Introduction to Process Control & Automation

University of Nottingham – Andrew Mieleniewski

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Industrial Food Manufacture – Process Control & Automation

- Agenda

1. Introductions
2. Introduction to batch process control
3. Control system hardware (overview only)
4. System software terminology and concepts

Why Automate?

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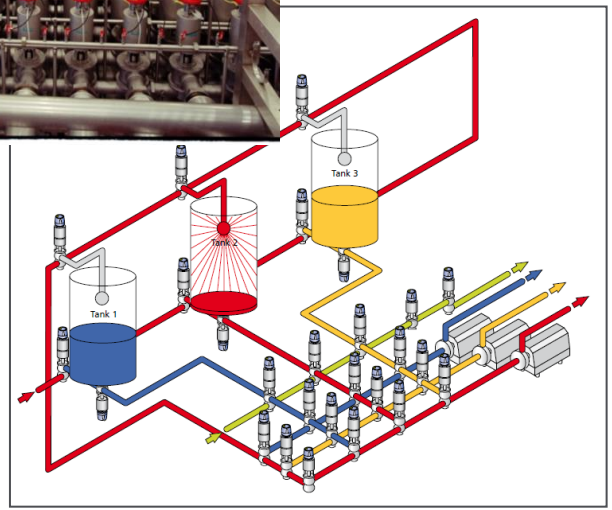
Introduction



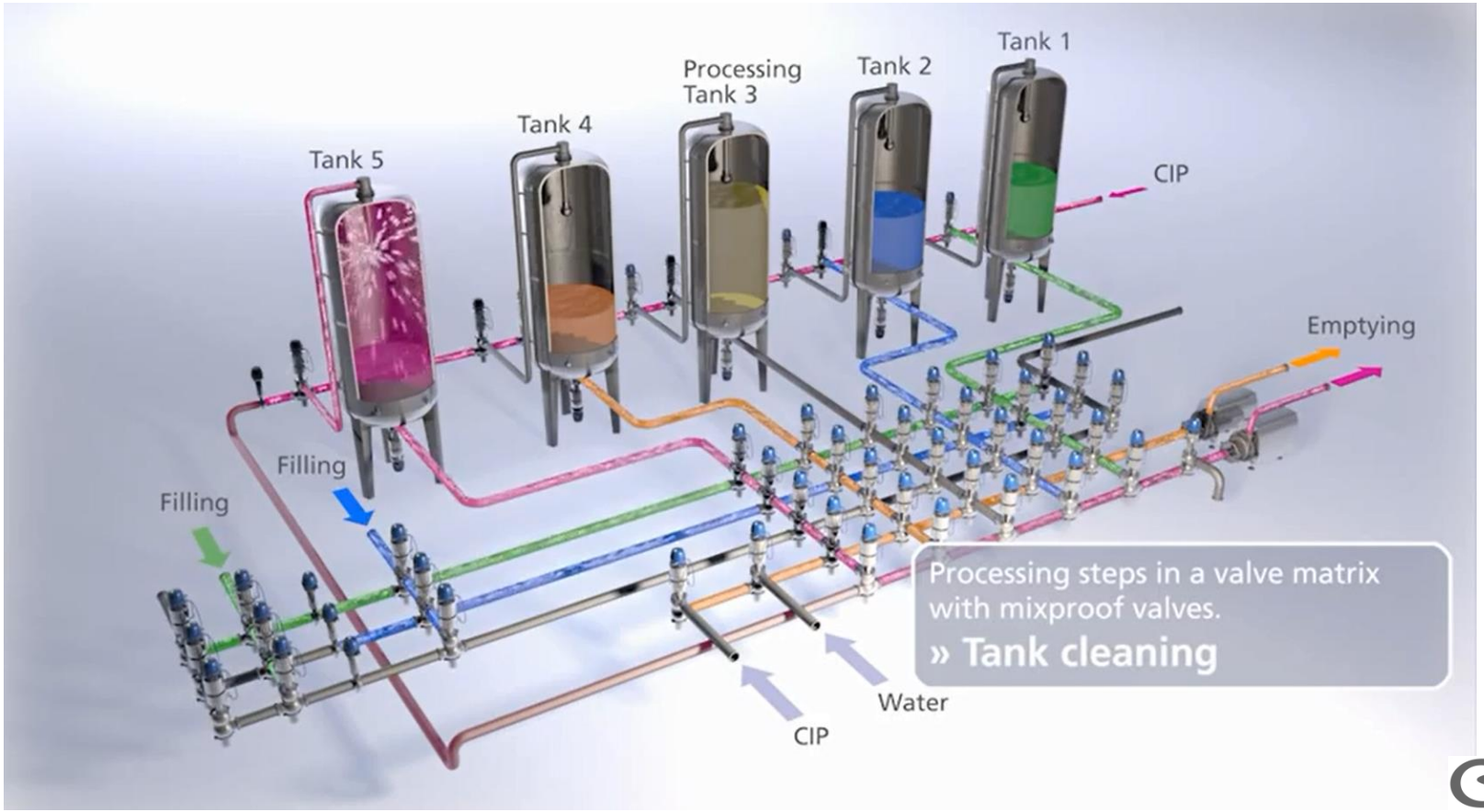
Automation is complex, expensive, and can be full of jargon and acronyms!

