PNOZmulti 2 Firing single burner

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Product

Type:	PNOZmulti 2 Burner
Name:	PNOZ m B1 Burner
Manufacturer:	Pilz GmbH & Co. KG, Safe Automation

Document

Release Number:	01
Release Date:	14 December 2023

Important Note

Document Revision History

Release	Date	Changes	Chapter
01	2023-12-14	Creation	all

Validity of Application Note

This present Application Note is valid until a new version of the document is published.
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The Pilz newsletter is free of charge and keeps you up to date on all the latest issues and trends in safe automation.

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We are grateful for any feedback on the contents.

December 2023

Industrial Security

To secure plants, systems, machines and networks against cyberthreats it is necessary to implement (and continuously maintain) an overall Industrial Security concept that is state of the art.
Perform a risk assessment in accordance with VDI/VDE 2182 or IEC 62443-3-2 and plan the security measures with care. If necessary, seek advice from Pilz Customer Support.

Abbreviations

Abbreviation / term	Description	Source
AN	**A**pplication **N**ote	www.pilz.com > AN content (1002400)
PNOZ	Pilz E-STOP positive-guided (DE: **P**ilz **NO**T-AUS-**Z**wangsgeführt)	www.pilz.com > PNOZ
PSS	Programmable control system (DE: **P**rogrammierbares **S**teuerungs**s**ystem)	www.pilz.com > PSS
PSS u2	**PSS**universal, **2**nd generation	www.pilz.com > PSS u2
POU	**P**rogram **O**rganisation **U**nit	
NC	**N**ormally **C**losed	
NO	**N**ormally **O**pen	
P&ID	**P**iping and **I**nstrumentation **D**iagram	en.wikipedia.org > P&ID

Definition of Symbols

- Information that is particularly important is identified as follows:

CAUTION!

This refers to a hazard that can lead to a less serious or minor injury plus material damage, and also provides information on preventive measures that can be taken.

NOTICE

This describes a situation in which the product or devices could be damaged and also provides information on preventive measures that can be taken.
It also highlights areas within the text that are of particular importance.

INFORMATION

This gives advice on applications and provides information on special features.

Contents

1 Useful documentation

Reading the documentation listed below is necessary for understanding this Application Note. The availability of the software used, and its safe handling are also presupposed for the user.

1.1 Documentation from Pilz GmbH & Co. KG

No.	Description	Item No. /Download
1	Pilz international homepage, download section	www.pilz.com
2	Pilz burner management systems for safe monitor and control all the functions of commercial and industrial gas and oil furnaces Operation manual 'PNOZmulti Special Applications' (Chapter 4)	www.pilz.com > Burner-management-systems www.pilz.com > Download 1002337
3	Software *PNOZmulti configurator*, *Online help* and *readme file* Pilz international Webportal > Products and Industries > Small controllers PNOZmulti > Software PNOZmulti Download the latest software version at:	www.pilz.com > Small-controllers >Software www.pilz.com > Download PNOZmulti Configurator
4	Small controllers PNOZmulti 2 Pilz international Webportal > Products and Industries > Small controllers PNOZmulti > Small controllers PNOZmulti 2	www.pilz.com >Small-controllers > Configurable-control-systems
5	System description 'PNOZmulti System Expansion'	www.pilz.com > Download 1002217
6	Technical catalogue PNOZmulti 2	www.pilz.com > Download 1006421
7	Installation manual PNOZmulti	www.pilz.com > Download 1002265
8	Operation manual 'PNOZmulti m B1 Burner'	www.pilz.com > Download 1005294
9	Operation manual 'PNOZ m ES Profinet' Operation manual 'PNOZmulti 2 Communication interfaces'	www.pilz.com > Download 1003386 www.pilz.com > Download 1002971
10	Operation manual 'PNOZ m EF 8DI4DO'	www.pilz.com > Download 1002661
11	Operation manual 'PNOZ m EF 4DI4DOR'	www.pilz.com > Download 1002702
12	Operation manual 'PNOZ m EF 4DI4DORD'	www.pilz.com > Download 1005465
13	Operation manual 'PNOZ m EF 4AI'	www.pilz.com > Download 1004650

1.2 Documentation from other sources of information

No.	Description	Item No. / Download
1	Karl Dungs GmbH & Co. KG Combustion Controls	www.dungs.com > Products documentation
2	Endress+Hauser GmbH & Co. KG Measurement instrumentation, services and solutions for industrial process engineering.	www.de.endress.com > EN
3	VENTUR Deutschland GmbH (Venture Industries Group) Fans and industrial equipment	www.ventur.eu > Industrial-ventilation

2 Used hardware and software

2.1 Pilz products

No.	Descriptions	Order number	Version	Number
1	PNOZ m B1 Burner	772102	1.9 (FW 0109)	1
2	PNOZ m ES Profinet	772138	2.0	1
3	PNOZ m EF 8DI4DO	772142	1.0	1
4	PNOZ m EF 4DI4DOR	772143	1.0	1
5	PNOZ m EF 4DI4DORD	772145	1.0	1
6	PNOZ m EF 4AI	772160	1.2 (FW 0102)	1

2.2 Third-party products

- This document shows illustrations of products from company *Karl Dungs GmbH & Co. KG*, these are only examples.
  - Please contact Dungs Solution Consultancy, if you require combustion technology hardware, at: https://www.dungs.com/en/service/contact
- In addition, products from *Endress+Hauser GmbH & Co. KG* for industrial temperature measurement technology are also shown.
  - You can find more information about these field instruments at: https://www.de.endress.com/en/field-instruments-overview.
- As an example of industrial fans, a picture of the company *Venture Industries Group* is shown.
  - An overview can be found at: https://www.ventur.eu/fans/fans-atex

2.3 Structure of the application (schematic)

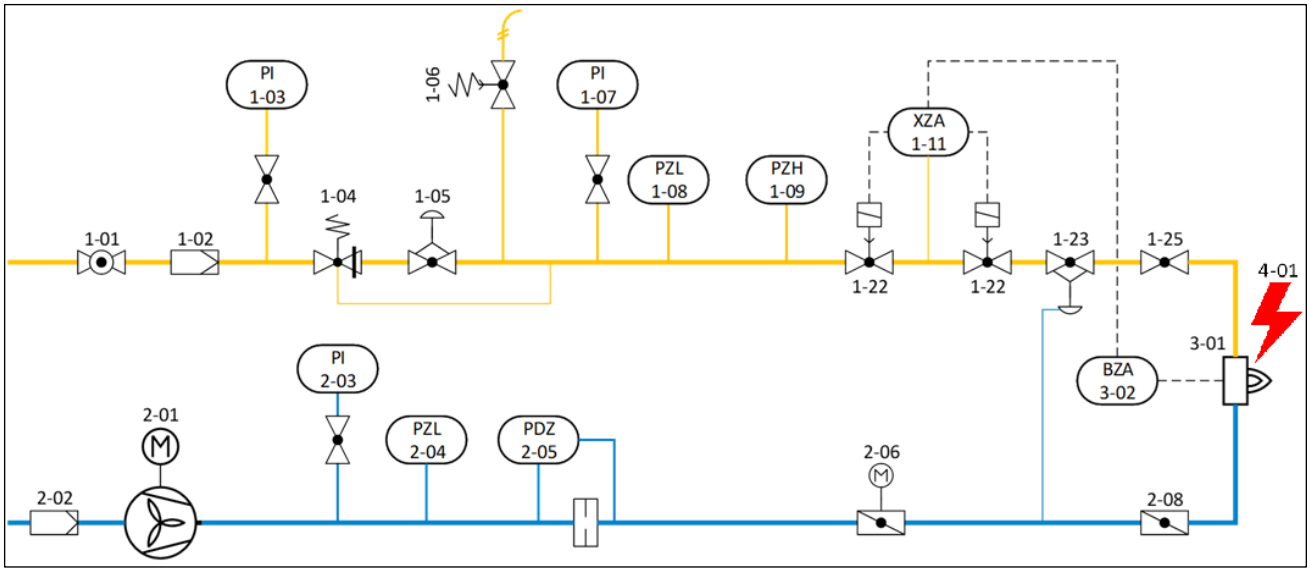

Figure 1: Overview – Structure of the application

Legend

Tag	Component / Function	Link hardware description	Link application description
1-01	Manual isolating valve	—	—
1-02	Filter / Strainer	Ch. 4.2.1 [09]	—
1-03	Pressure indicator (PI) upstream with gauge cock	Ch. 4.2.4 [10]	—
1-04	Overpressure cut-off device	—	—
1-05	Gas pressure regulator	Ch. 4.2.2 [09]	—
1-06	Pressure relief valve	Ch. 4.2.3 [10]	—
1-07	Pressure indicator (PI) downstream with gauge cock	Ch. 4.2.4 [10]	—
1-08	Pressure switch, Low gas protection	Ch. 4.2.5 [10]	Figure 28 [23]
1-09	Pressure switch, High gas protection	Ch. 4.2.5 [10]	Figure 28 [23]
1-11	Pressure switch, for the Tightness control	Ch. 4.2.6 [11]	Figure 24 [20] Figure 33 [26]
1-22	Burner automatic shut-off valves (Safety valve)	Ch. 4.2.7 [11]	Figure 24 [20] Figure 34 [27] Figure 35 [27]
1-23	Pneumatic air / Gas ratio control	Ch. 4.2.9 [12]	—
1-25	Gas flow adjustment for burner	Ch. 4.2.4 [10]	—
2-01	Combustion air blower	Ch. 4.2.11 [12]	—
2-02	Air inlet filter	—	—
2-03	Pressure indicator (PI) with Gauge cock	Ch. 4.2.12 [13]	—
2-04	Air pressure detector (PZL)	Ch. 4.2.13 [13]	Figure 31 [25]
2-05	Air flow detector (PDZ)	Ch. 4.2.13 [13]	Figure 31 [25]
2-06	Air flow control valve with motor (M)	Ch. 4.2.14 [13]	—
2-08	Air flow adjustment valve for burner	Ch. 4.2.12 [13]	—
3-01	Burner	—	Figure 20 [16]
3-02	Flame monitor	Ch. 4.2.10 [12]	Figure 32 [25]
4-01	Ignition transformer	Ch. 4.2.8 [11]	Figure 36 [28] Figure 37 [28]

3 Preface

This Application Note describes the implementation of a burner application in the 2nd generation PNOZmulti 2 controller 'PNOZ m B1 Burner'. It shows the configuration in the user program as well as electrical drawings of the application. Additionally optional configurations are described.

