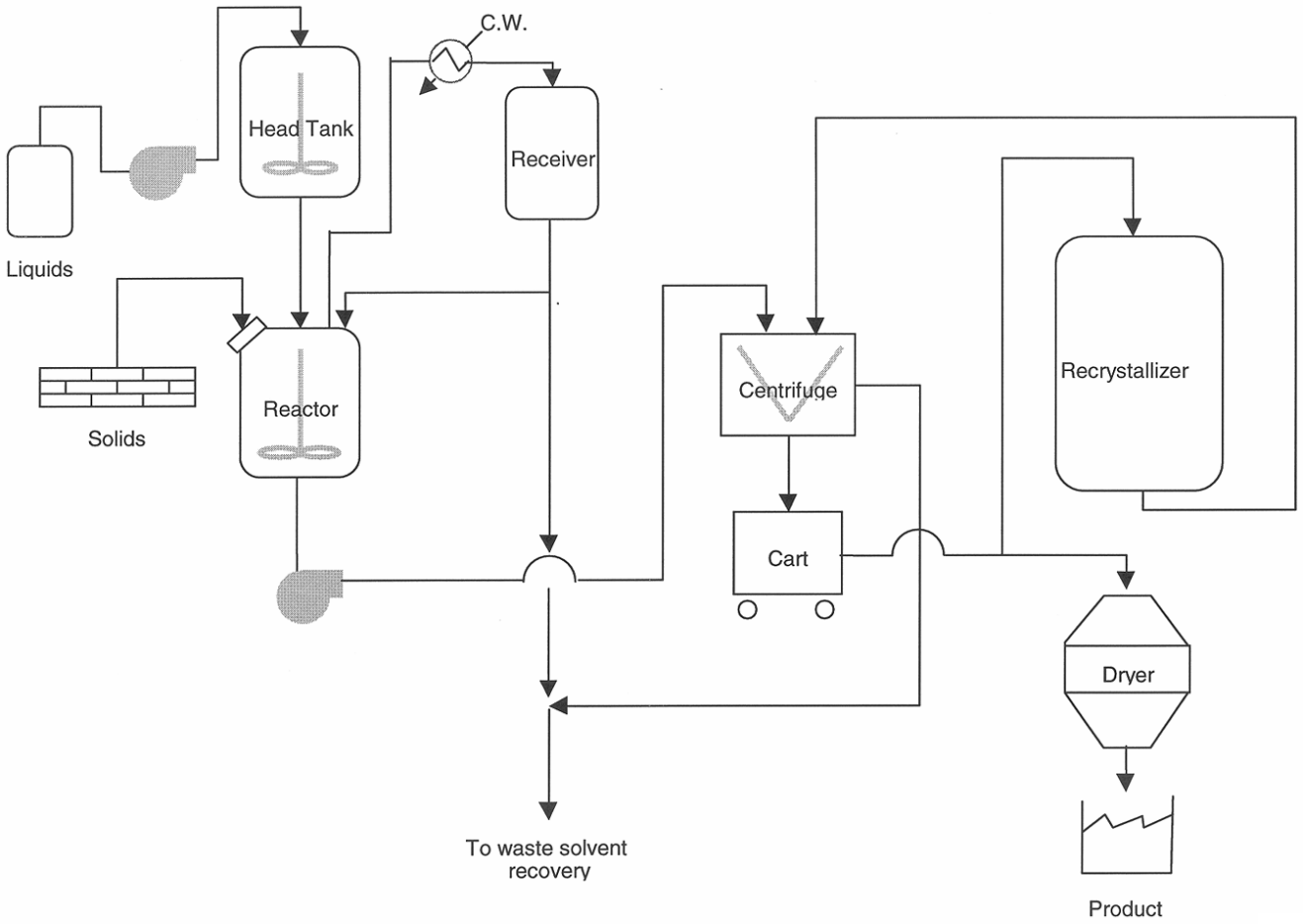
Content

- Typical batch production line
- Batch process safety differences
- Batch instrumentation and control systems safety issues
- Batch safety practices

Typical batch production line



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Safety issue points

- Chemistry
  - Understanding the behaviour of all the chemicals involved in the process—raw materials, intermediates, products, is a key aspect to identifying and understanding the process safety issues relevant to a given process.
- Equipment Configuration and Layout
  - Facility layout, electrical classification, fire protection requirement, equipment location inside the building, ventilation, etc.
- Equipment, Units
  - Equipment, units are used for different processes during its lifecycle
  - Frequent start-up and shut down sequences -> accelerated equipment aging

Safety issue points

- Instrumentation/Control Systems
  - control for a wide variety of operating conditions and a wide variety of processes
- Operations and Procedures
  - scheduling, equipment setup, cleaning, charging, executing and controlling procedure, monitoring, fault diagnosis and corrective action, sampling, handling of finished and off-spec/partially finished products, maintenance, emergency response are typical operator actions.