So why do we do it?

Three key points:

- Improvements in quality (improved repeatability and increased precision)
- Reduction in human intervention (redeploy personnel or allow more to be done for similar manual input).
- Because the underlying technology requires it (speed of response or complexity difficult for a human to provide).

Example – Storage Tank Farm Valve Matrix



Example – Storage Tank Farm Valve Matrix

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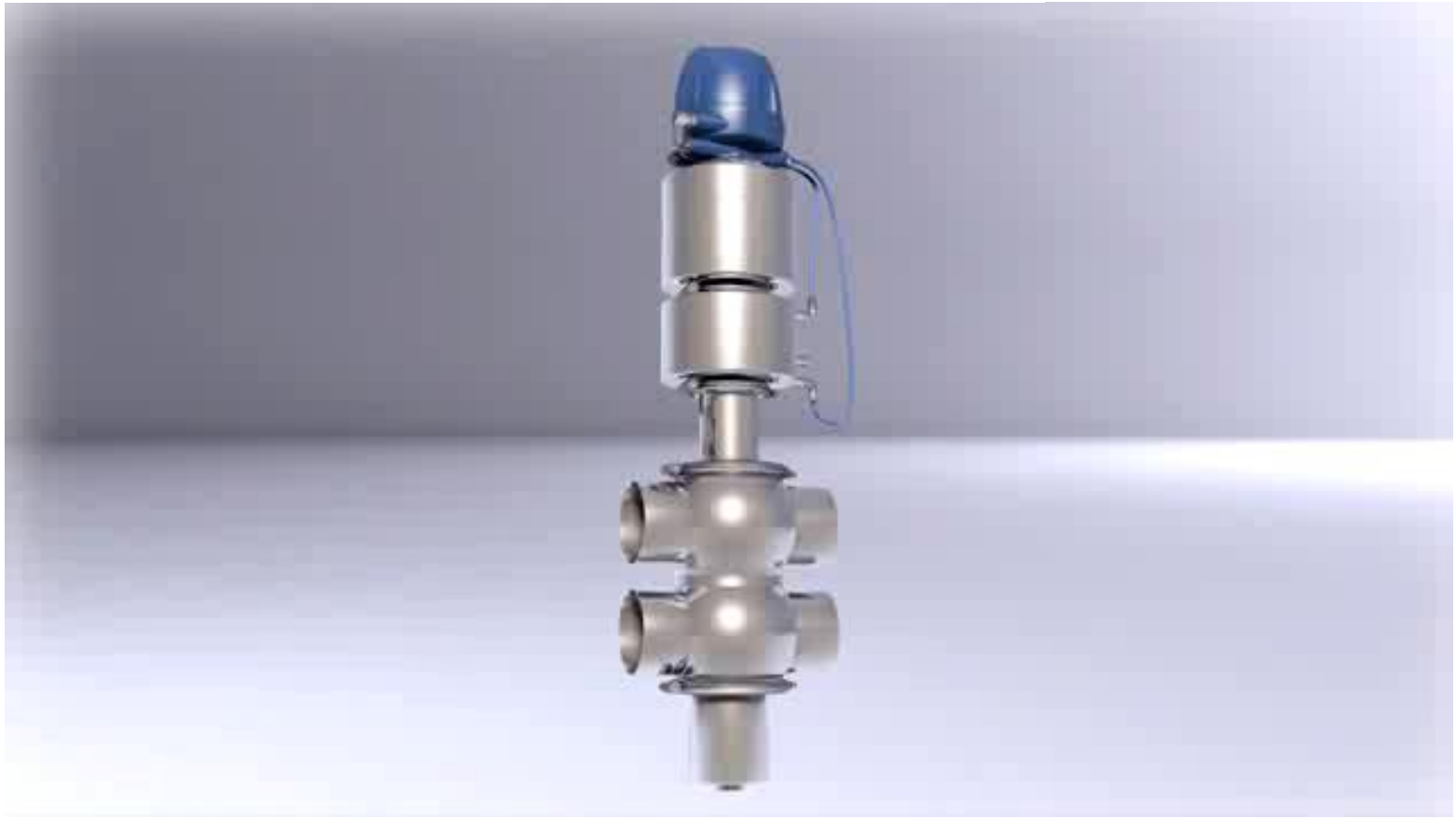

