UNICOS: UNIFIED INDUSTRIAL CONTROL SYSTEM

CPC (CONTINUOUS PROCESS CONTROL)

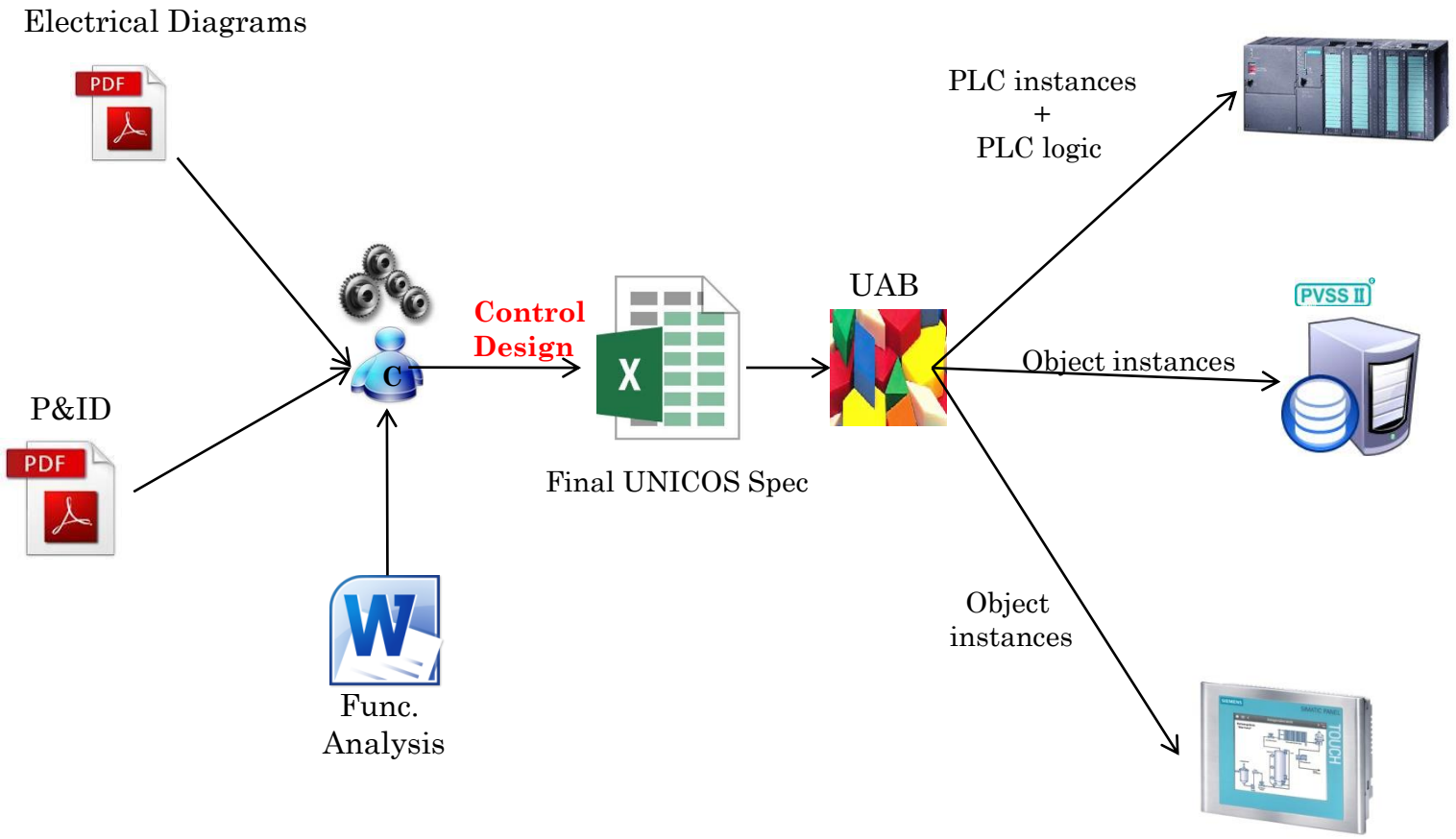
PROJECT SPECIFICATIONS

CERN BE/ICS group

Project Specification: Content

- **Introduction**
- **Hardware architecture** *[vsd]*
  - Contain the PLC/SCADA architecture
- **Electrical Diagrams** *[pdf]*
  - Contain electrical schema of the cubicle with all PLC I/O connections
- **P&ID** *[pdf]*
  - Piping and Instrumentation Diagram
- **Functional Analysis** *[docx]*
  - Describe the automatic behavior of the process
- **UNICOS Spec** *[xlsx]*
  - Used to generate PLC program and SCADA instances

