ALARM ENGINEERING

OBJECTIVE

In this instruction module, students learn the fundamentals of a signaling system. They understand the purpose and the areas of use of alarm and signaling systems, and know the requirements resulting from this for such systems. They are acquainted with the possibilities of representing messages and alarms, and interacting with them. Based on this, the students are able to design an alarm management that is appropriate to and suitable for use in **PCS7**.

THEORY IN SHORT

Signaling systems play an extremely important part in economically operating process engineering plants. Designed ergonomically, they inform the operator specifically of unintentional deviations in the process state from a defined normal state (refer also to the chapter 'Functional Safety). Signaling systems make it possible for the operator to directly locate the cause of the fault and through adapted intervention, adjust the process control strategy in such a way that despite the fault, specification-conforming products can continue to be manufactured, or the process is stabilized in such a way that the fault causes a minimum of production outage.

The control system **PCS7** includes a number of technical resources to implement a signaling system. The palette ranges from function blocks for generating messages, icons for representing alarm states, group alarms along the plant hierarchy to components for representing and managing messages in lists (refer to Figure 1).

Based on this and by taking note of a number of design rules for the intended purpose of message texts and for the assignment of priorities, we can implement very efficiently an effective signaling system that meets all the requirements of the presently valid national and international standards and guidelines.



Figure 1: From alarm block to visualization at alarm lists

THEORY

SIGNALING SYSTEMS

Because of the consistent usage of modern process control, process engineering plants are automated to a high degree and optimized with respect to safety. For that reason, the operator of such a plant monitors a largely automated process that requires operator action only when, because of a process or the plant fault, manual intervention is required. The objective of such manual interventions always is to take the process back to its normal state (refer also to the chapter 'Functional Safety') before the automatic safety devices are activated.

Since in general, safety devices take the monitored technical facility to a safe state, this action causes as a rule either a loss in product quality, production delays or even the standstill of the entire production. This has considerable negative effects on the profitability of the plant. For that reason, the danger -that an impermissible fault activates a protective device- should be detected early so that the fault can be prevented by suitable manual intervention. In addition, the operator should be informed that if a safety device is activated, he can monitor the consequences.

The signaling system in this case serves as the central interface between the operator and the monitored process, and makes all facilities for managing messages and alarms in the control system available [2]. It allows the operator to detect deviations from setpoints in the area of the intended operation early and to specifically counteract them.



The operator has to be supported regarding the situation-oriented evaluation of an indication or an alarm as well as regarding the selection of a suitable operator intervention. To this end, always a suitable action prompt has to be provided, depending on the process state.

To prevent the operator being overburdened, the number as well as the frequency of indications and alarms has to be minimized. In addition, the work load should be kept as low as possible for the operator while indications and alarms occur. Beyond this, the

operator can be supported in his work through suitable tools for documenting and evaluating indications and alarms.

When designing a signaling system, the limits of the performance capability of the later operators have to be taken into account. The total number of tasks that a signaling system requires an operator to handle and that have to be mastered must not exceed human capability limits either short term or permanently.

On the one hand, a brief sharp rise in the number or the rate of alarms can cause the operator to be briefly overloaded (alarm surge). It should be noted that on the average, an operator can not process more than a maximum of seven items of information at the same time $(7\pm rule)$.

On the other hand, a continuously high workload -caused by a constantly large number of arriving alarms- can cause the operator to be permanently overstrained. This leads to a growing decrease of the operator's performance capability and reliability.

A signaling system has to be designed in a way that it utilizes the characteristic attributes of human perception, and takes their limits into account. Important alarms have to be emphasized in order to be noticed quickly. Events that occur rarely have to be presented in a special way to attract the attention of the user. Important information should be presented redundantly, to facilitate it being noticed. In addition, several sensory channels should be addressed if at all possible to convey the information (for example, acoustical warning signals).

Only when a signaling system meets these requirements is it actually supporting the operator in his task to control and monitor the plant.

ALARMS AND INDICATIONS

Signaling systems are used to manage indications and alarms in control systems. *Indication* means in general any report and any indication of the occurrence of a specific event. However, in a narrower sense, the term is used only for those indications that do not require the operator to respond immediately[1]. Otherwise, the term *Alarm* is used. That is, the term indication is used as a general term as well as a specific term. Below, the following definitions are used consistently:

- Alarm: Indication or report of the occurrence of an event that requires immediate operator reaction. The reaction may be an activity, such as performing an operation. However, the reaction may be exclusively mental; for example, increased attention.
- Indication: Indication or report of the occurrence of an event that does not require the operator's immediate reaction.

Alarms signal deviations of the process or of the plant from the setpoint and thus make it possible for the operator to avert a hazardous situation or economic damage. To perform this task, good alarms have to have the following features [3]:

- *relevant*: The alarm is justified and valuable to the operator.
- *clear*: The alarm contains information for the operator. It does not repeat any other alarm.
- *timely*: The alarm arrives timely if intervention is required. But it arrives early enough that the operator can still intervene.
- **prioritized**: The alarm provides an indication how urgent the operator's reaction is.
- understandable: The alarm contains information that can be understood clearly and easily.
- *diagnostic*: The alarm allows the operator to diagnose the problem.
- *directional*: The alarm provides suitable action instructions for solving the problem that occurred.
- **focusing**: The alarm guides the attention to the most important problems.

Alarms should always be used purpose-oriented. It has to be clarified **what** is monitored, **how** monitoring is carried out and **when** an alarm is triggered. In addition, we have to

define how the operator can react to an alarm. Based on these criteria, alarms can be subdivided into numerous types (refer to [3]). The most important alarm types are:

- Absolute alarm: The alarm is generated when a specified limit is exceeded or dropped below.
- *Time delayed alarm*: The alarm is generated when the alarm criterion for a specified time span is met.
- Control engineering alarm: The control system itself generates an alarm signal that requires immediate operator reaction.