The description of the application bases on the P&ID (*Piping and Instrumentation Diagram*) of an imaginary gas train. This gas train serves as the interface of the burner to the 'PNOZ m B1 Burner'. The components of this gas train, how these are connected to the 'PNOZ m B1 Burner' (including electrical drawings) and how the configuration in the user program must be realized to control and monitor the gas train is described in this document.

The Pilz device 'PNOZ m B1 Burner' is also designated as "the controller" in this document.

NOTICE

- A detailed explanation of safety functions used in the failsafe application and its evaluation regarding functional safety are not a part of this document.
- This document only describes the procedure for use of Pilz device 'PNOZ m B1 Burner' with the order number 772102 and the Pilz products listed in the Ch. 2.1 Pilz products [📖 6].
- The described application is only an example and cannot be regarded as a standard burner application and most likely will not fit completely to your application.
  Also the configured step times shown in the sequences are also only examples!
- Third party products shown in this document only serve as an example.
  Similar products of other manufacturers can also be used.
  The responsibility for the selection of these products lies at the system integrator integrating Pilz products with third party products.
- The description of the gas train in this document cannot be regarded as a manual of how a gas train is to be arranged. It only serves as an example.

4 Application description

4.1 General

The application is described by the components of the gas and air train in the next sections. The described components are marked yellow in the P&ID.

- Further aspects of the application (not displayed in the P&ID) are:
  - the burner is in continuous operation,
  - start, stop and reset commands come via fieldbus and
  - additional safety functions are emergency stop and maximum temperature monitoring.

4.2 Components of the gas and Air train

4.2.1 Filter / Strainer

A filter or strainer **[1-02]** is needed to prevent particles from the upstream pipe getting in the safety armatures or in the process.

This is a mechanical part, required by the EN 746-2. It has no interfaces to the controller.

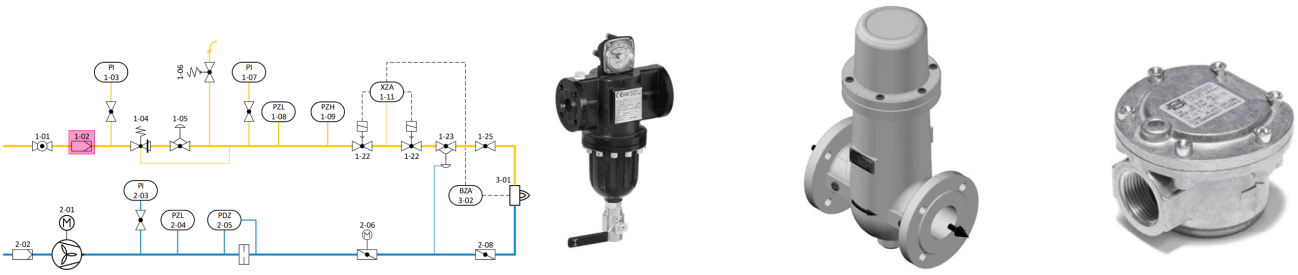

Figure 2: Burner hardware component – Filter / Strainer
© Karl Dungs GmbH & Co. KG

4.2.2 Gas pressure regulator

The gas pressure regulator **[1-05]** is a mechanical part required by EN 746-2 and must comply to EN 88 or EN 334. It is needed to reduce the inlet pressure to a suitable pressure for the burner. It has no interfaces to the controller.

Eventually also used is an over pressure cut off device (Over Pressure Shut-Off / OPSO) **[1-04]** to secure downstream armatures against over pressure. It stops the flow, if the downstream pressure gets too high.

Figure 3: Burner hardware component – Gas pressure regulator
© Karl Dungs GmbH & Co. KG

4.2.3 Pressure relief valve

The pressure relief valve [1-06] is a mechanical part without interfaces to the controller. It prevents the OPSO to trigger due to short pressure peaks, for instance when the safety valves close. It is provided for availability and not for safety. It is not required by the standards and it does not have interfaces to the controller.

Figure 4: Burner hardware component – Pressure Relief valve
© Karl Dungs GmbH & Co. KG

4.2.4 Pressure indicators and Volume adjusting cock (gas)

Pressure indicators [1-03], [1-07] and volume adjusting cock [1-25] are used for maintenance and commissioning and for burner adjustment. They are not required by the standards, and they do not have interfaces to the controller.

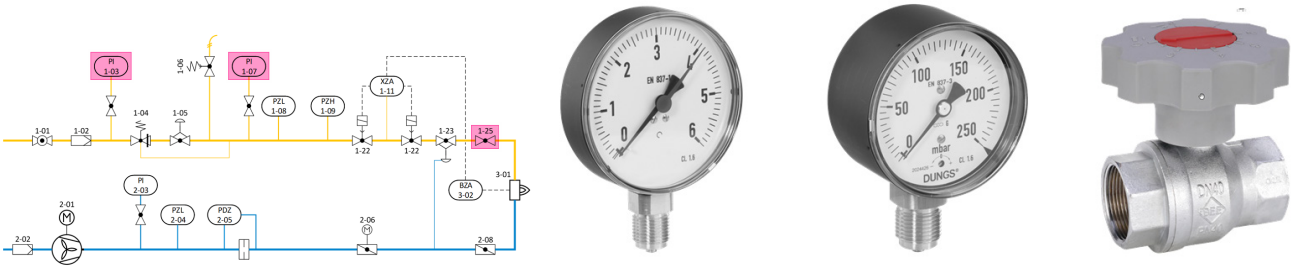

Figure 5: Burner hardware components – Pressure indicators and volume adjusting cock for gas
© Karl Dungs GmbH & Co. KG

4.2.5 Pressure switches (gas)

- Pressure switches are required by the EN 746-2. Required are:
  - Low gas protection: Against not enough gas [1-08]
  - High gas protection: Against high gas flow [1-09]

Pressure switches must comply to EN 1854. They consist of electromechanical contacts, actuated by a pressure membrane, and are operated with 24 VDC or 115/230 VAC. Pressure switches operated with 24 VDC can be connected to the inputs of the controller, for instance the inputs of the 'PNOZ m EF **8DI**4DO' or of the 'PNOZ m EF **16DI**' or of the 'PNOZ m EF **4DI**4DOR(D)'.

Figure 6: Burner hardware components – Pressure switches gas
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4.2.6 Tightness control pressure switches

A pressure switch [1-11] is required for the tightness control.
A tightness control is required by the EN 746-2, if the burner capacity is larger than 1.200 kW.
The used pressure switches must comply to EN 1854. They consist of electromechanical contacts, actuated by a pressure membrane, and are operated with 24 VDC or 115/230 VAC. Pressure switches operated with 24 VDC can be connected to the inputs of the controller, for instance the inputs of the 'PNOZ m EF **8DI**4DO' or of the 'PNOZ m EF **16DI**' or of the 'PNOZ m EF **4DI**4DOR(D)'.

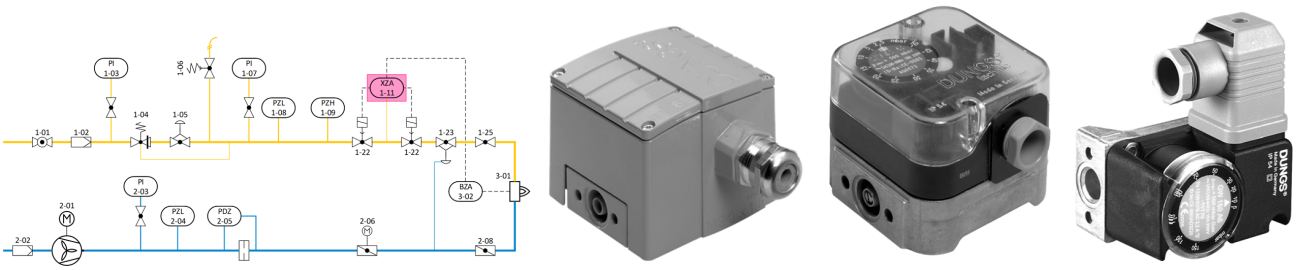

Figure 7: Burner hardware component – Tightness control pressure switches
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4.2.7 Safety valves

According to EN 746-2 two automatic shut-off valves (safety valves [1-22]) for each burner must be foreseen. The valves must comply to EN 161. They are driven by 115/230 VAC or 24 VDC. If they are driven by 115/230 VAC relay outputs, for instance the outputs of the 'PNOZ m EF 4DI**4DOR(D)**', can be used. If they are driven by 24 VDC, semiconductor outputs, for instance the outputs of the 'PNOZ m EF 8DI**4DO**', can be used, if the current to the valve does not exceed 2 A in continuous operation. If so, relay outputs must be used.