UNICOS-CPC TOOLS



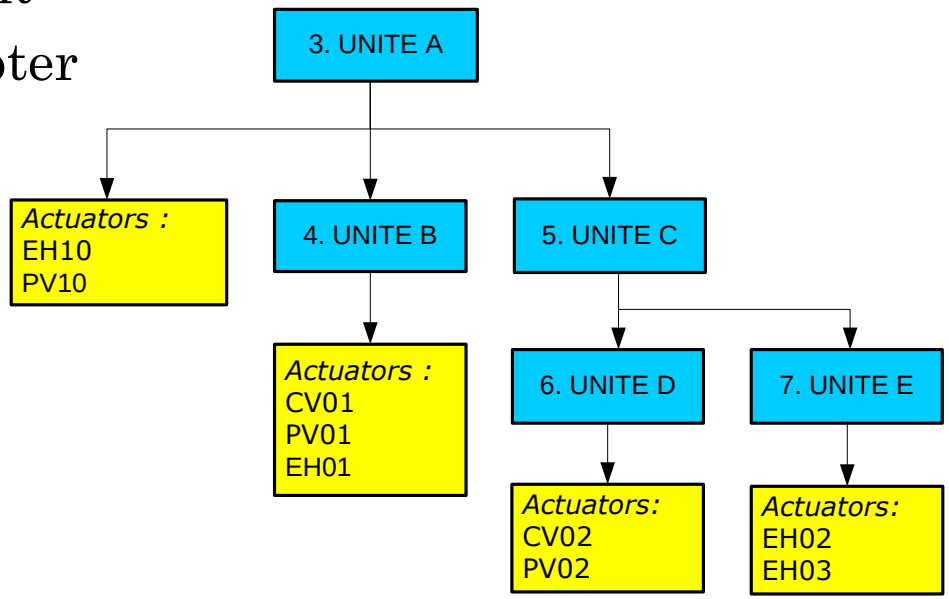
Functional Analysis

- Descriptive document (based on ISA-88)
  - Oriented for Continuous Process Control (CPC)
  - Exhaustive document
  - No PLC language inside
  - No platform oriented
  - Drawings and diagrams can be used

- Describe the automatic behavior of the process
  - General description of process
  - Decomposition of the process into control units
  - Exhaustive descriptions of unit behaviors
  - Exhaustive descriptions of actuator behaviors
  - Exhaustive descriptions of regulation loops
  - Exhaustive descriptions of alarms and interlocks
  - Exhaustive descriptions of possibilities given to operators