Instrumentation/Control Systems according to S88

- Recipe Management
- Process Management
- Equipment Control
- Unit Control
- Safety interlocking

Key issues

- Batch processes may require more monitoring in order to take supervisory action (e.g., put the system on hold if a particular manual valve is not closed).
- Discontinuous operation (idle periods) of instruments such as flow meters, pH meters, analyzers, etc., could lead to failure as a result of plugging, drying out, etc.
- Change in service may lead to inappropriate instrumentation for the current process.
- Same sensor used for basic process control system and safety instrumented system. Failure of sensor leads to loss of control system and safety system functionality.
- Variety of instrumentation leads to complex maintenance and calibration procedure, e.g., different types, different manufacturer, and ages of instrumentation leading to problems in maintenance.
- Manual mode control operation is very common leading to increased potential for human error.
- Process equipment function changes with different steps in process sequence (e.g., same vessel used as feed tank, reactor, crystallizer; buffer to pump in/out). Instrumentation and controls not kept in phase with the current process step (e.g., control set points, interlocks etc.)
- Excessive number of alarms resulting in confusion and reduction in efficiency of pinpointing the root cause of the upset.

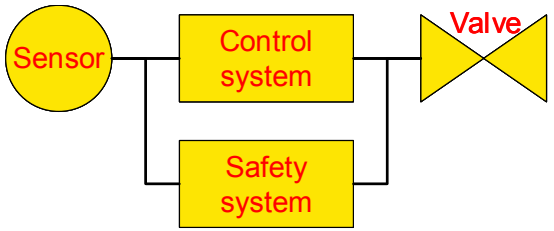
Practices

- Segregation of the batch process control system (BPCS) and SIS
- Synchronization of the process steps between the BPCS and the SIS
- Operator interaction
- Implementation of variable (recipe-dependent) trip levels
- Frequent operational state changes
- Frequent recipe changes

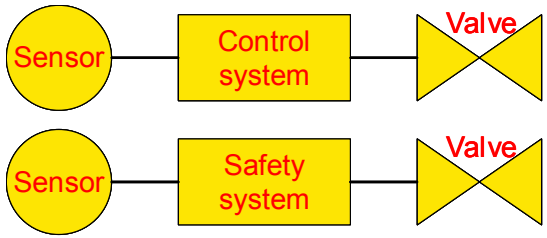
Segregation of the batch process control system (BPCS) and SIS

- Industry practices regarding the separation of control and safety are no different for batch processes than for continuous processes.

- Solutions in the industry show a separate safety system and control system where both systems are connected to the same field instruments. This industry practice is justifiable *only* when the safety system has the final vote over the output instruments.



SAFETY AND CONTROL PARTIALLY SEPARATED



SEPARATION INCLUDING FIELD INSTRUMENTATION

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Synchronization of the process steps between the BPCS and the SIS

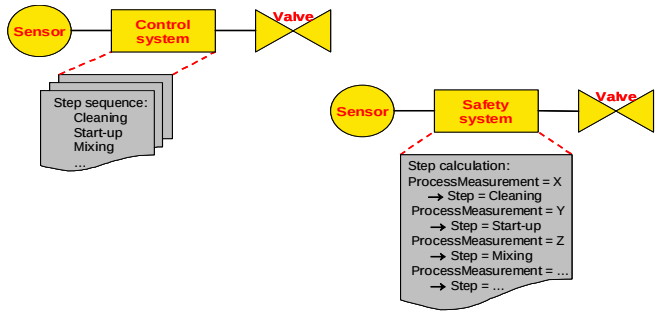
•Practice 1:

Control system transmits recipe and batch steps to the safety system. The safety system performs plausibility checks on the correctness of the step change conditions.

•Practice 2:

the safety system calculates the process step independently from the BPCS. This means that the SIS has to determine the batch step or recipe by its own measurement of valve positions, levels, pressures, or other parameters.

The batch status sensing should also be part of a safety integrity level, or SIL, assessment.



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Operator interaction

- Human operator is an integral part of the batch production process
- Operator attention may not be optimal due to the fact that the batch process is not always active
- Human operator interaction should be avoided where possible for safety-critical actions
- Using recommendations of ASM consortium for Effective Operator Display and Effective Alarm Management helps for avoiding operator mistakes.