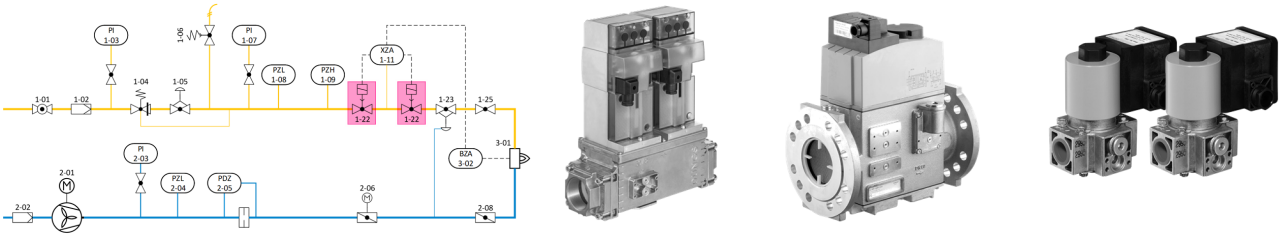

Figure 8: Burner hardware components – Safety valves
© Karl Dungs GmbH & Co. KG

4.2.8 Ignition transformer

The primary circuit of the ignition transformer [4-01] is driven by 115/230 VAC or 24 VDC. If the primary circuit is driven by 115/230 VAC relay outputs, for instance the outputs of the 'PNOZ m EF 4DI4**DOR(D)**', can be used. If the primary circuit is driven by 24 VDC semiconductor outputs, for instance the outputs of the 'PNOZ m EF 8DI**4DO**', can be used, if the peak current to the transformer does not exceed 12 A. If so, relay outputs must be used.

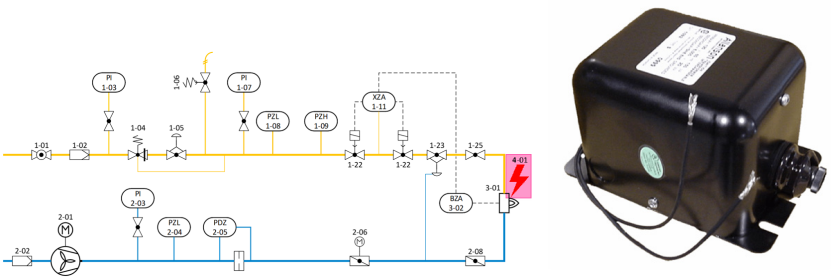

Figure 9: Burner hardware component – Ignition transformer
© Karl Dungs GmbH & Co. KG

4.2.9 Control valve

The control valve for modulating the gas flow to the burner and with that the capacity (kW/MW) of the burner [1-23] is operated by the combustion air pressure by a pneumatic signal connection from the combustion air duct to the valve (pneumatic compound control).

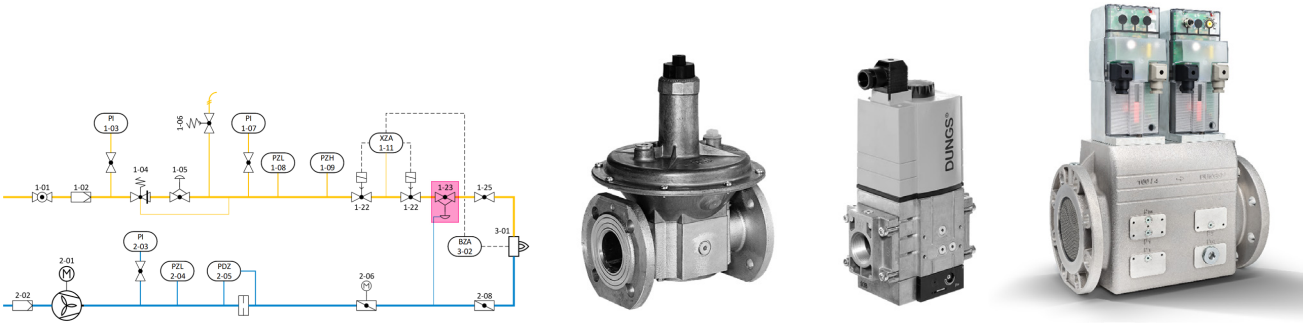

Figure 10: Burner hardware component – Control valve
© Karl Dungs GmbH & Co. KG

4.2.10 Flame monitor

For the flame monitoring an external flame monitor [3-02] with a relay output for the flame signal must be provided. The relay output must switch a 24 VDC signal (with high signal for flame present and low signal for flame extinguished). This signal can be connected to the inputs of a controller, for instance the inputs of the 'PNOZ m EF **8DI**4DO' or of the 'PNOZ m EF **16DI**' or of the 'PNOZ m EF **4DI**4DOR(D)'. The flame monitoring is required by the EN 746-2 and must comply to EN 298.

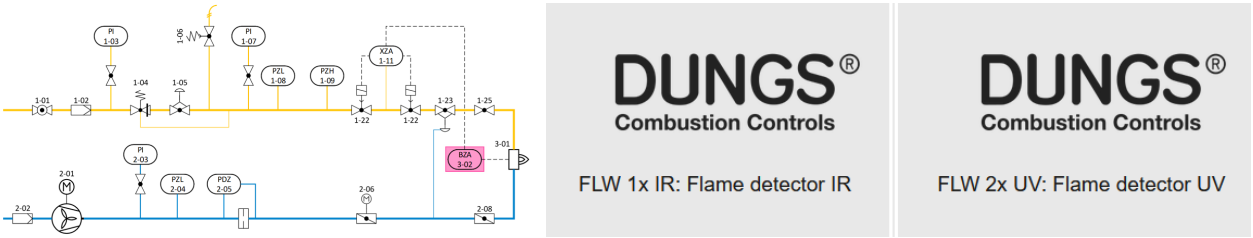

Figure 11: Burner hardware component – Flame monitor
© Karl Dungs GmbH & Co. KG

4.2.11 Combustion air blower / Ventilator

The combustion air blower [2-01] supplies the burner with combustion air. It is switched by a contactor, which again is controlled by a controller output. If the contactor is driven by 115/230 VAC relay outputs, for instance the outputs of the 'PNOZ m EF 4DI4**DOR(D)**', can be used. If the contactor is driven by 24 VDC, semiconductor outputs, for instance the outputs of the 'PNOZ m EF 8DI**4DO**', can be used.

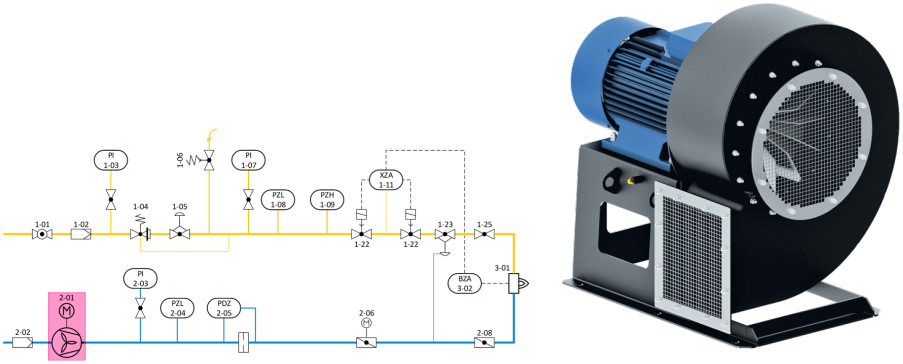

Figure 12: Burner hardware component – Combustion air blower
© VENTUR Deutschland GmbH (Venture Industries Group)

4.2.12 Pressure indicators and Volume adjusting cock (air)

Pressure indicators [2-03] and volume adjusting cock [2-08] are used for maintenance and commissioning and for burner adjustment. They are not required by the standards, and they do not have interfaces to the controller.

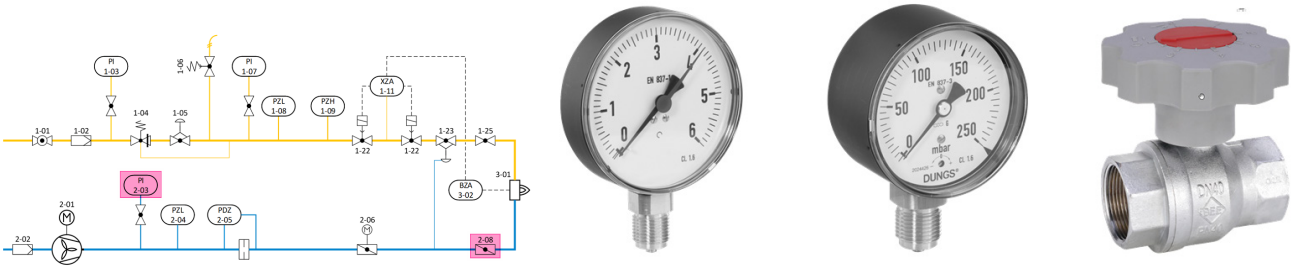

Figure 13: Burner hardware components – Pressure indicators
© Karl Dungs GmbH & Co. KG

4.2.13 Pressure switches (air)

A monitoring of sufficient combustion air supply is required by the EN 746-2. For this purpose, a pressure switch [2-04] and/or a flow switch, consisting of a differential pressure switch over an orifice plate [2-05] is used. The pressure switches must comply to EN 1854. They consist of electromechanical contacts, actuated by a pressure membrane, and are operated with 24 VDC or 115/230 VAC. Pressure switches operated with 24 VDC can be connected to the inputs of a controller, for instance the inputs of the 'PNOZ m EF **8DI**4DO' or of the 'PNOZ m EF **16DI**' or of the 'PNOZ m EF **4DI**4DO(R)'.