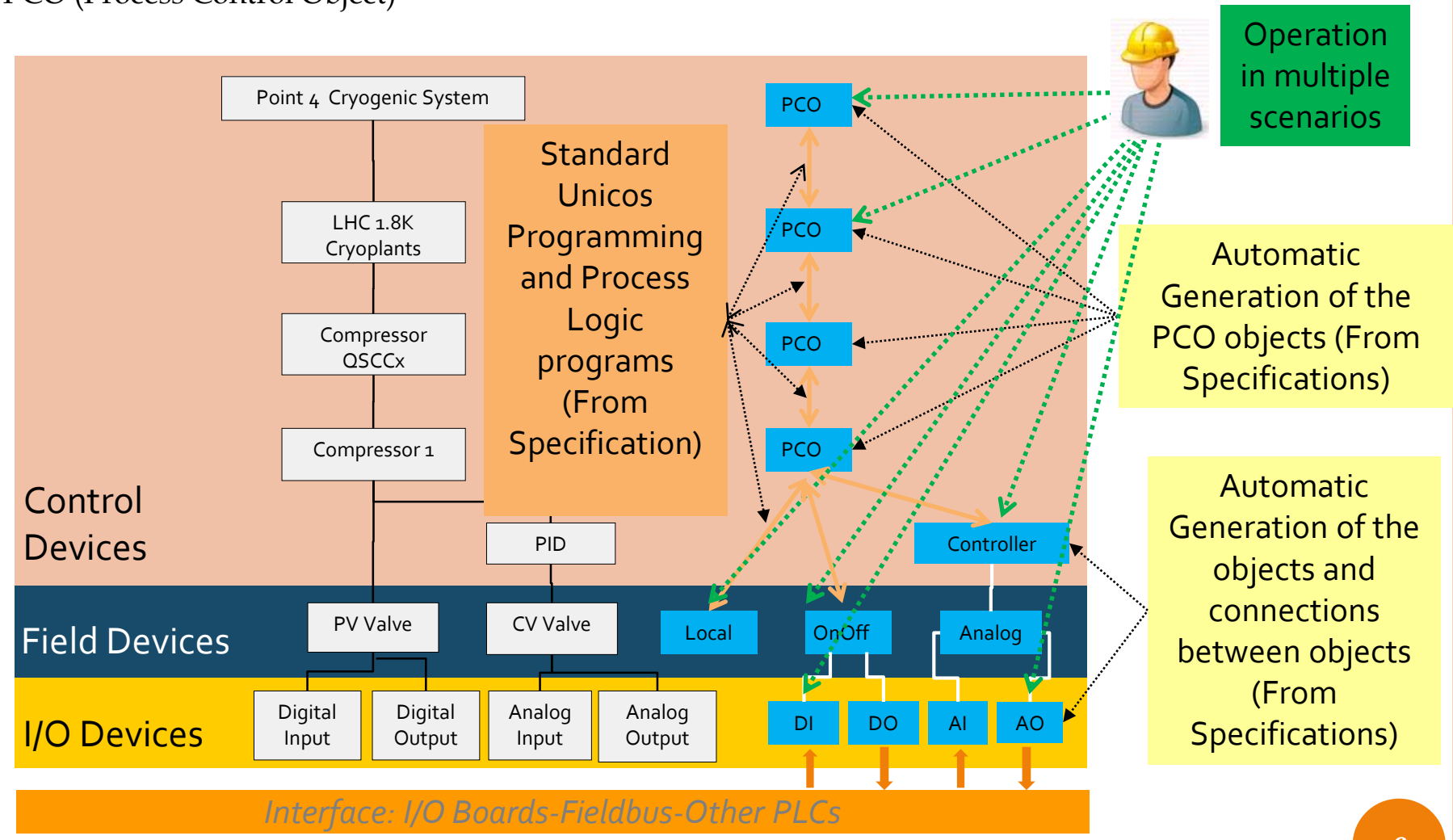
Functional Analysis

- Chapter 1: Introduction
- Chapter 2: Description of process
- Chapter 3,4,5, etc. : Control units
  - Follow the process decomposition (Plant Hierarchy)
  - One chapter per unit
  - 10 paragraphs/chapter



PROCESS VS. CONTROL

-Each control module or equipment module is a device
-Equipment modules and Units are embedded in a unique object class:
PCO (Process Control Object)