ALARM PROCESSING BY THE OPERATOR

The operator processes the alarms in three phases: First, the operator has to recognize that a problem occurred (1st phase: *Recognition*). To this end, the signaling system has to turn the operator's attention to the problem. Then, with the aid of the control system, the operator has to identify the problem. (2nd phase: *Identification*). After the operator located the cause, he can initiate steps to eliminate the fault and compensate for the consequences of the problem (3rd phase: *Troubleshooting*). During each of these phases the signaling system has to be able to suitably support the operator. Table 1 lists the most important capabilities of the signaling system to provide that support.

Phase	Supporting options of the alarm system
Recognition	 Effective guidance of attention
	 Suitable presentation of information
	 Pre-processing and sampling information
Identification	 Significant description of errors
	 Tools for investigation of errors
	 Jumping to the appropriate operator display of PCS
Troubleshooting	 Significant instructions for solving the problem
	 Jumping to the appropriate operator display of PCS for operator intervention

To make alarm processing possible to the plant operator in a way that makes sense, occurring alarms have to be suitably managed by the signaling system. Alarm management supports all phases of the interaction between the operator and the signaling system of the process control system.



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Generation

Indications and alarms are generated process-oriented in the devices of the control engineering equipment of the plant. Indication and alarm generation can be linked to certain conditions (for example, time conditions, hysteresis), and always takes place with a synchronous time stamp.

When defining indications and alarms, the operator's reaction time has to be taken into account. After an indication or an alarm occurs, the operator has to have sufficient time to eliminate the problem that was signaled before another alarm is activated.

This can be easily illustrated using the overflow protection of a reactor as an example. Corresponding to the inlet rate of a reactor, a defined time passes between the overflow indication and the corresponding overflow alarm. If the operator's counter-measures can not take effect in time, the indication is not useful to the operator, since the alarm and the automated protection function pertaining to this are activated in any case.

Prioritization

Large process plants are equipped with a considerable number of alarm sources that in turn can activate different types of alarms. To keep this diversity controllable for the operator, it is advisable to structure the signaling system. A suitable method for this is alarm prioritization. This refers to the clear arrangement of all alarms of a signaling system according to their importance and urgency [2]. If several alarms pile up, a processing sequence can be suggested to the operator based on alarm priorities.

		\langle	Priority	
	Response time		Seriousness	
$\widehat{ }$		Shutdown	Off spec	delay in production
ority	< 5 min	High	Medium	Low
P	5 - 20 min	Medium	Medium	Low
	> 20 min	Low	Low	Low

Figure 2: Example of a prioritization matrix according to [2]

To this end, a *prioritization matrix* can be set up as shown in Figure 2. This matrix depends on the requirements for the respective process plant and is usually applied to the entire plant uniformly. According to this matrix, each individual alarm is assigned a priority (*static prioritization*).

As an alternative, alarms can be prioritized depending on the current plant situation and the combination of other queued alarms (*dynamic prioritization*). Alarms are customarily color coded corresponding to their priority.

Prioritization has to be defined in a way that the long term average alarm rate is not above one alarm every ten minutes for each operator station in the normal operating mode [2]. For that reason, a priority distribution that is appropriate has to be the aim:

- 5% Priority *high*
- 15% Priority *medium*
- 80% Priority *low*

The reduction of the operator load resulting from this prevents overload consequences and ensures the necessary time span for controlling and monitoring [2].

Representation

How alarms are represented is of essential importance to the applied suitability of a signaling system. The following types of representation have proven themselves and prevailed in actual usage [2]:

- Area overview of alarms: Alarms are arranged in an unconcealable total overview (also referred to as group status display). In this case, the alarms are arranged in a way that it is possible to assign them directly to the corresponding plant segments. The assigned process or plant displays can be reached directly by means of corresponding jump functions.
- Alarm representation by means of the alarm list: The pending alarms are arranged in the form of a list. The list can be sorted and filtered in various ways. Often, jump functions to the assigned process and plant displays are offered in this type of representation also.
- Alarm representation in a schematic flow diagram: Alarms are signaled in the process or plant display, using saturated colors (preferably red or yellow) for the corresponding symbols
- First-up signaling system: If occurring signals pile up, the system ascertains the primary alarm and then filters out the subsequent resulting alarms. This reduces the number of alarms the operator has to process.

Often, the graphic representations are supplemented with optical or acoustical signal transmitters. They inform the operator in addition that an alarm occurred.

The operator has to acknowledge alarms and indications that occurred. This documents that he has taken note of the state change.

Evaluation

To evaluate an alarm or an indication, the operator has to be able to correctly interpret the current state of the process and of the plant. He is supported in this through the types of representation just discussed as well as meaningful message texts, alarm descriptions and suitable tools for preprocessing larger alarm volumes.

Operator Intervention

After the operator evaluated the state of the plant and the consequences of the alarm, he has to decide what to do and implement it based on the situation. This is done within the control system, but outside the signaling system. For that reason, it is extremely helpful to the operator if he is able to jump directly from the signaling system to the corresponding operating display where he can intervene as necessary. Often, signaling systems provide corresponding jump functions. In addition, help texts that are assigned to the various alarms support the operator in making action decisions.

ALARM MANAGEMENT IN PCS7

PCS7 provides a high performance signaling system. It informs the plant operator about occurring events and displays them in the process mode in the form of signal lists and a group display. Another list indicates the interventions by the plant operator. The display for signals is configured in **WinCC**.

PCS7 differentiates three different event classes [4]:

- Control engineering indications: in PCS7 they are generated by driver blocks when they detect errors at their own components (AS, OS, etc.). These indications don't have to be configured.
- Process indications: they signal events of the automated process, such as limit violations and process indications. These indications don't have to be configured. However, message texts and signaling priority can be changed if needed.
- Operator input messages: are generated when process variables are operated; for example, when the operating mode is switched. Operator input messages are generated automatically if the picture blocks in the PCS7 Library are used, or one's own blocks that are configured in conformance with PCS7.