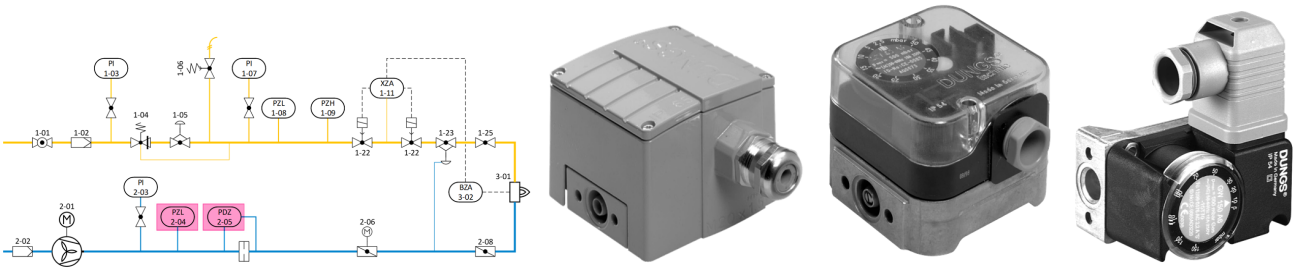

Figure 14: Burner hardware components – Pressure switches for air
© Karl Dungs GmbH & Co. KG

4.2.14 Control damper

The control damper is modulating the capacity of the burner (kW/MW) by the combustion air. It is usually driven by a 4...20 mA by a standard controller.

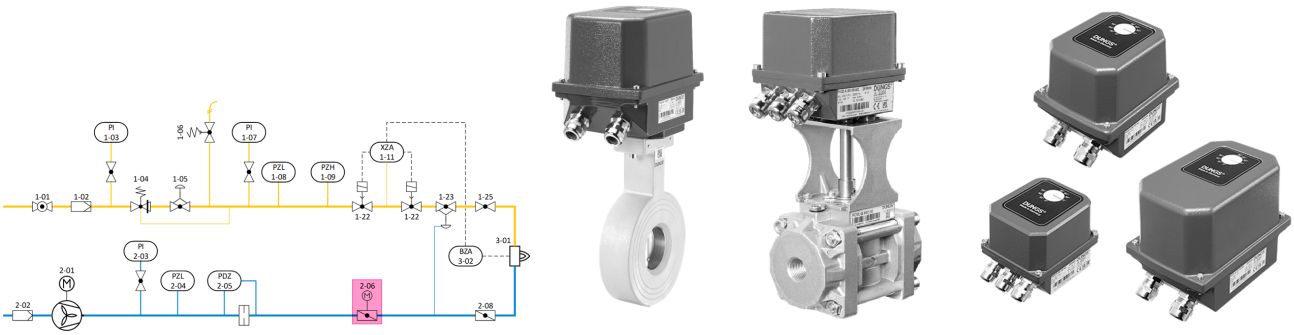

Figure 15: Burner hardware component – Control damper
© Karl Dungs GmbH & Co. KG

5 Realization of the application

5.1 Required in- and outputs and resulting system

- 24 VDC digital inputs (DI) according to the P&ID:
  - **PZL 1-08** : Gas pressure low
  - **PZH 1-09** : Gas pressure high
  - **XZA 1-11** : Gas pressure tightness control
  - **BZA 3-02** : Flame monitor
  - **PZL 2-04** : Air pressure low
  - **PDZ 2-05** : Air flow low

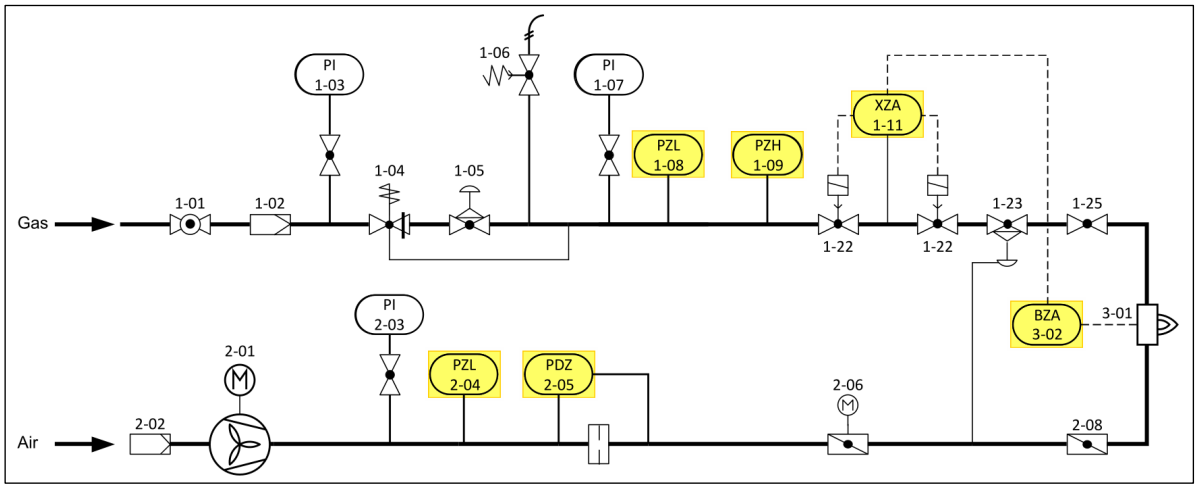

Figure 16: Control hardware – 24 VDC digital inputs (DI) according to the P&ID

- Inputs from additional safety functions:
  - Emergency Stop contacts 1 and 2:
    Two 24 VDC digital inputs (2 DI)
  - Maximum temperature measurement signal 1 and 2:
    Two 4...20 mA analogue inputs (2 AI)
- 24 VDC semiconductor digital outputs (DO) or relay outputs (DOR) according to the P&ID:
  - **1-22** : Safety valve 1
  - **1-22** : Safety valve 2
  - **2-01** : Combustion air ventilator
  - **4-01** : Ignition transformer

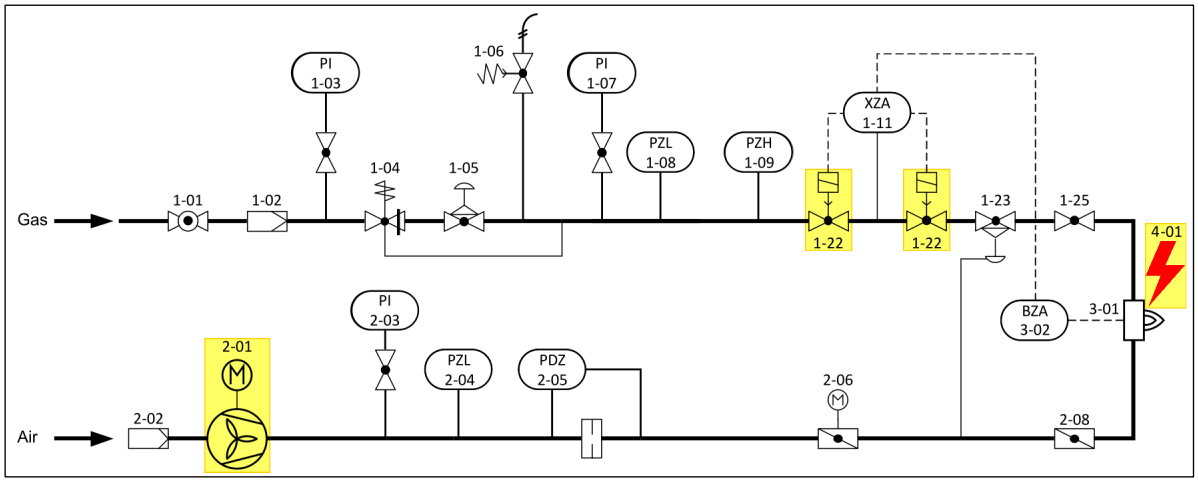

Figure 17: Control hardware – 24 VDC semiconductor digital outputs (DO) or relay outputs (DOR) according to the P&ID

- A count of the listed in- and outputs here results in following system:
  - Inputs from the gas and air train : 6 DI
  - Inputs from additional safety functions : 2 DI + 2 AI
  - Outputs : 4 DO or 6 DOR
  - When using DOR, two diverse relay outputs per safety valves are needed to meet the requirements of the EN 50156 regarding the control of the safety valves with relay outputs in continuous operation. The device 'PNOZ m EF 4DI4DORD' is equipped with diverse relays (relays *A/B/A/B* for outputs *o0*/*o1*/*o2*/*o3*).
- This again leads to following I/O-modules:
  - 1 'PNOZ m EF 8DI4DO' when using semiconductor outputs (DO) or
  - 1 'PNOZ m EF 4DI4DORD' and 1 'PNOZ m EF 4DI4DOR' when using relay outputs DOR,
  - 1 'PNOZ m EF 4AI' for the analogue inputs (AI)
  - Fieldbus module for the start, stop and reset commands.
- Resulting PNOZmulti 2 system when using semiconductor outputs (DO):