Matrix Valve Actuator

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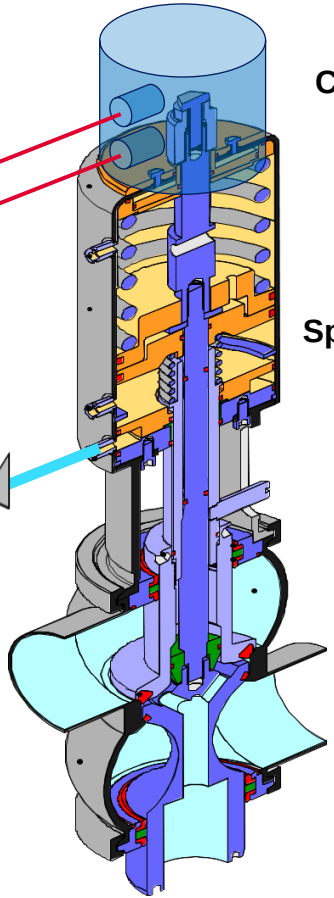
Digital control signals

- Open feedback signal
- Closed feedback signal
- Energise signal

Solenoid Valve (small electrically operated valve)

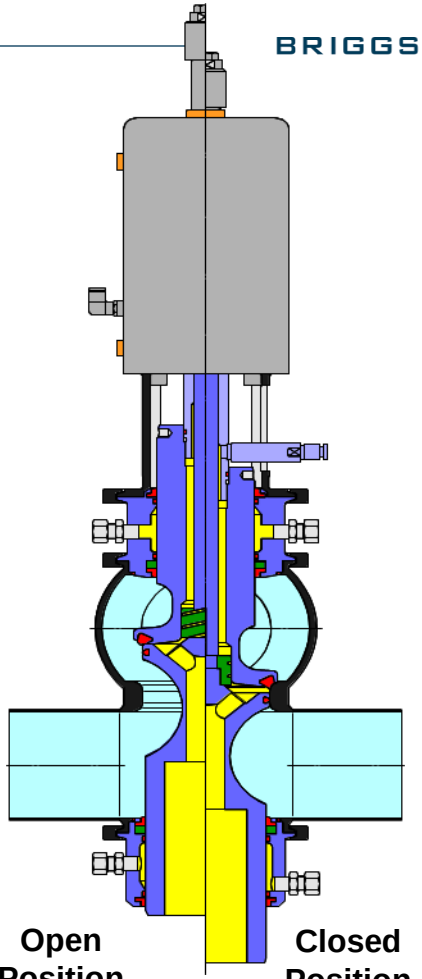
Compressed Air



Control Top

Actuator

Air-to-open
Spring-to-close



Open Position

Closed Position

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System Hardware

- PLC (Programmable Logic Controllers)
- HMI (Human Machine Interface)