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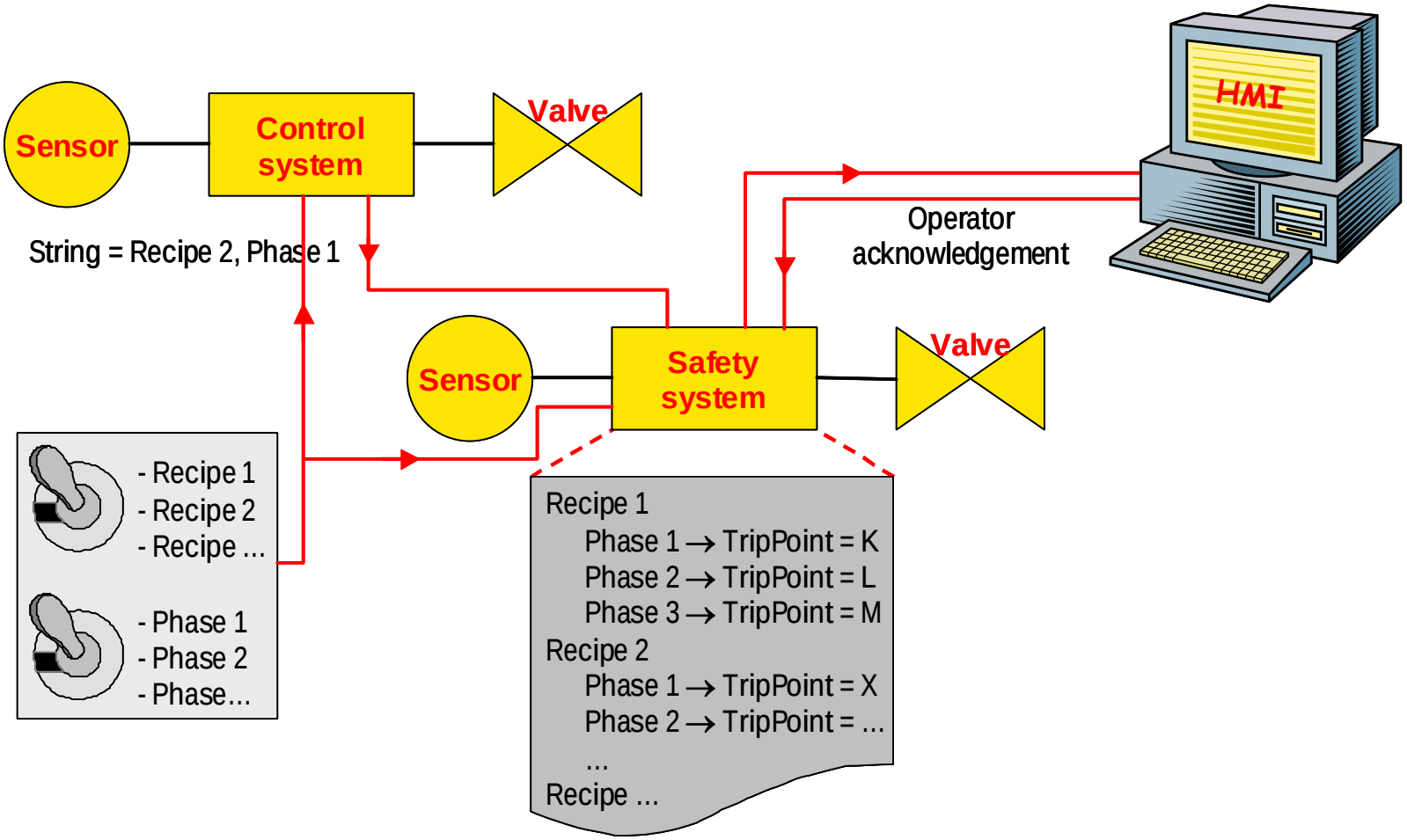
Trip level adjustment

- „Most critical” trip levels
  - related to the equipment (max. pressure, max. temperature, etc…)
- Recipe-dependent trip levels
  - implemented in the BPCS
  - recipe list and their corresponding trip levels are stored in the safety system.
    - »BCS sends the recipe code to the SIS -> the safety system displays the selected recipe, and the operator has to acknowledge the selected recipe. Only after operator acknowledgement do the trip levels change
    - »switch position changes the trip levels in the SIS according to stored recipe trip levels

Trip level adjustment



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Frequent operational state changes

Continuous processes:

start-up, normal operation, shutdown

Batch processes:

start-up, recipe dependent states, shutdown

protective functions are specific for all states and state transitions (Exception Handling)

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Frequent recipe changes

Modification of the process environment

↓

BCS modification

↓

SIS modification

↓

Revalidation

Summary

There are no available good engineering practices, recommendations, standards for batch process safety issues.

Implementation of Safety Instrumented Systems in a batch process has a number of special problems not normally encountered with continuous processes. The most dominant issue is the implementation of variable trip points.

References

- Iwan van Beurden, Rachel Amkreutz — Safety in Batch Production
- American Institute of Chemical Engineers — Process Safety in Batch Reaction Systems
- ANSI/ISA-S88.01, — Batch Control Part 1: Models and Terminology

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