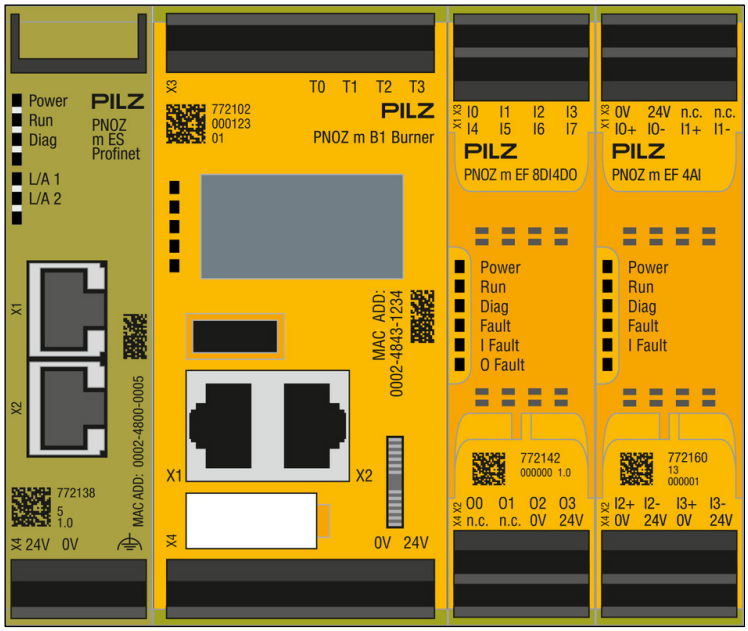

Figure 18: Control hardware – PNOZmulti 2 system with semiconductor outputs (DO)

Resulting PNOZmulti 2 system when using relay outputs (DOR):

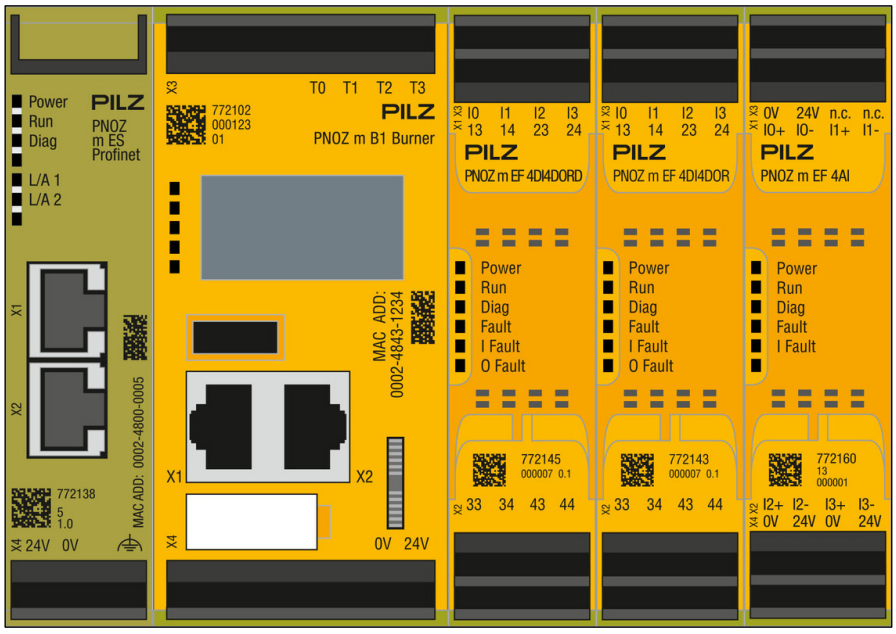

Figure 19: Control hardware – PNOZmulti 2 system with relay outputs (DOR)

5.2 Configuration of the burner block

When the burner software element is pulled out from the software element library and dropped in the program working space, a wizard for the configuration of the burner software element appears. Following up the configuration of this wizard is shown for this application.

- **Burner type**:
  - As burner type "*Master Burner, ...*" must be configured to include the control and monitoring of the combustion air blower in the sequence, as the burner is equipped with a combustion air blower `[2-01]`.
  - Also "*... , direct ignition*" must be configured, as the main flame is ignited directly by the ignition transformer and not by an ignition flame (indirect ignition, see also Chapter 5.5.1 Indirect ignition [📖 36]).
- Therefore, the resulting configuration for the burner type is "*Master burner, direct ignition*":

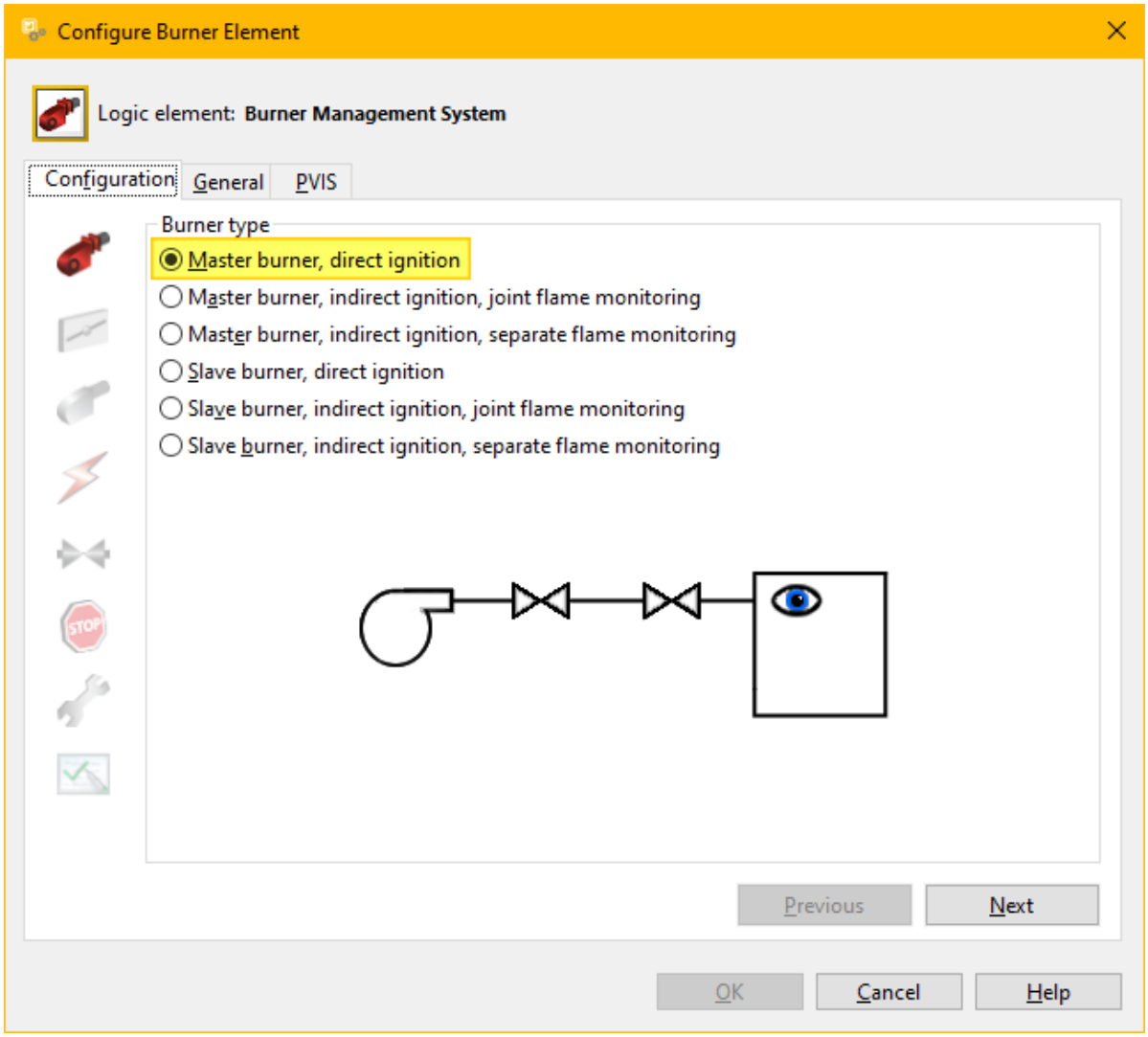

Figure 20: PNOZmulti Burner element – Configuration of burner type

- **Compound Controller**:
  - As this application is not equipped with a electronic compound control, "*Cycle without compound controller*" must be configured here.

If the application would have been foreseen with an external electronic compound control, then the other option had to be configured. In that case additional in- and outputs on the burner software element as well as additional steps inside the burner software element would appear to interface with this external electronic compound controller; see also Chapter 5.5.3 External electronic compound controller [📖 38].