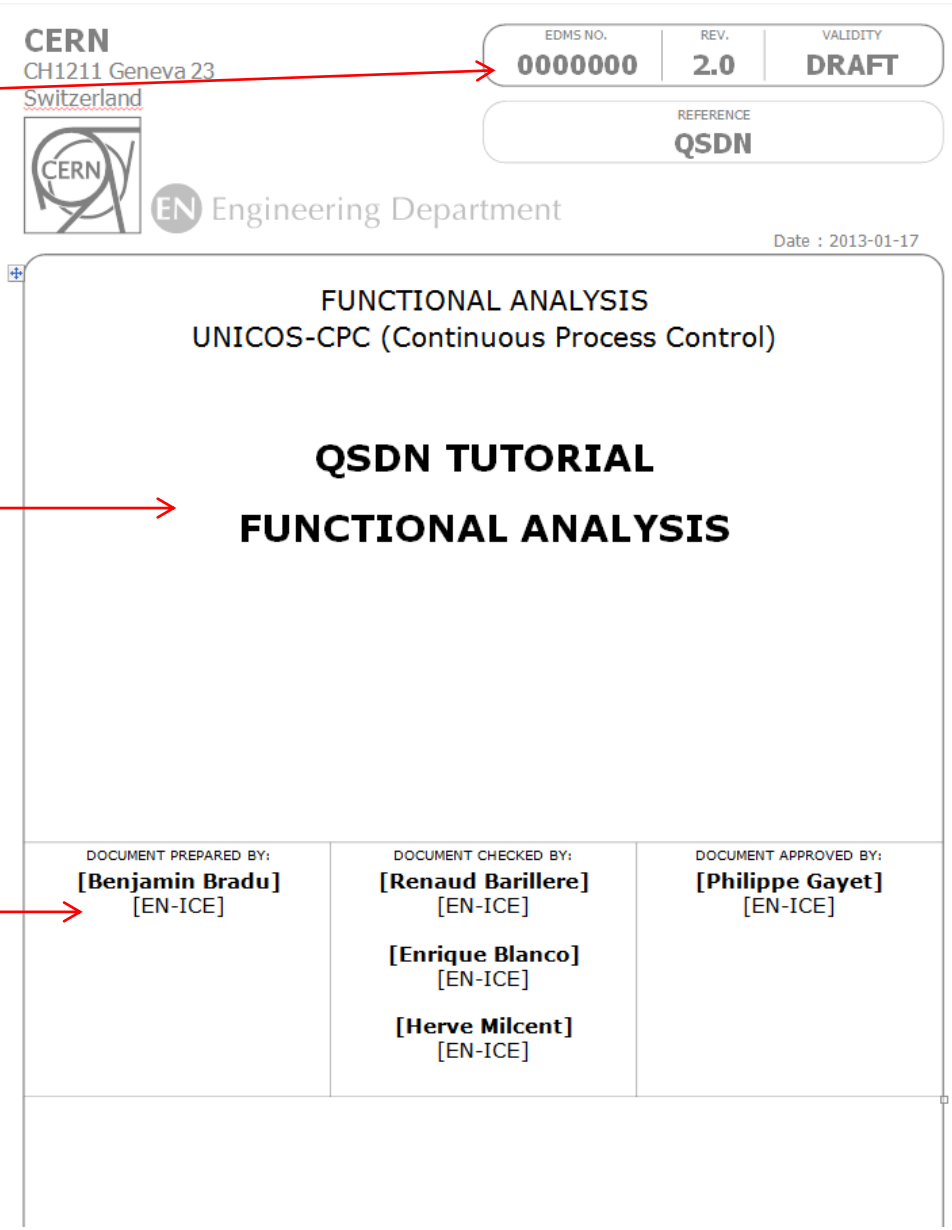


Title Page

EDMS Number and revision (CERN Database)

Application Name (Unique at CERN)

Name of involved People



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REFERENCE QSDN

EN Engineering Department

Date : 2013-01-17

FUNCTIONAL ANALYSIS
UNICOS-CPC (Continuous Process Control)

QSDN TUTORIAL

FUNCTIONAL ANALYSIS

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1. Introduction

- Brief explanation of the general context of the project
  - Can give main engineering data of the process (capacity, power…)

An example is given here for a functional analysis for the control system of the QSDN_TUTORIAL which is composed of 2 nitrogen storage vessels of 100 m^3 each.

This example has been extracted from a CERN existing process and adapted to perform a tutorial adding some actuators and functionalities.

1.1 TERMINOLOGY

- **Actuator:** defined as *control module* in IEC 61512-1:
  - A piece of equipment acting on the plant
  - Acts as a single entity from a control standpoint
  - Is the direct connection to the process and can embed sensors
  - Cannot execute procedural sequences
  - Examples: valves, motors, pumps, fans etc.
- **Unit:** defined as *unit* or *equipment module* in IEC 61512-1:
  - Collection of actuators and/or other units
  - Can carry out a finite number of minor processing activities
  - Contains all the necessary processing equipments to carry out these activities
  - Can execute procedural sequences
  - Examples: Compression station : 3 compressors + 4 valves
- **Controller:** Regulation algorithm able to control a process variable (ex: PID controller)
- **Object:** Unit or Actuator or Controller
- **Operational State**: unit can be setup in different operational states (ex: Cooling, Heating).