Indications for the AS and the IO are configured within the scope of setting up CFCs, or in the process object view. It is possible to change indications of block types or individual block instances, and to configure one's own message texts. SFCs, types and instances are also able to generate indications.

Indications for the OS are configured by using the application *Alarm Logging* in *WinCC Explorer*. There, the triggering event for an indication is specified also.

When indications are configured, different aspects have to be taken into account. The most important aspects are discussed below:

- Message text: Blocks with signaling behavior have preset message texts with the corresponding event class and event type. These texts and attributes can be adapted depending on requirements. In addition, information from the process or block comments can be added to the message text as associated values.
- Signal number: During compilation, each signal configured in the ES is assigned a unique signal number automatically in alarm logging. The signal number range is specified when the project is set up. Signal numbers are assigned uniquely either project-wide or CPU-wide. The latter is the precondition for assigning signal priorities.
- Signal priority: A signal can be assigned a priority between 0 (lowest) and 16 (highest). Signal lists can be sorted and filtered according to their priority. In the message line in the overview area, always the indication is shown that has the highest priority and has not yet been acknowledged.

Plant blocks that are visualized on the OS have the function *Loop-In-Alarm*. In the case of process and control engineering alarms, this function allows for changing to the corresponding picture block directly from the signal list.

PCS7 uses a central acknowledgement concept. If a signal is acknowledged on an OS, the acknowledgement is first sent to the triggering block, and from there to all additional relevant OSs.

LITERATURE

- [1] VDI 3699 (Edition. 2005-05): Process Control with Display Screens.
- [2] NAMUR NA 102 (Edition. 2005-12): Alarm Management.
- [3] c 191 (Edition. 2007-10): Alarm Systems.
- [4] SIEMENS (2009): Process Control System PCS7: Engineering System (V7.1).

STEP BY STEP INSTRUCTIONS

TASK

This task requires setting up alarms and warnings for the operator station (OS). As an example, we are programming filling level monitoring for reactor A1T2R001. The alarms and warnings set up there will be indicated in *WinCC*.

OBJECTIVE

In this chapter, the students

- Learn to integrate monitoring blocks and alarm blocks in the CFC
- Get to know **WinCC**
- Learn to represent alarms and warnings in the operator station (OS)
- Get to know additional functions in the WinCC Graphics Designer

PROGRAMMING

1. To program filling level monitoring, first we open the already existing CFC A1T2L001 for the level of reactor A1T2R001.

 $(\rightarrow A1_multipurpose_plant \rightarrow T2_reaction \rightarrow A1T2L001 \rightarrow A1T2L001)$



2. On the second sheet of the CFC, we then insert -from the folder 'CONTROL' of the **PCS7 Library V71-** in the library catalog the block MEAS_MON.

$(\rightarrow \text{Libraries} \rightarrow \text{PCS7 Library V71} \rightarrow \text{Blocks+Templates/Blocks} \rightarrow \text{CONTROL} \rightarrow \text{CONTROL}$
MEAS_MON)

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DEADT_P [FB37: Dead time part]			A 33 40	
DIF_P [FB38: Difference- Trapezium				
ELAP_CNT [FB64: Measuring the peri				
FMCS_PID [FB114: Function Block for				
FMT_PID [FB77: Function Block for FI				
GAIN_SHD [FB141: Souce Chart for F				
INTERLOK [EB75: INTERLOK-Block]				
LIMITS P [FB41: Limiter]				
MEAS_MON [FB65: Meas.value monitoring t	block]			
MOT_REV [FB67: Control reversable				
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MOTOR [FB66: Motor]			2	
NOISE GN [FB143: Noise Generator]				
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Press F1 for help.		A/Overview	0B35 A1T2L001 A1T2L0	01\2

$\underline{\mathbb{A}}$

Note: Block MEAS_MON is used to monitor a measuring value (analog signal) for the limit pairs:

- Warning limit (high/low)
- Alarm limit (high/low)

3. Next, we rename the MEAS_MON block to 'Monitor_A1T2L001'. Then, the values at inputs 'U_AH', 'U_WH', 'U_WL' and 'U_AL' are changed as shown here, and input 'U' is connected to output 'V/Process value' of block LISA+_A1T2L001 from the first sheet.

(→ Monitor_A1T2L001 → U_AH: 1000.0 → U_WH: 900.0 → U_WL:150.0 → U_AL: 50.0 → U → V/Process value)



4. So that later in the operator station (OS), the level is indicated with the correct unit we are opening the object properties of the MEAS_MON block. Then, under Connections, we enter the unit 'ml' at 'U'.

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$(\rightarrow \text{Object Properties} \rightarrow)$	Connections \rightarrow Name: U	\rightarrow Unit: ml \rightarrow OK)
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#	Name	F S	Comment	Invisible	Watched	Archive	Identifier	Unit	Text 🔨
1	EN								
2	005		1= Out of Service	Image: A state of the state		No archi			In Se
3	M_SUP_AH		1=Suppress HH Alarm	Image: A state of the state		No archi			Suppi
ŧ	M_SUP_AL		1=Suppress LL Alarm			No archi			Suppi
5	M_SUP_WH		1=Suppress H Alarm (Warning)			No archi			Suppi
5	M_SUP_WL		1=Suppress L Alarm (Warning)			No archi			Suppi
7	CSF		Control System Fault 1=External		~				
3	MSG_LOCK		Enable 1=Messages locked		 Image: A start of the start of	No archi			-
9	MO_PVHR		High Limit Bar Range			No archi	Bar UL		
10	MO_PVLR		Low Limit Bar Range			No archi	Bar LL		
1	USTATUS		User Status Bits			1	1		
12	U		Analog Input (Measured Value)			No archi	PV	ml	-
13	QC_U		Quality Code for Input U						
14	U_AH		HH Alarm Limit			No archi	HH alarm		
15	U_WH		H Alarm Limit (Warning)			No archi	H alarm		_
16	U_WL		L Alarm Limit (Warning)			No archi	L alarm		
17	U_AL		LL Alarm Limit			No archi	LL alarm		
18	HYS		Hysteresis of Analog Input			No archi	Hysteresis		
19	MSG_EVID		Message ID					1	
20	BA_EN		Batch Enable	 Image: A state of the state of		No archi			
21	OCCUPIED		Occupied by Batch	~		No archi			
22	BA_ID		Batch ID	Image: Second		No archi			
23	BA_NA		Batch Name	Image: A state of the state					
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Here, all changes in chart 'A1T2L001Sheet2' are listed once more:

Block	Catalog/Folder	Number of Connections
MEAS_MON / Monitoring measured values	Libraries/PCS7 Library V71/ Blocks+Templates\Blocks/CONTROL	

Table 2: New Blocks in Chart 'A1T2L001Blatt2'

Table 3: Input Wiring in Chart 'A1T2L001Sheet2'

Input	Connected to	Inverted
MEAS_MON.Monitor_A1T2 L001.U	A1T2L001(A,1) / CH_AI.LISA+_A1T2L001.V Process value	
MEAS_MON.Monitor_A1T2 L001.U_AH	1000.0	
MEAS_MON.Monitor_A1T2 L001.U_WH	900.0	
MEAS_MON.Monitor_A1T2 L001.U_WL	150.0	
MEAS_MON.Monitor_A1T2 L001.U_AL	50.0	

Table 4: Changes at the block properties in Chart 'A1T2L001Sheet2'

Name of Connection	Changes
MEAS_MON.Monitor_A1T2 L001.U	Enter unit 'ml'

Table 5: Output Wiring in Chart 'A1T2L001Sheet2'

Output	Connection to	Inverted
None	None	None

5. To compile and download the AS and OS at the same time, highlight the project in the component view of the *SIMATIC Manager*. Then, select for the PLC 'Compile and Download'

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 $(\rightarrow SCE_PCS7_Prj \rightarrow PLC \rightarrow Compile and Download Objects)$

 Next, we select -as shown here- the objects to be compiled and start the process as we learned it in the previous chapters. (→ Start)

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Compile and Download Objects	×					
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OS(1)	FC7	'55 is being generated.				
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				Cancel		
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Compile only IV Do not load if compilation error	r is detected					
Start Close						Help

7. After a successful compilation, we open the OS. (\rightarrow OS(1) \rightarrow Open Object)

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Opens selected object.	Display compilation log Display load log Generate server data			

 Within *WinCC*, in the *Graphics Designer* we open the picture 'T2_reaction.Pdl'. (→ Graphics Designer → T2_reaction.Pdl)

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9. In this picture, the block icon for the MEAS-MON block 'Monitor_A1T2L001' was already set up through the compilation run. We are positioning it to the right of the reactor, and save the picture.



TIA Training Manual Status: 12/2010 10. In the *Graphics Designer* we now open the picture 'A1_multipurpose_plant.Pdl'.

 $(\rightarrow$ Graphics Designer \rightarrow A1_Mehrzweckanlage.Pdl)



11. Into this picture we now drag an IO field from the smart objects of the object palette, in order to display in it the filling level of reactor A1T2R001. Then, we open its tag



12. Within the tag selection, we select as data source the ES variables. After that, we see in the left window the hierarchy of our project. Here, we can easily locate our MEAS_MON block 'Monitor_A1T2L001'. To display it in the IO field, we select the connection 'U'.

 $(\rightarrow \text{ES Variables} \rightarrow \text{SCE}_Plant \rightarrow \text{A1}_multipurpose}_plant \rightarrow \text{T2}_reaction \rightarrow \text{A1T2L001} \rightarrow \text{A1T2L001} \rightarrow \text{U} \rightarrow \text{OK})$

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E S S E S	Data source: Variables WinCC Tags	bol Server		
🗐 🙆 T2_reaction 🛛 🔨	Name	Туре	Comment	~
A1T2H003 A1T2H004 A1T2H004 A1T2H005 A1T2H007 A1T2H007 A1T2H008 A1T2H008 A1T2H016 A1T2H016 A1T2L001	M_SUP_WH M_SUP_WL OCCUPIED OOS QERR QMSG_SUP STEP_NO	Binary va Binary va Binary va Binary va Binary va Binary va Unsigned 32-bit flo	1=Suppress H Alarm (Warning) 1=Suppress L Alarm (Warning) Occupied by Batch 1= Out of Service 1=Error 1=Message Suppression Active Batch Step Number Analog Input (Measured Value)	
A1T2L001		32-bit flo 32-bit flo 32-bit flo 32-bit flo	HH Alarm Limit LL Alarm Limit H Alarm Limit (Warning) L Alarm Limit (Warning)	<u> </u>
			OK Cancel -	Help

- 13. This tag is now displayed in the configuration dialog. After the following changes, we accept this configuration.
 - $(\rightarrow$ Update: Upon change \rightarrow Type: Output \rightarrow OK)

Tag:	A1_multipurpose_pl
Update	Upon change 🖌
Туре	
💿 Output	O Input O I/O Field
Format	
Font Size	12
Font Nam	e Arial

14. At the Properties, we are setting the output format to 4 positions in front of the comma, without decimal positions.

 $(\rightarrow \text{Properties} \rightarrow \text{Output/Input} \rightarrow \text{Output Format} \rightarrow 9999 \rightarrow \text{OK})$

Object Properties	1/0 Field1			? 🛛
Properties Events			Output Format	
 J/O Field Geometry Colors Styles Font Flashing Miscellaneous Limits Output/Input Effects 	Attribute Field Type Input Value Data Format Output Format Apply on Full Apply on Full Clear on New Input Clear on Invalid Input Hidden Input	Stal Output 0.0 0,000000 Decimal 9999 No No Yes No No Yes No No	9 99 999 99999 99999 99999 9.9 99.99 Enter a format: 9999	DK A