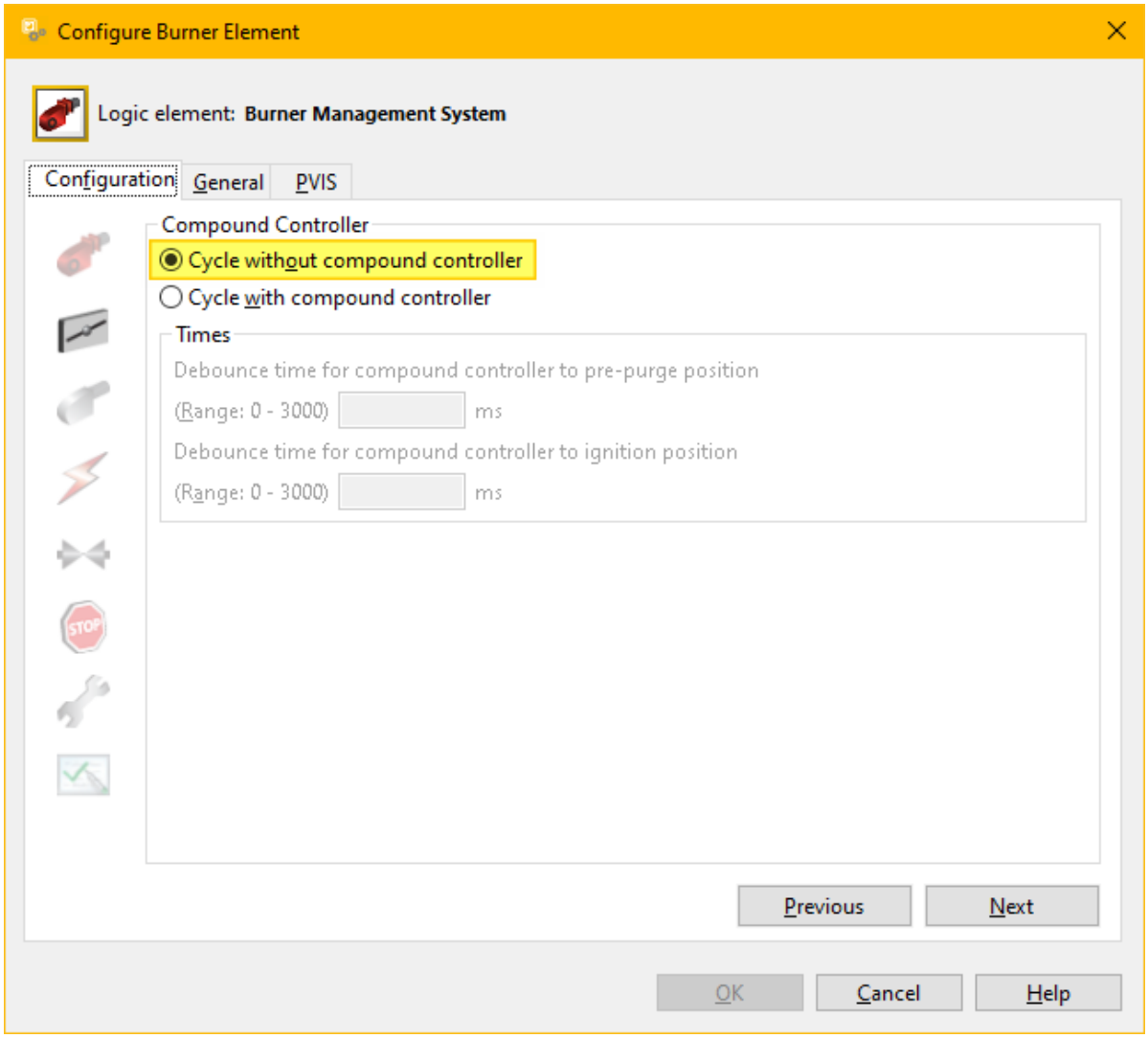

Figure 21: PNOZmulti Burner element – Configuration of compound controller

- **Combustion Air**:
  - The "*Debounce time*" shortens the step time for the step "*Afterburn*":
    As soon as the combustion air pressure switch (input "*AirP*") is low and the debounce time is elapsed, the sequence jumps to the next step.
  - When "*Monitor pre-purge conditions*" is activated, the input "*PUR*" is activated, to monitor additional signals during pre-purge.

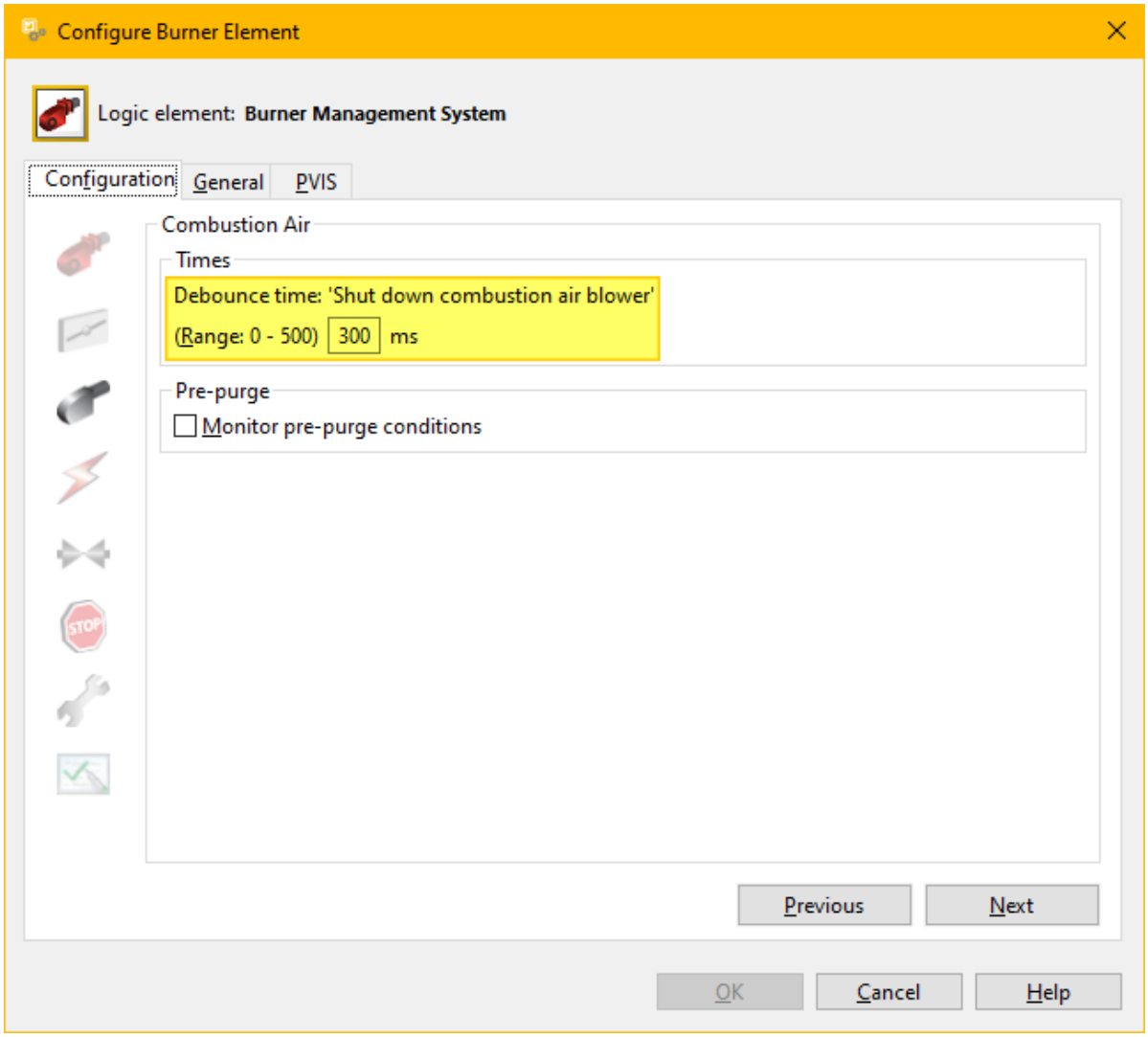

Figure 22: PNOZmulti Burner element – Configuration of combustion air

- Settings regarding **Ignition**:
  - No settings for ignition valve possible, as no ignition valve is implemented (direct ignition).
  - When "*Monitor ignition conditions*" is activated, the input "*IGN*" is activated, to monitor additional signals during ignition.
  - If "*Enable 'High temperature' operating mode*" is activated, the high temperature operating mode (explained later) can be activated via input "*HTmp*".