1.1 TERMINOLOGY

- **Interlock**: Asynchronous condition stopping an actuator or a unit or preventing from starting for security reasons. An interlock must not be used for normal operation but for abnormal behaviour. Software interlocks are not guarantying human security.

- The possible interlocks for a complete unit or for an actuator are:
  - **Full Stop Interlock (FS)**: Stop the unit/actuator (all dependent units/actuators are set to their fail-safe position) and wait manual acknowledgement before restarting.
  - **Temporary Stop Interlock (TS)**: Stop the unit/actuator (all dependent units/actuators are set to their fail-safe position) and restart automatically when the interlock disappears.
  - **Start Interlock (SI)**: Prevent the unit from starting (all dependent units/actuators stay in their fail-safe position).

- **Alarm (AL)**: It is an indication of a potential problem to aware operator in SCADA.
  - Each interlock is generating an alarm automatically

- **User command**: Specific operator order to specify a particular action.

- **Computed Variables**: Values computed from a set of I/O signals or from parameters.

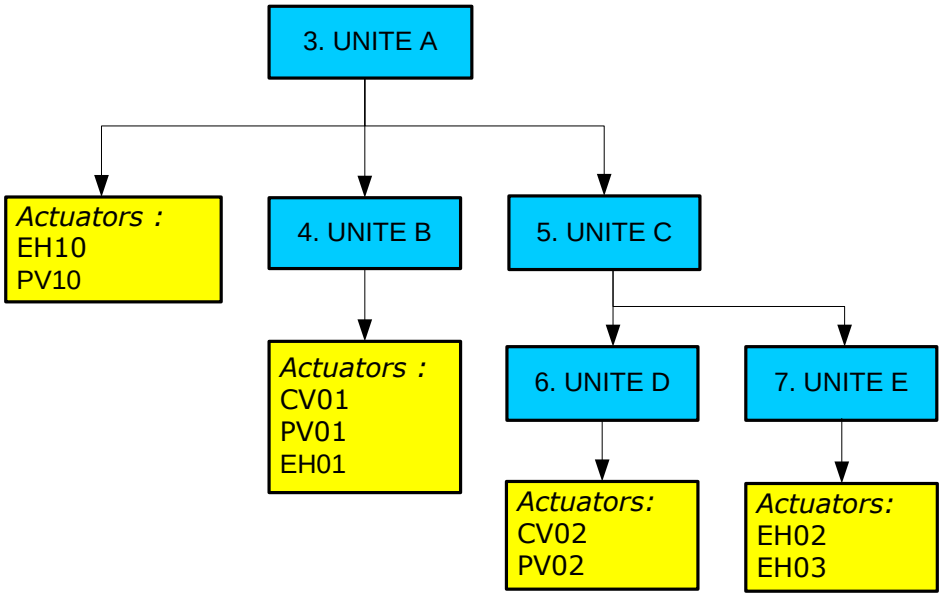
2. Process Description

- 2.1 General consideration
  - Description of process, its objective and its task to perform
  - You can explain briefly the different behaviours of the system here in subparagraphs if necessary.

The QSDN represents 2 nitrogen storage vessels of 100 m^3 each. They can provide liquid nitrogen to cryoplants via 2 on/off valves (xPV409). Moreover, each vessel can be filled from a nitrogen truck and the internal pressure of vessels is regulated by an electrical heater xEH400. Each vessel has also a gas outlet xPV408 to provide warm gaseous nitrogen.

2. Process Decomposition

- The process decomposition must respect all the following constraints:
  - Top to Bottom
  - Modular
  - Hierarchical
  - Structured



X. Unit

- X. Unit
  - Introduce briefly the unit and its aim

This unit represents the vessel number 1. Its internal pressure should be controlled.