15. Then, the following font attributes are selected.

 $(\rightarrow \text{Properties} \rightarrow \text{Font} \rightarrow \text{X Alignment: right} \rightarrow \text{Y-Alignment: centered})$

Object Properties			? 🛛
Properties Events	I/O Field1		~
 □ I/O Field Geometry Colors Styles Font Flashing Miscellaneous Limits Output/Input Effects 	Attribute Font Font Size Bold Italic Underline Text Orientation X Alignment Y Alignment	Static Arial 12 No No Horizontal Right Top	Dyna Up I

- 16. To be able to better interpret the value in runtime, we are entering a tooltip text.
 - $(\rightarrow \text{Properties} \rightarrow \text{Other} \rightarrow \text{TooltipText: filling level reactor A1T2R001})$

2 2 1/0 Field	I/O Field1			
perties Events				
🖃 I/O Field	Attribute	Static	Dyna	LA
Geometry	Operator-Control Enable	Yes	Σ	
Colors	Authorization	<no access-protection=""></no>	2	
- Styles	Display	Yes	X.2	=
Font	Tooltip Text	filling level reactor A1T2R001	<i>₽</i>	
Flashing	Visualize tag status	Yes	\mathcal{D}	
Miscellaneous	Operator Activities Report	t No	₹Ç₹	
Limits	Operator Input Message	No	Q.	
- Output/Input	Adapt Border	No	300	
Effects	Cursor Control	No	x7x	~
	<			>

17. Then, the IO field -as shown here- is placed below reactor A1T2R001 and two texts are generated next to it. (\rightarrow Object Palette \rightarrow StaticText)

🛉 Graphics Design	ner - [A1_multipurpose_plant.Pdl]	
- File Edit View	Arrange Tools Window Help _	₽ ×
ी∰r Arial		
Zoom 800 400 100 50 25 10 10 100.000 *	Style Palette A1 multipurpose T1 educt tanks A1T1B001 A1T1B002 Standard Objects Une Standard Objects Une Standard Objects Une Polygon Pol	
0 1 2 3 4	5 6 7 8 9 10 11 12 13 14 15 » 0-Layer0 v	
For He Englisch (USA)	📩 X:149 Y:4 🖬 X:0 Y:0	

-

18. Below educt tank A1T1B003, a display is to be implemented with a text list that indicates whether this tank is empty or not. After we dragged it from the Object Palette into the picture, we open its tag selection.

$(\rightarrow Object Pale)$	ette \rightarrow Smart Objects \rightarrow IO Field -	\rightarrow \square)
Image: Second state of the se	multipurpose_plant.Pdl] ools Window Help	X - 8 × 2 2 4 4 5 2 2 2 1 2
2000 400 100 50 25 10 100.000 [%] 10 100.000 [%] 10 100 100 100 100 100 100 100	tipurpose plant tList Configuration ag pdate 2 s Field Type Output O Input O I/O-Field Font Font Size 12 Font Arial Color OK Cancel 7 8 9 10 11 12 13 14 15 D-Laverth	Style Palette Solid Dashed Dotted Object Palette Selection Object Palette Polygon Pie Segment Pie Segment Pie Retangle Rounded Rectangle Pie Solid Pie Solid
」U 1 2 3 4 5 6 	/ 8 9 10 11 12 13 14 15 ≫ 0-Layer0 王 ⊟ 표 표	
For He Englisch (USA)	Text List1 1:00 Y:170	1 X:70 Y:20

19. Within the tag selection, this time we select 'STEP 7 Symbol Server'. After that, we see in the left window the symbols of our S7 program. Here, we select input I3.1 'A1.T1.A1T1L003.LSA-.SA-'.

 $(\rightarrow$ STEP 7 Symbol Server \rightarrow S7 Program(1) \rightarrow Symbols \rightarrow I3.1 'A1.T1.A1T1L003.LSA-.SA-' \rightarrow OK)

> ﷺ 🕹	Data source: STEP 7 ES Vari	7 Symbol Serv iables Tags	/er		
STEP 7 Symbol Server	Name	Data T	Add	ress	Comment
😑 🛐 S7 Program(1), SCE	a1.A1H001.HS+START	BOOL	I	0.0	Main power switch multipurpose plant
표 🔄 Symbols	a1.A1H002.HS+OFF	BOOL	I	0.1	emergency switch OFF
⊞ • DB	a1.A1H003.HS+LOC	BOOL	I	0.2	local operation mode switch
	a1.T1.A1T1L001.LSA+.SA+	BOOL	I	1.0	level monitoring educt tank B001 switchpoint high
	a1.T1.A1T1L001.LSASA-	BOOL	I	1.1	level monitoring educt tank B001 switchpoint low
	a1.T1.A1T1L002.LSA+.SA+	BOOL	I	2.0	level monitoring educt tank B002 switchpoint high
	a1.T1.A1T1L002.LSASA-	BOOL	I	2.1	level monitoring educt tank B002 switchpoint low
	a1.T1.A1T1L003.LSA+.SA+	BOOL	I	3.0	level monitoring educt tank B003 switchpoint high
	a1.T1.A1T1L003.LSASA-	BOOL	Ι	3.1	level monitoring educt tank B003 switchpoint low
	A1.T1.A1T15001.SO+.O+	BOOL	I	1.2	pump outlet educt tank B001 feedback running
	₩1.T1.A1T15001.SV.C	BOOL	0	0.1	numn outlet educt taok 8001 control signal

20. This tag is then displayed in the configuration dialog. After the following changes, we accept this configuration.

 $(\rightarrow$ Update: Upon change \rightarrow Field Type: Output \rightarrow OK)

Tag	S7\$Prog	gram(1)/A1\$		
Jpdate	Upon change 🖌			
Field Type				
💿 Output	O Input	O I/O-Field		
Font				
Font Size] 12			
Font	Arial			
Color				