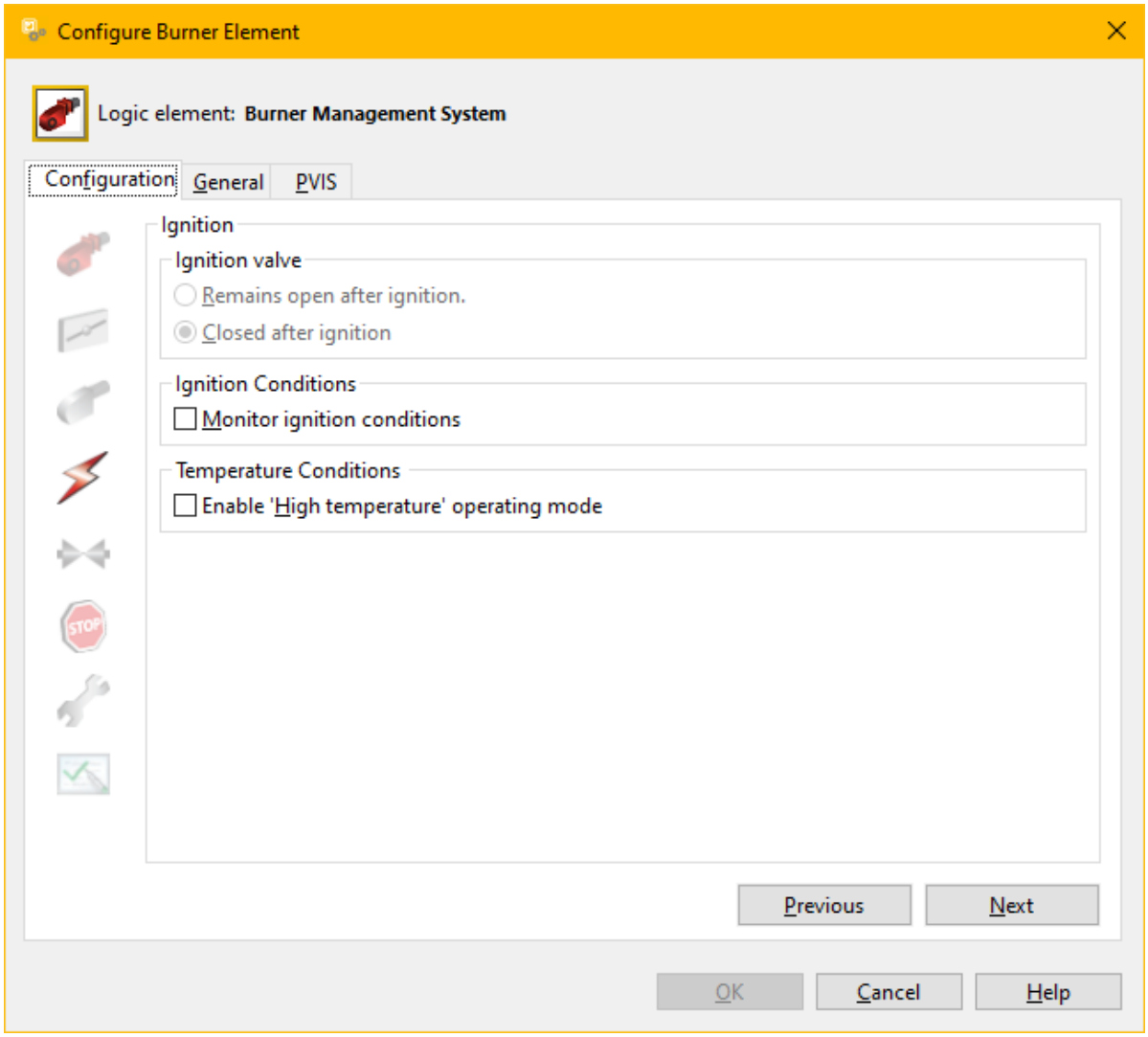

Figure 23: PNOZmulti Burner element – Settings regarding ignition

- Settings **Tightness Control**:
  - Venting "*... via safety valve 2*" `[1-22]` is set, as no vent valve is foreseen.
  - Tightness control takes place "*Prior to ignition*", meaning during pre-purge.
  - Pressure monitoring with pressure switch `[1-11]` via input "*GP*".

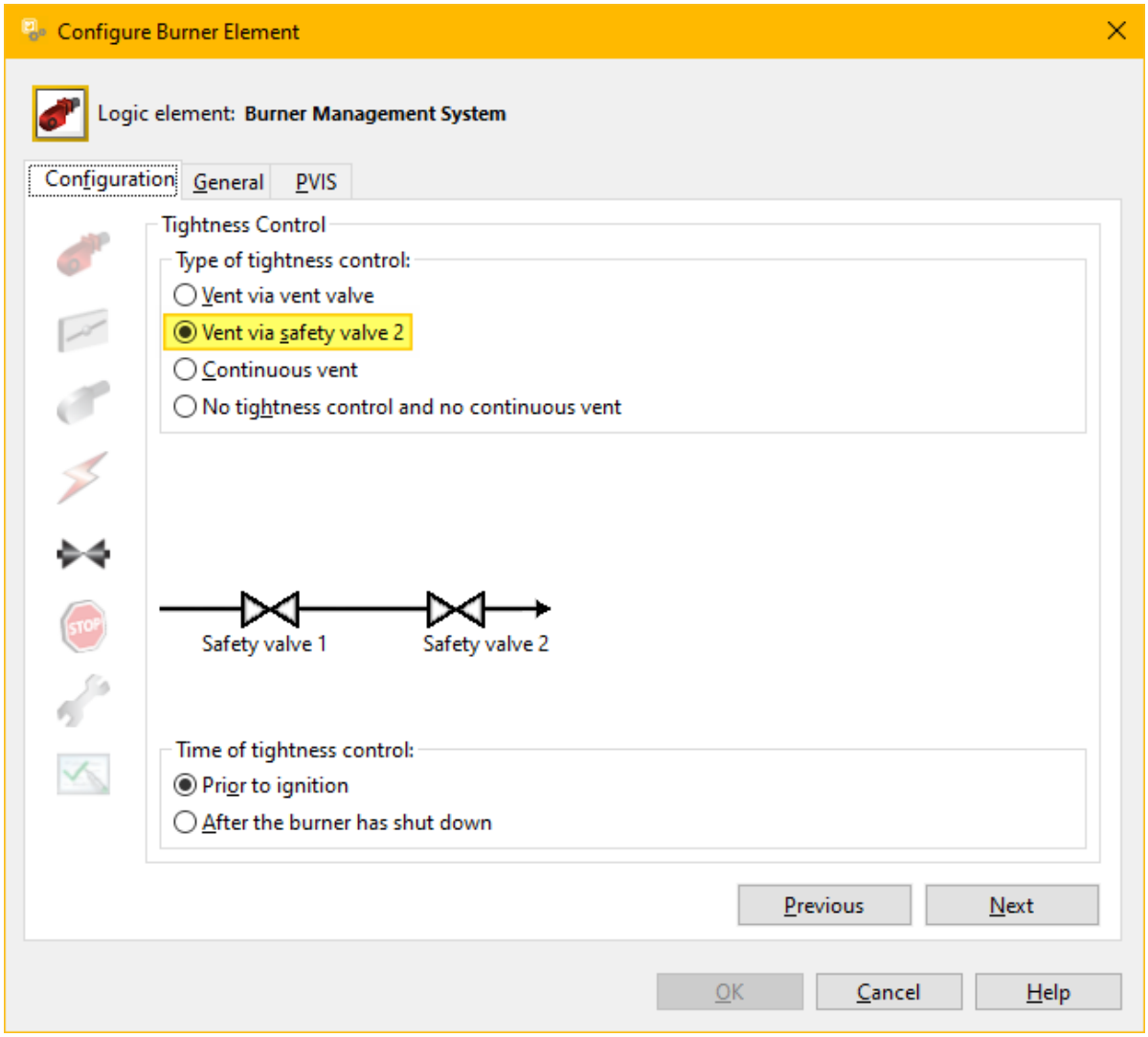

Figure 24: PNOZmulti Burner element – Settings tightness control

- Settings **Afterburn**:
  - It is set, that "*Safety valve 2 is closed during* (step) *Afterburn*".
  - It can be an advantage to set "*Safety valve 2 is open during afterburn*", when in the previous step "*Time of tightness control*" is configured "*After the burner has shut down*" (here not the case), because then the gas pressure between the safety valves will be low causing the step venting of the tightness control to be skipped, because then venting then already has taken place by leaving safety valve 2 open during afterburn.