- X.1. Controlled objects
  - X.1.1. Unit
  - X.1.2. Actuators
    - Specify range and speed
  - X.1.3. Controllers

Actuators

- 1CV400: Filling Valve
  - *Range: 0-100 %*
  - *Speed: 2%/s*
- *1EH400: electrical heater driven by PWM*
  - *Range: 0-72 kW*
  - *Speed: 1kW/s*
  - *PWM period = 2s (min pulse = 0.2s)*

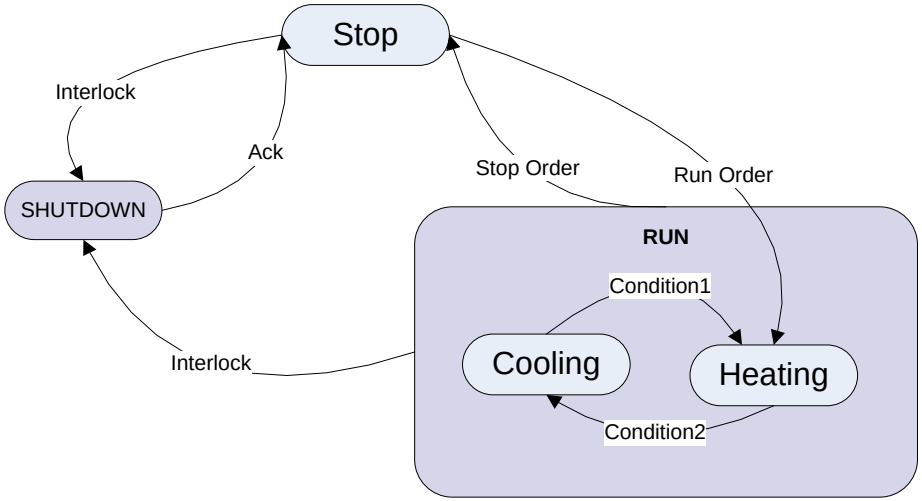
- *1PV408: onoff Valve going to dryer*
- *1PV409: onoff valve going to precooler*

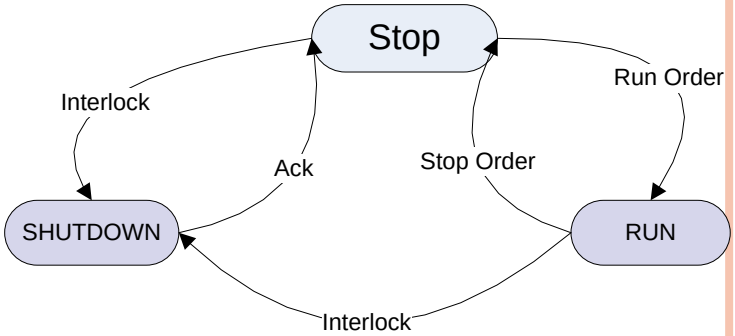
Controller

- 1PC400: Pressure Controller

X.2 Operational states

- X.2 Define the operational states of the unit
  - Makes use of a process control diagram





- X.2.1. Define operational states

Mode « STOP » : everything is stopped and there is no interlock on the unit.

Mode « SHUT DOWN » : The process is stopped because an interlock was triggered and it has not been acknowledged

Mode « RUN » The motor is running and the temperature is controlled

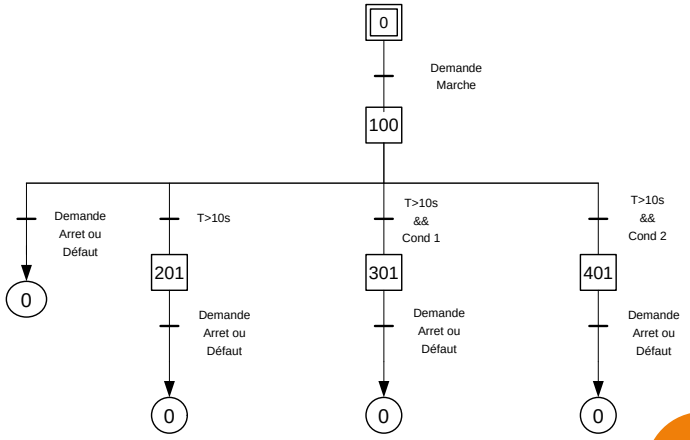
X.2 Operational states

- X.2.2. Transition condition
  - Eventual complex transition

Condition1 = valves CVXX is openned more than 10 sec and the pressure PTXX is below 1 bar.