- 21. The representation of the font is set in the properties of the text list.
 - $(\rightarrow \text{Properties} \rightarrow \text{Font} \rightarrow \text{X} \text{Alignment: centered} \rightarrow \text{Y} \text{Alignment: centered})$

- 🕅 🌌 💋 Text List			
Properties Events	Text List1		
Text List Geometry Colors Styles Font Flashing Miscellaneous Output/Input Effects	Attribute Font Font Size Bold Italic Underline Text Orientation X Alignment Y Alignment	Static Arial 12 No No Horizontal Centered Centered	Dyna Up

22. The texts are assigned to the values of the variable in the Properties also. (\rightarrow Properties \rightarrow Output/Input \rightarrow Assignments)

Object Properties			? 🛛
Properties Events	Text List1		~
 Text List Geometry Colors Styles Font Flashing Miscellaneous Output/Input Effects 	Attribute Field Type Output Value List Type Assignments Bit Number Apply on Exit Number of visible lines	Static Output Decimal 0,????? 0 No 3	Dyna Up
	<		>

23. The indication 'EMPTY' is assigned to value 0 and 'OK' to value 1.

 $(\rightarrow$ Range type: Single Value \rightarrow Value range: $0 \rightarrow$ Text: Empty \rightarrow Change \rightarrow Range type: Single Value \rightarrow Value range: $1 \rightarrow$ Text: OK \rightarrow Append \rightarrow OK \rightarrow \bigotimes)

value range	Text		
	EMPTY OK		
			➡
Value range attribute	88		Delete
Value range attribute Range type Single Value 💙	value range	Text	Delete
Value range attribute Range type Single Value	Value range	Text	Delete Change Append

24. We need just such a text list a second time for a textual display below product tank A1T3B001. It indicates whether this tank is full or not. To this end, the text list that was already generated is highlighted and duplicated. (→ Duplicate)

🛉 Graphics Design	ner - [A1_multipurpose_plant.Pdl	<u>j</u>			
	Arrange Tools Window Help			_ 8 ×	
	D 1 ≫ 3 → X 11 11 ∽ ⊂ 2 ₽ 8 🐼 Q Q Q X 2 4 4 4 5 2 2 2 4 4 5 2 2 2 4				
™ Arial	💙 12 💌 🎦 🗸 🎢				
Zoom 800 400 100 50 25 10	nultipurpose	e plant	Cobject Pale	te ne Style Solid Dashed Dotted Vette	
	A1T1B002		Cut Ctrl+> Copy Ctrl+C	tandard Objects Line ygon Lyline se	
			Paste Ctrl+V Delete Del	cle ose Segment	
	0ml	A1T2R002	Customized object Group object	 Segment pse Arc 	
			Linking	▶ cular Arc	
	<		Configuration Dialog Properties	ctangle unded Rectangle 🗸	
0 1 2 3 4	5 6 7 8 9 10 11 12 1	3 14 15 » 0 - Layer0	~	, , , , , , , , , , , , , , , , , , , ,	
		a free de la prove de la constanción de			
Duplica Englisch (USA)	Text List1		I∰ X:50 Y:20		

25. For product tank A1T3B001 we select input I12.1 'A1.T3.A1T3L001.LSA+.SA+'.

(→ STEP 7 Symbol Server → S7 Program(1) → Symbols → I12.1 'A1.T3.A1T3L001.LSA+.SA+' → OK)

Tags - Project: D:\Progr	Data source:	oj\SCE_PC 7 Symbol Serv iables Tags	\$7\\$ /er	CEP	Prj\wincproj\QS(1)\QS(1).mcp ?	
🕞 🞒 STEP 7 Symbol Server	Name	Data T	Ad	dress	Comment	~
😑 📴 S7 Program(1), SCE	A1.T2.A1T2X008.XV.C	BOOL	0	7.5	valve inlet reactor R001 from reactor R002 contr	
🕀 😓 Symbols	A1.T3.A1T3H001.GO+O+	BOOL	I	12.0	hand valve outlet product tank B001 feedback sig	
⊕ • • DB	A1.T3.A1T3H001.GO+O-	BOOL	I	12.4	hand valve outlet product tank B001 feedback sig	
	A1.T3.A1T3H002.GO+O+	BOOL	I	13.0	hand valve outlet product tank B002 feedback sig	
	A1.T3.A1T3H002.GO+O-	BOOL	I	13.4	hand valve outlet product tank B002 feedback sig	
	A1.T3.A1T3L001.LSA+.SA+	BOOL	I	12.1	level monitoring product tank B001 switchpoint high	
	a1.T3.A1T3L001.LSASA-	BOOL	I	12.2	level monitoring product tank B001 switchpoint low	
	A1.T3.A1T3L002.LSA+.SA+	BOOL	Ι	13.1	level monitoring product tank B002 switchpoint high	_
	a1.T3.A1T3L002.LSASA-	BOOL	I	13.2	level monitoring product tank B002 switchpoint low	-
	A1.T3.A1T3X001.GO+O+	BOOL	I	12.3	valve inlet product tank B001 feedback signal ope	
	A1.T3.A1T3X001.GO+O-	BOOL	T	12.5	valve inlet product tank B001 feedback signal closed	*
<	<				>	
					OK Cancel Help	

26. Now, we are changing the assignment at the Properties. This time, 'OK' is assigned to value 0 and 'Full' to value 1.

 $(\rightarrow$ Range type: Single Value \rightarrow Value range: $0 \rightarrow$ Text: OK \rightarrow Change \rightarrow Range type: Single Value \rightarrow Value range: $1 \rightarrow$ Text: FULL \rightarrow Change \rightarrow OK)

xtList assignment	s (decimal)		
Value range	Text		1
U 1	FULL		
			↓
Value range attribute: Range type	s Value range	Text	Delete
Single Value 💌	1 0	FULL	Change
			Append
		ОК	Cancel