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PLC Based Control System

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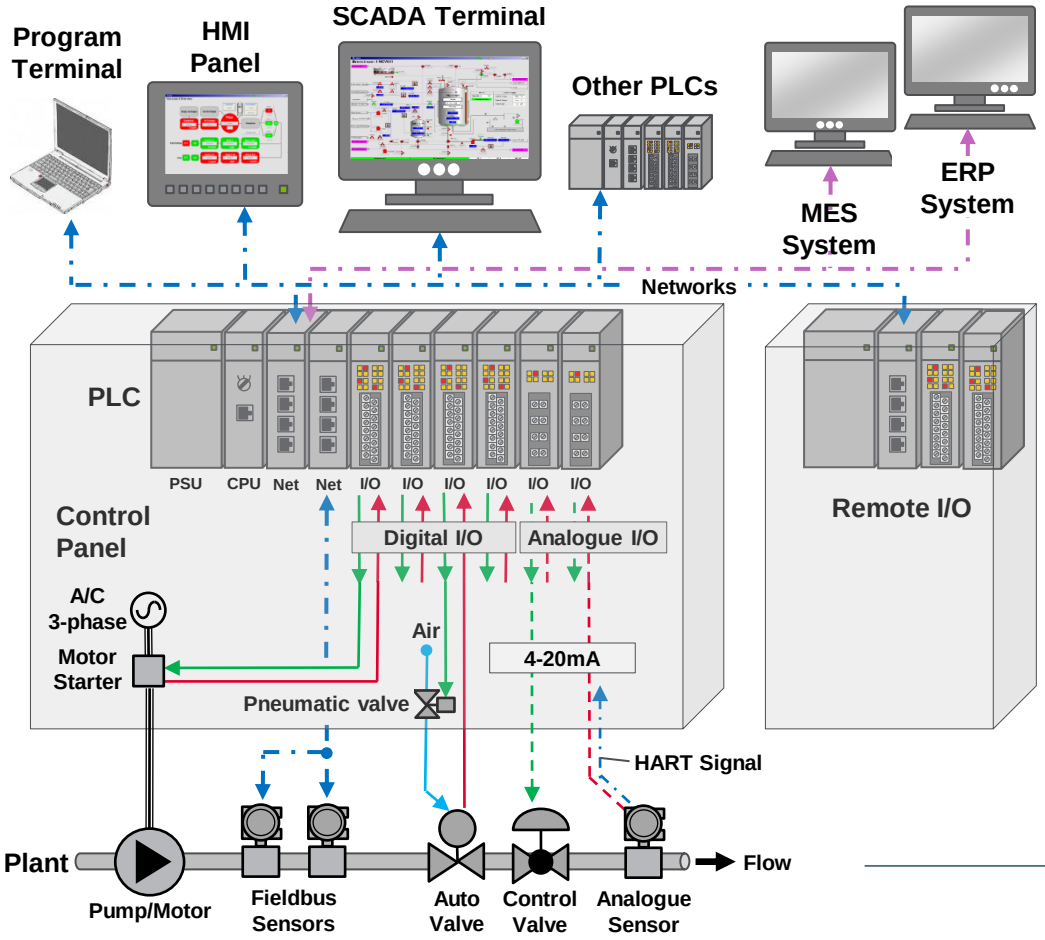

- Food & Drink Automation
  - Mainly batch sequence processing
  - Using Programmable Logic Controllers (PLC)
- Modular Rack/chassis
  - Power Supply Unit (PSU)
- Central Processing Unit (CPU)
- Network Modules (Ethernet)
  - Terminals and other systems
  - Fieldbus (smart instruments)
- Digital Input/Output (I/O)
- Analogue I/O
  - 4-20mA loops
  - HART (Highway Addressable Remote Transducers) Instruments – additional digital information
- Remote I/O
- Field Item Interface
  - Valve actuators
  - Motor Starters
- Control Panels

PLC Hardware

- PLC are industrialised
  - Rugged & reliable
  - Handle high temperatures, humidity, & electrical noise
  - mean-times-between-failures are two orders of magnitude higher than that of a PC

PLCs are proprietary closed architecture systems

- Parts and software from one manufacturer cannot be used with parts of another
- Once you have made your initial choice you will be locked into your suppliers range for future upgrades and expansions
- The two big vendors are Siemens and Rockwell

Siemens – S7 PLC

Rockwell Allen Bradley – Controllogix PLC

Cable Management

Control Panels

Valves & Instrumentation

HMI - Glen Ord Distillery Control Room

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HMI (Human Machine Interface)