- X.2.3. logical sequence
  - Inside an operational states, you can define sequences
  - Text or sequential chart

When we enter in the state "Cooling":
- Open valve PV01
- Wait10s
- Start regulation PC01
- Wait CV01 >10%
- Close PV01

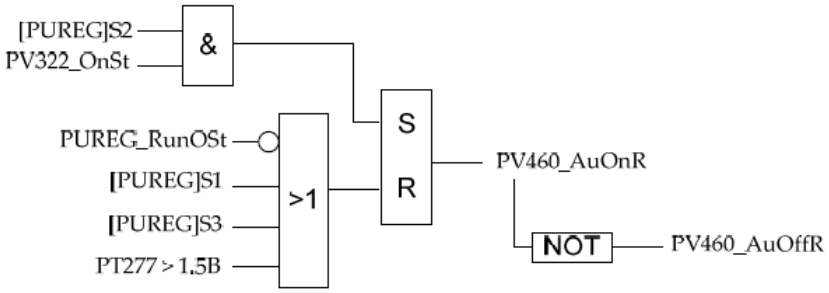


X.3 Actuator behaviour

- X.3 Actuator Behaviour
  - 3 possibilities according to the process
    - Behaviour = f(operational states) ➔ Table
    - Behaviour = more complex➔ Structured English or Block Diagrams

Unité/actionneurs	*Stop*	*Mode1*	*Mode2*	*Mode3*
Unit B	*OFF*	*OFF*	*ON*	*ON*
CV01	*0%*	*10 %*	*Controlled by PC01 SetPoint = 2 bar*	*Controlled by PC01 SetPoint = 1 bar*
EH01	*0kW*	*1 kW*	*50kW*	*10 kW*
PV01	*OFF*	*OFF*	*ON*	*OFF*

CV01
- *Position = 0% if UnitA=Stop and PT01<5 bar*
- *Position = 5% if UnitA=Stop and PT01>5 bar*
- *Position = 10% if Unit1= mode2 and PT01 <5 bar*
- *Position = 20% if Unit1= mode2 and PT01 >5 bar*
- *Regulée par PC01 if Unit1= mode2 or mode3*

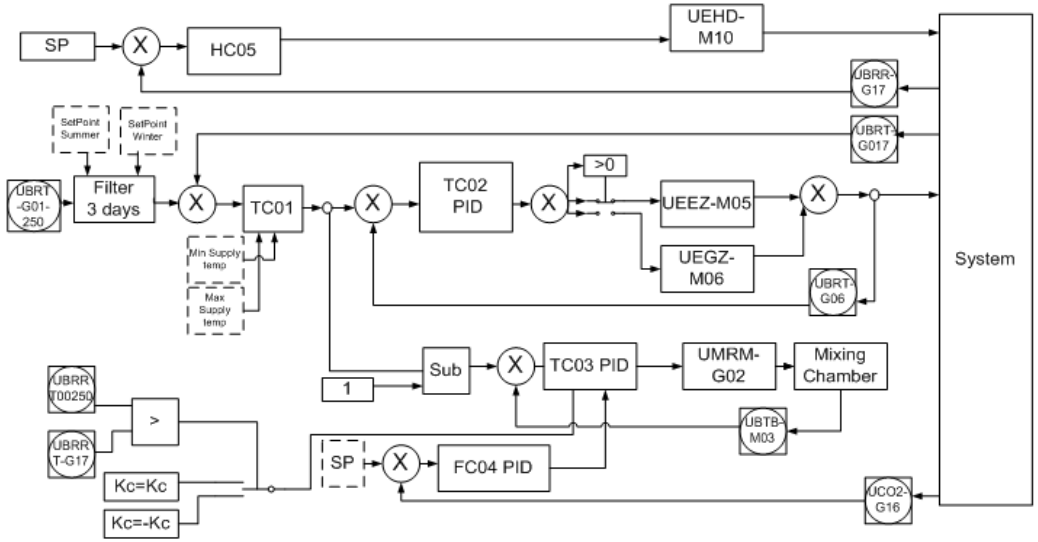


X.4 REGULATION LOOPS

- Description of regulation loops
  - Simple text description if simple loops
  - General schema if complexe cascades