27. Now, the second text list is placed below product tank A1T3B001 and the picture is saved. (→)

$\dot{\hbar}$ Graphics Designer - [A1_multipurpose_plant.Pdl]	
까 File Edit View Arrange Tools Window Help	_ @ ×
□ 1 2 2 4 4 2 2 4 4 4 4 4 4 4 4 4 4 4 4 4	N?
12 V Arial Save 12 V To V K V	
	Style Palette
A1 multipurpose plant	Line Style
	Dasrieu
T1 educt tanks	
	Object Palette
A1T1B001 A1T1B002 A1T1B003	Selection
EMPTY	Standard Objects
T2 reaction	
Zoom	Ellipse
A1T2R001 A1T2R002	- Circle
400 [filing level 0 ml	🛋 Ellipse Segment
	Pie Segment
50 T2 product tanks	Ellipse Arc
	Circular Arc
	Rectangle
90.000 %	Rounded Rectangle 🖌
	Standard 🔂 Controls
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 » 0-Layer0	
Saves the current documer Englisch (USA) Text List2 📩 X:250 Y:430 🖬 X:50 Y:20	

- 28. Here, the representation of a warning in runtime is shown. In the message line, the warning or alarm that occurred last and has not been acknowledged yet appears. If the operator wants to switch directly to the picture where it was triggered, he has two options:
 - With the button Alarm in the message line
 - With a click on the disturbance indication and in the display hierarchy



1	12/12/10 02:39:50.999 0	A1_multipurpose_plant/T2_r	eactior High warning	3
11_muLoop i	n Alarm 1 D			

🛅 🔊	12/12/10	0 2:39:50.999 0	A1_multipurpose_plant/T2_r	eactior High warning		2/12/2010 2:42:27 AM
11_multipurpos	se_plan	0 0 0 0				0 SIEMENS 0 0 0 0
	ultipurpose T1_educt_t T2_reacti T3_product_ T4_rinsii	plar anks S ion A W S tanks S display		e plant	003	SfC. productor
T2 re	eaction	A1T filling leve	2R001	A1T2R002	Ŷ	
ТЗ р	roduct ta	anks	3B001	A1T3B002		
T4 ri	nsing		A1T4B001			
	8		🚺 🔷 🔶 🛃			

29. In picture 'T2_reaction', there is a display of the warning in the block icon. By clicking on the block icon, additional information is displayed in the faceplate for the MEAS_MON block about the cause of the warning. Here, indications that have to be acknowledged can be acknowledged or the limits can be adjusted.



	12/12/10	02:39:50.999 0	A1_multipurpose_plant/T2_r	eactior High warning		12/12/2010 2:44:20 AM
41_multipurp	oose_plan	Û		J. J	0	SIEMENS
		4		Ф.	0	B 88 7
		4	0	0	0	
		0.	0 D	D.	0	



🗯 Meas.value monitoring block	🖌 Meas. value monitoring block 🛛 🗙					
	MEAS_MON	A1_multin	purpose_plant/T2_reaction/A1T2L001/monitor_A1T2L001			
110.000 PV	1158,03 ml Suppress mess.	□ □	110.000			
50 HH alarm Hysteresis	1000 900 5	HAHAHU HAHAHAHAHAHAHAHAHAHAHAHAHAHAHAHAHAHAH	50 - Bar Bar UL 110			
-10.000 Lalarm	150 D	List: 10 Window: 2 Ack: 10	- <u>10.000</u> Bar LL -10 Actual			
1160.0 1159.6 1159.2		enabled Coupled				
1158.8 - 1158.4 - 1158.0 - 12/12/10 2:41:37.671 AM	2:46:37.671 AM	Batch Name				

30. By clicking on the button Signaling System \square in the message line, all pending indications are displayed. (\rightarrow \square)

	A 12/12	10 02:39:50.999	0 A1_multipurp	pose_plant/T2_reactior High w	/arning	2/12/2010 2:48:12 AM				
41_r	nultipurpose_plan	Û			0	SIEMENS				
		D.		0	0					
		0		0	0					
	1	0	1111	0	0					
_		- Andrew Street Street								
	T2 reaction									
			•							
6						AATOMOOT				
				Feederate						
	🛃 🔮 👼	🛐 📥 🖷 🕿	2 2 6 2 2							
	Date 🔫 2	Time Time	Source			Event				
1	12/12/10	02:39:50.99 0	A1 multipurpose	plant/T2 reaction/A1T2L001/	monitor A1T2L001	High warning				
2	12/12/10	02:39:50.99 0	A1_multipurpose_	plant/T2_reaction/A1T2L001/	monitor_A1T2L001	High alarm				
3	12/12/10	02:39:50.99 0	A1_multipurpose	plant/T2_reaction/A1T2X008/	valve_A1T2X008	Runtime error				
4	12/12/10	02:39:50.99 0	A1_multipurpose_	plant/T2_reaction/A1T2X005/	valve_A1T2X005	Runtime error				
5	12/12/10	02:39:50.99 0	A1_multipurpose_	plant/T2_reaction/A1T2X004/	valve_A1T2X004	Runtime error				
6	12/12/10	02:39:50.99 0	A1_multipurpose_	_plant/T1_educt_tanks/A1T1X	005/valve_A1T1X005	Runtime error				
7	12/12/10	02:39:50.99 0	A1_multipurpose_	_plant/T1_educt_tanks/A1T1X	004/valve_A1T1X004	Runtime error				
8	12/12/10	0 2:39:50.99 0	A1_multipurpose_	_plant/T2_reaction/A1T2X003/	valve_A1T2X003	Runtime error				
9	12/12/10	0 2:39:50.99 0	A1_multipurpose_	_plant/T1_educt_tanks/A1T1X	006/valve_A1T1X006	Runtime error				
10	12/12/10	02:39:50.99 0	A1_multipurpose_	_plant/T3_product_tanks/A1T3	3X001/VALVE_A1T3X001	Runtime error				
11										
12										
4										
Read	y				Pending: 10 To ackr	nowledge: 10 Hidden 0 List: 10 🛛 📑				
		(
		0	M M			M				
				N						
			4							
			📑 🚹 🧔		😼 🖻 👼 👘	x 📙 🦉 🐗 😽				