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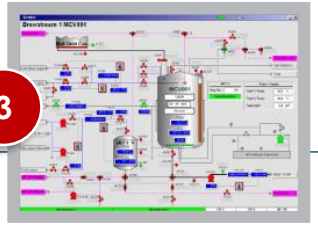
	HMI Type	Hardware Platform	Functionality							
			Batch Initiation	Batch Supervision	Alarm Handling	Plant Visualisation	Data Trending	Diagnostic data	Recipe handling	Batch Scheduling
4	MES (Management Execution System)	General Business PC	-	-	Yes	Yes	Yes	Yes	Yes	Yes
3	SCADA (Supervisory Control and Data Acquisition)	Dedicated PC	Yes	Yes	Yes	Yes	Yes	Yes	Limited	Limited
2	HMI Graphic Terminal	PLC Proprietary	Yes	Yes	Limited	Limited	Limited	No	No	No
1	Lamps & push buttons	Component	Yes	Limited	No	No	No	No	No	No



System Software

- Ladder Logic
- System Size
- Control Loops
- Software Development
- State of the Art Systems

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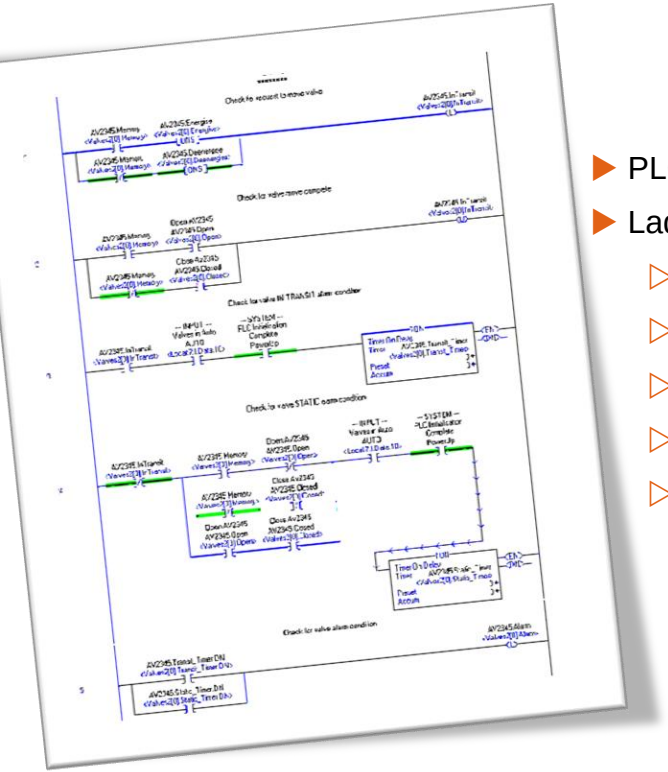
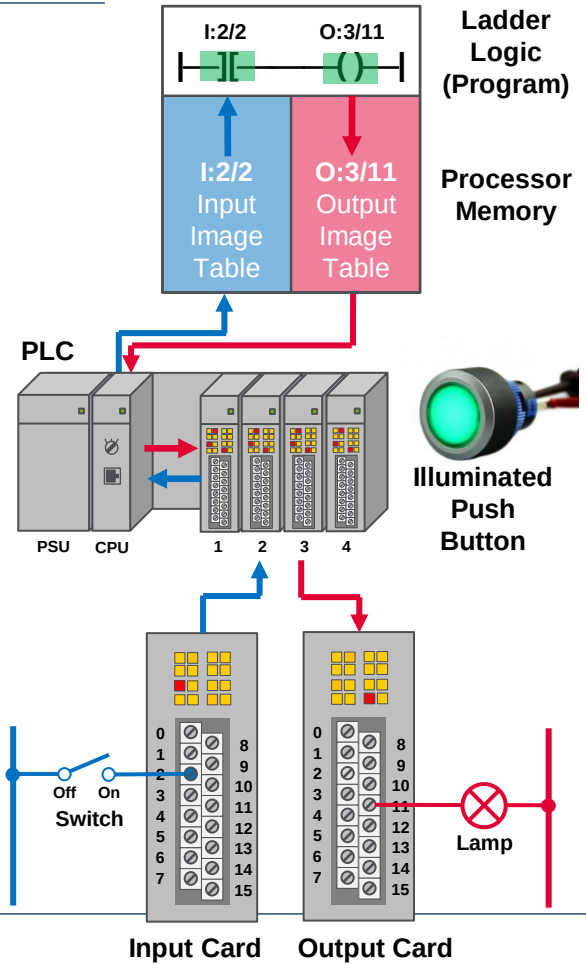
Software – Ladder Logic