TC02

- **Function**: Supply temperature regulation
- **Controlled variable**: UBRT-G06 (ºC)
- **Output Range:** -100%.. 100%
- **Reverse Action**:No
- **Controlled actuator**:
  1. UEEZ-M05 (0..100%)
  2. UEGZ-M06 (-100%..0%)
- **PID default parameters**: Kp/Ti = 0.7/600s
- **SP:** given by TC01
- **Set Point speed:** 1C/min



User command and parameters

- X.5. User commands and parameters
  - Dont contain standard user commands
    - Run/Stop Order on units/actuators
    - Setpoint/parameters/limits of controllers

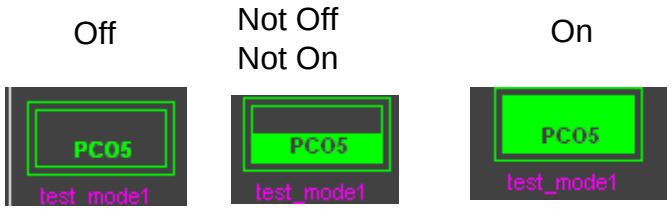
***DN1CT_Fill**: Operator order to fill-in vessel 1. When the vessel is in Run Mode, this button must be disabled.*

- X.6. Computed variables
  - Definition of calculation necessary to mak the installation working or to display in SCADA
    - Thermodynamic properties
    - Working time of a pump

Nom, description	Type	Unit	Calcul
LT1 Level in percentage	Real	%	LT1 = (M1 * 50)/100
P1_Time	INT	hr	Working time of the pump P1

STATUS AND EVENTS

- X.7 unit feedback
  - Allow to compute the unit feeback in SCADA
    - On: unit is considered as running
    - Off: unit is considered as stopped
  - Display in SCADA:



- X.8. Events
  - Can define significant events for a set of actuators

Overflow = tank level >90% and valve CV01 > 90%.

X.9. UNIT ALARM

- List and classify all alarms/interlocks having an impact on the **full unit.**
- **Consequences**:
  - The unit receives a stop request
  - All dependent actuators will pass to auto mode (except if they are forced)
  - After the stopping of the unit, all dependent actuators can be taken in manual mode again

Name	Condition	Action*	Message
UAVA_002_FS1	UMFV_M10 is in Full Stop	FS	Interlock Moto-Ventilateur UMFV.M10
UAVA_002_FS2	UBTA_M06_002 for 30s	FS	UAVA is FREEZING
UAVA_002_AL1	UAVA_UBAY_M03_002	AL	Filter UFPZ.03 full
UAVA_002_AL2	UAVA_UBAY_M05_002	AL	FilterUFFM.05 full
UBT2_M08_002_AL	UAVA_UBT2_M08_002 > 12C (H)	AL	Return chilled temperature too high

**FS = Full Stop Interlock ; TS = Temporary Stop Interlock ; SI=Start Interlock ; AL=Alarm*

X.10. ACTUATOR ALARMS

- List and classify all alarms/interlocks having an impact on a **single actuator.**
- **Consequences**:
  - The actuator goes in its fail-safe position
  - Impossible to send Manual/Forced actions on the actuator during interlock

Name	Condition	Action*	Message
UMFV_M10_002_FS1	UIAC_DisjO_017 AND UMFV.M10 Start Request for 3 sec	FS UMFV_M10	Breaker UIVM Open
UMFV_M10_002_FS2	UIVM_Def_026 and Start Request for 5sec	FS UMFV_M10	Default on Speed variator UIVM
UMFV_M10_002_FS3	UAVA_UMFVDef_M10_002	FS UMFV_M10	Thermal default
UMFV_M10_002_FS4	UAVA_UIOA_M10_002	FS UMFV_M10	Fan Emergency Stop
UMFV_M10_002_FS5	UMFV On & NOT (UAVA_UBAY_M10_002) for 30sec	FS UMFV_M10	Pressure Discordance on Fan
UMRM_M08_002_AL1	UMRM_M08 start request and no feedback On	TS UMRM_M08	Damper Open Discordance
UMRM_M08_002_AL1	UBTT_M09 > 30 C (HH)	AL UMRM_M08	Supply Temperature High

**FS = Full Stop Interlock ; TS = Temporary Stop Interlock ; SI=Start Interlock ; AL=Alarm*