31. By clicking on the button 'Signaling System' on the key set, we can switch to the complete display of the signaling system. Here, selection options are provided for displaying the indications according to different filter criteria. Below, the chronicle list is

shown. (→	$\square \rightarrow$	
(,



	A 12/12/	10 02:39:50.999	0 A	1_multipurpos	e_plant/T2_re	actior Hig	n warning		1	12/12/2010 2:51:06 AM
41_m	۱1_multipurpose_plan 🛛 🖓				0		1 D		0	SIEMENS
					0		1 D		1 D	
					0	11	L D		L L	1P997/
					1.1	11	1 0			
Biournal liet										
					\$ 7					
	Date	Time	Priori	Source			Event			Messa
122	12/12/10	00:55:16.733	0	A1_multipurp	ose_plant/T1_	educt_tan	Runtime er	ror		00:00:
123	12/12/10	00:55:16.733	0	A1_multipurp	ose_plant/T2_	reaction/A	Runtime er	ror		00:00:
124	12/12/10	00:55:16.733	0	A1_multipurp	ose_plant/T2_	reactionIA	Runtime er	ror		00:00:
125	12/12/10	00:55:16.733	0	A1_multipurp	ose_plant/T2_	reactionIA	Runtime er	ror		00:00:
126	12/12/10	01:57:06.564	0	A1_multipurp	ose_plant/T2_	reactionIA	Runtime er	ror		01:01:
127	12/12/10	01:57:07.179	0	A1_multipurp	ose_plant/T2_	reactionIA	Runtime er	ror		01:01:
128	12/12/10	01:57:08.254	0	A1_multipurp	ose_plant/T2_	reaction/A	Runtime er	ror		01:01:
129	12/12/10	01:57:09.214	0	A1_multipurp	ose_plant/T1_	educt_tan	Runtime er	ror		01:01:
130	12/12/10	01:57:10.281	0	A1_multipurp	ose_plant/T1_	educt_tan	Runtime er	ror		01:01:
131	12/12/10	01:57:11.363	0	A1_multipurp	ose_plant/T2_	reaction/A	Runtime er	ror		01:01:
132	12/12/10	01:57:12.300	0	A1_multipurp	ose_plant/T1_	educt_tan	Runtime er	ror		01:01:
133	12/12/10	01:57:13.211	0	A1_multipurp	ose_plant/T3_	product_t	Runtime er	ror		01:01:
134	12/12/10	01:58:52.707	0	S7\$Program(1)/@(2)/SIMA1	IC_400(1)	OB reques	: OB3x still in process		00:00:
135	12/12/10	01:58:54.018	0	S7\$Program(1)/@(2)/SIMA1	IC_400(1)	OB reques	: OB3x still in process		00:00:0
136	12/12/10	02:02:42.467	0	S7\$Program(1)/@(2)/SIMA1	IC_400(1)	OB reques	: OB3x still in process		00:03:
137	12/12/10	02:39:50.999	0	A1_multipurp	ose_plant/T3_	product_t	Runtime er	ror		00:00:
138	12/12/10	02:39:50.999	0	A1_multipurp	ose_plant/T1	educt_tan	Runtime er	ror		00:00:
139	12/12/10	02:39:50.999	0	A1_multipurp	ose_plant/T2	reaction/A	Runtime er	ror		00:00:
140	12/12/10	02:39:50.999	0	A1_multipurp	ose_plant/T1_	educt_tan	Runtime er	ror		00:00:
141	12/12/10	02:39:50.999	0	A1_multipurp	ose_plant/T1	educt_tan	Runtime er	ror		00:00:
142	12/12/10	02:39:50.999	0	A1_multipurp	ose_plant/T2_	reactionIA	Runtime er	ror		00:00:
143	12/12/10	02:39:50.999	0	A1_multipurp	ose_plant/T2_	reactionIA	Runtime er	ror		00:00:
144	12/12/10	02:39:50.999	0	A1_multipurp	ose_plant/T2	reaction/A	Runtime er	ror		00:00:
145	12/12/10	02:39:50.999	0	A1_multipurp	ose_plant/T2_	reactionIA	High alarm			00:00:
146	12/12/10	02:39:50.999	0	A1_multipurp	ose_plant/T2	reaction/A	High warning	ng		00:00:
147										-
4						000000			0000000000	
Ready Pending: 10 To acknowledge: 10 Hidden 0 List: 146 🖉 📑										
	1	1 2 1			journal list		5			a

EXERCISES

We are going to apply what we learned in the theory chapters and the step by step instructions to the exercises. To this end, we are using the already existing multi-project from the step by step instructions (PCS7_SCE_0202_R1009.zip) and expand it.

In the step by step instructions, again only one line of the plant was implemented. For that reason, the objective of the exercise is to implement the missing line. The tasks are to be an aid to generate all necessary plant parts in the *WinCC* application.

TASKS

The tasks below are based on the step by step instructions. The corresponding steps in the instructions can be used as an aid for each of the exercises.

- Implement a MEAS_MON block for the temperature in A1T2T001. As a basis, use the MEAS_MON block for the filling level in A1T2L001 that was set up in the step by step instructions. As the high limit for the alarm, '60.0' is to be set, and as the high limit for the warning '55.0'. After you have compiled the PLC program, place the automatically generated block icon in picture 'T2_reaction.pdl' at a suitable location.
- 2. Open the picture 'A1_multipurpose_plant.pdl' and generate two more text lists for the educt tanks A1T1B001 and A1T1B002. As in the case of tank A1T1B003, these text lists are to indicate whether the educt tanks are empty or not.