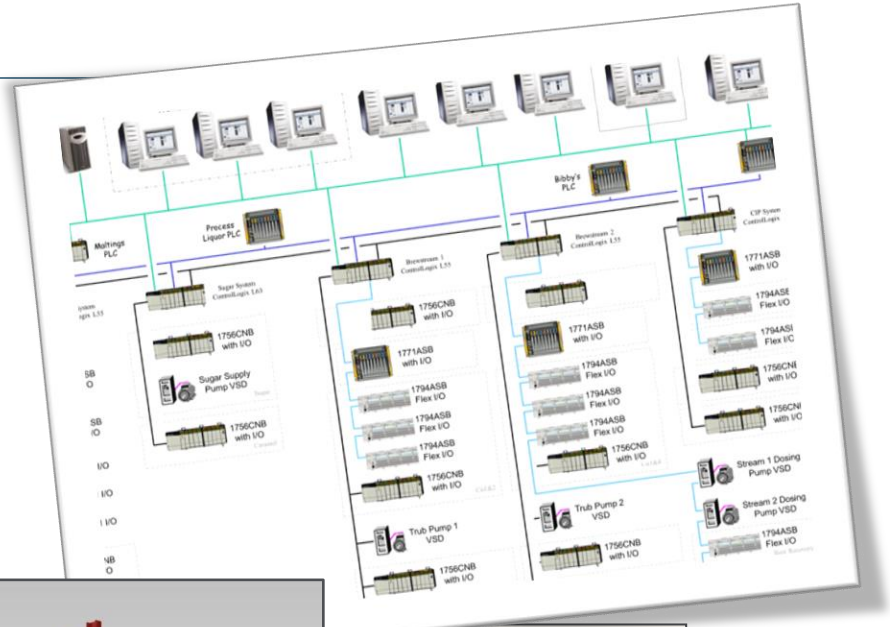


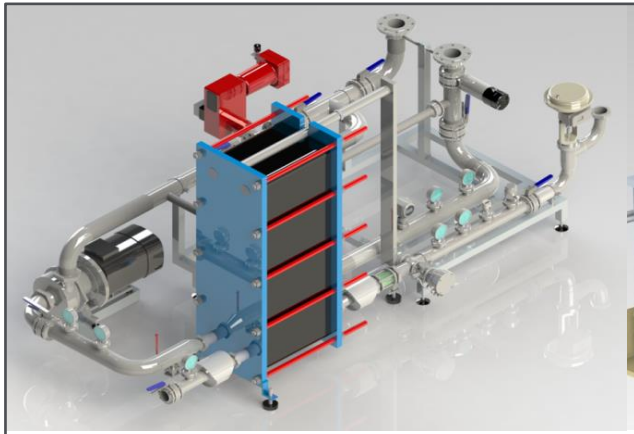
- PLC Software – Ladder logic
- Ladder logic
  - Replicates relay logic
  - Logic conditions on left
  - Outputs on right
  - Rungs processed sequentially
  - Scanned many times per second



System Size

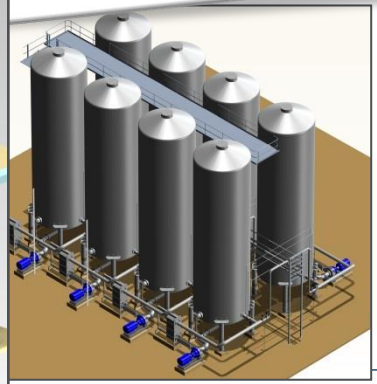
- Hardware Setup
  - Proportional to I/O points (# Racks → # Chassis)
  - Each valve could have 3 I/O points
  - Large systems can have 1000's of I/O points
- Software
  - Proportional to I/O
  - Process complexity is a factor





Chiller with 12 I/O points

Brewhouse Vessels with 126 I/O points



Control Loops – PID Controllers

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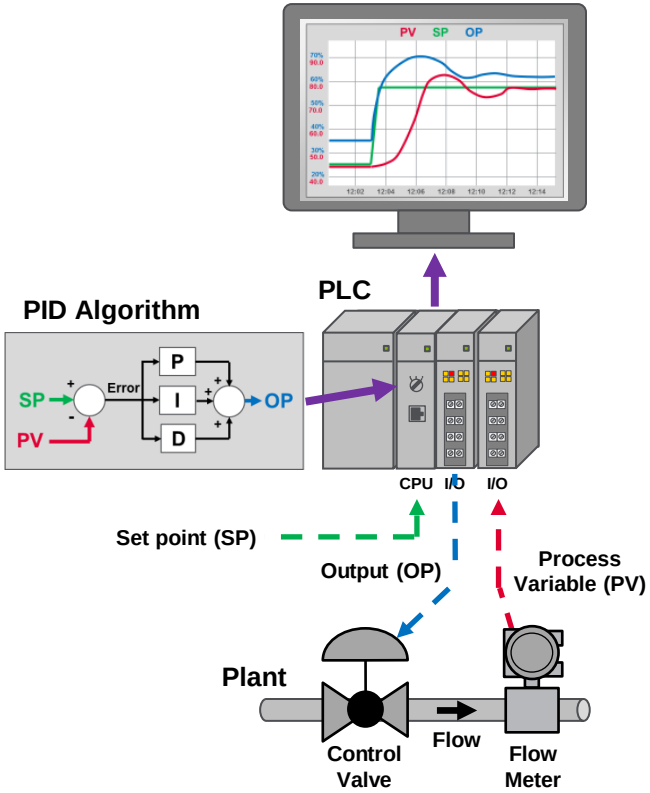

- **Feedback control loops** are often used and have three elements:
  - **Process Variable (PV)** – measurement of the parameter to be controlled
  - **Set Point (SP)** – required or target value of the process variable
  - **Output (OP)** – output from the control loop
- Common feedback loop controller is a **PID controller**.
  - **Proportional (P)** – the output value is changed in proportion to the size of the error
  - **Integral (I)** – the output value is changed in proportion to the duration of the error
  - **Derivative (D)** – the output value is changed in proportion to the rate of change of the error.
- The ratio of each of the three terms can be varied thereby **tuning** the loop to give good control.
- PID controllers used to be separate electronic units but now usually algorithms built into the PLC software.

Software Development

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User	Design Engineer	Software Developer	Notes
URS (User Requirement Specification)			Defines automation requirements from users point of view
	FDS (Functional Design Specification)		Detailed definition of how the automation system works
		Software Development	Development structured by in-house and/or customer coding standards
	Internal Testing / software simulation		In-house testing of software code and function – most bugs removed at this point
Customer Acceptance Testing (CAT)			Functional demonstration of system requirements
	Field Testing / Commissioning		Parameter setting, fine tuning, and hopefully only minor changes to support process commissioning

Getting the specification right

Writing Code

Testing & Verification

State Of The Art Systems

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1

Process Control

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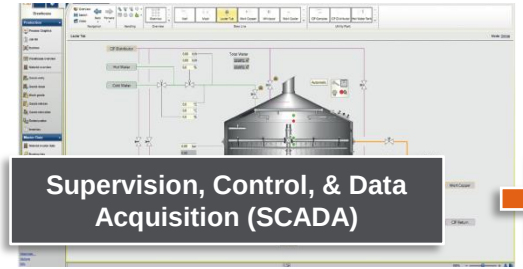

Supervision, Control, & Data Acquisition (SCADA)

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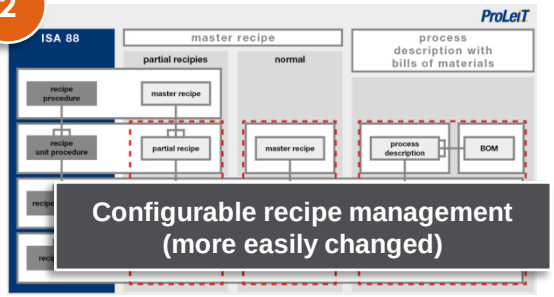
Management Information & Execution (MES/MIS)

In one system

2



Configurable recipe management (more easily changed)

3

Parameterised software development - No ladder logic coding

For example – brewmaxx by ProLeit

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Mobile data monitoring

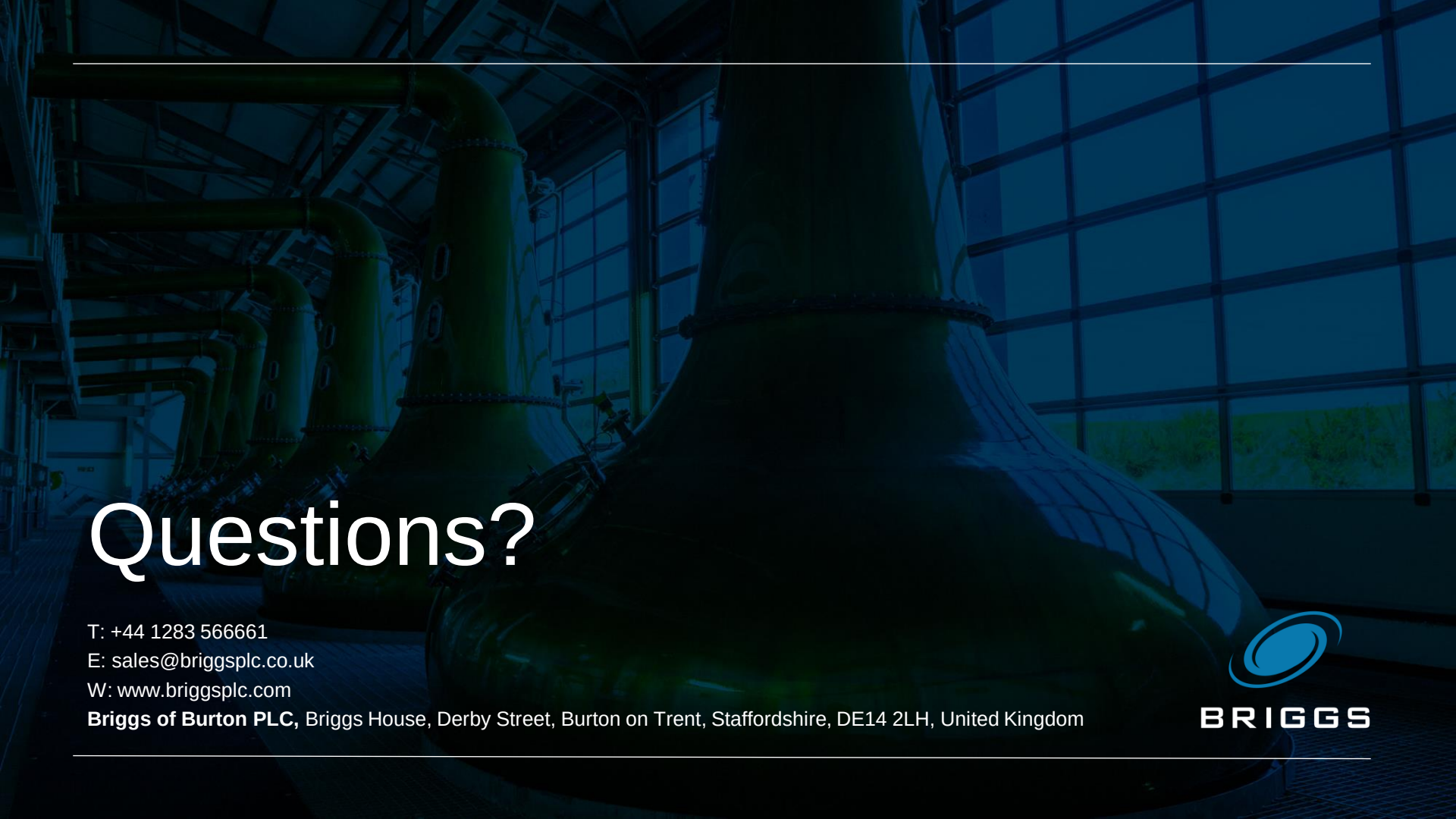
Rockwell Automation

MITSUBISHI ELECTRIC

SIEMENS

5

Run on multiple PLC hardware platforms



Questions?

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