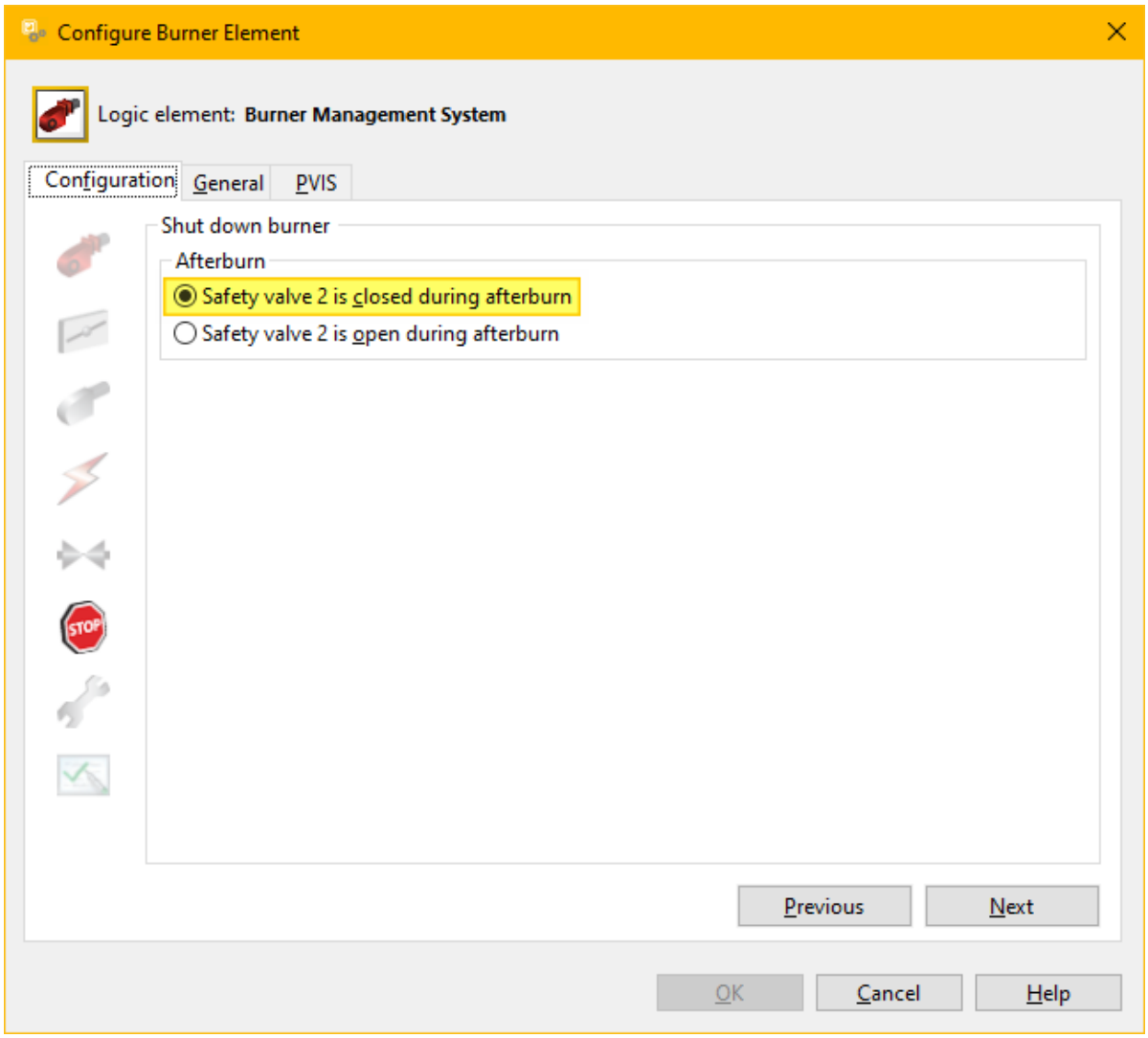

Figure 25: PNOZmulti Burner element – Settings afterburn

- Settings **Failure reaction**:
  - Normally, in case of an error a fault lockout takes place (manual reset and start to restart). However, for some events an automatic restart can be configured.
    These events are:
    - Safety chain 1 interrupted (*CHA1*)
    - Safety chain 2 interrupted (*CHA2*)
    - Safety chain ignition and operation interrupted (*CHAi*)
    - Air pressure error during operation (*AirP*)
    - Flame error during operation (*FLAM*)
  - The time to automatic restart can be set in a range from 5 to 60 s.
  - Conditions for restart in any case: Freedom of errors.

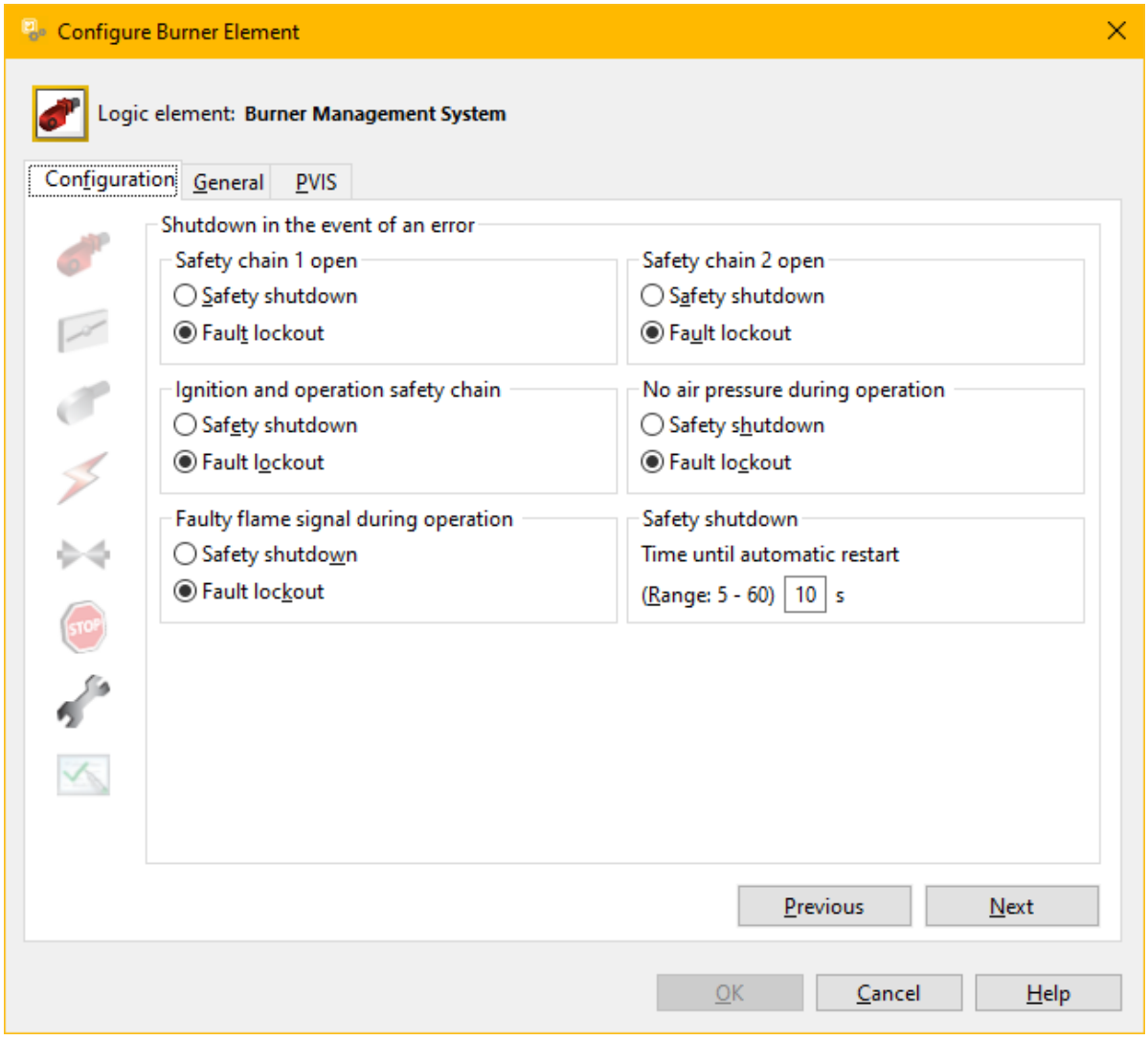

Figure 26: PNOZmulti Burner element – Settings failure reaction

5.3 Realizing the user program

5.3.1 Burner software element

5.3.1.1 Input interface

- **Start**, **Stop** and **Reset** from higher level controller:
  - *Start*, *Stop* and *Reset* coming via fieldbus (*a4.i0*, *a4.i1* and *a4.i2*).
  - As the *Start*, *Stop* and *Reset* inputs of the burner software element only accept fail safe signals, an AND operation with *safe TRUE* is required.

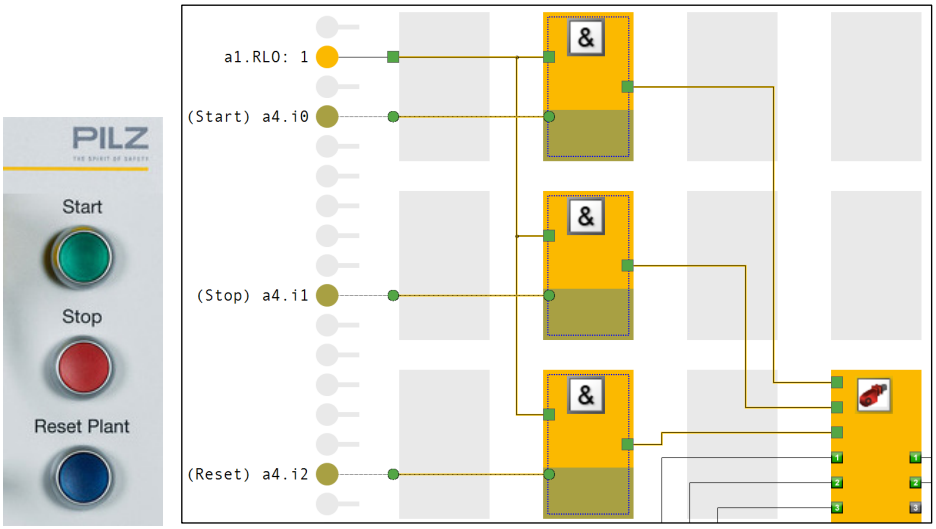

Figure 27: PNOZmulti program – Functions 'Start', 'Stop' and 'Reset'

- **Gas low and high pressure** switches on safety chain 1 (*CHA1*):
  Logic AND Operation of `[1-08]` Gas pressure low and `[1-09]` Gas pressure high is provided.
  The result connected to *CHA1*.
  - *CHA1* must be TRUE in each step.

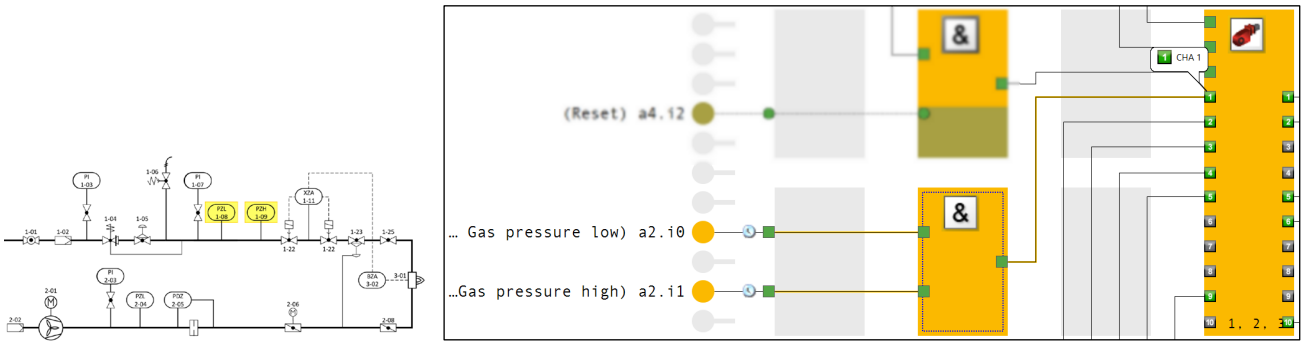

Figure 28: PNOZmulti program – Functions 'Gas low' and 'High pressure'

- **Emergency stop** on safety chain 2:
  Enable signal of emergency stop monitoring connected to *CHA2*.
  – *CHA2* must be TRUE in each step.

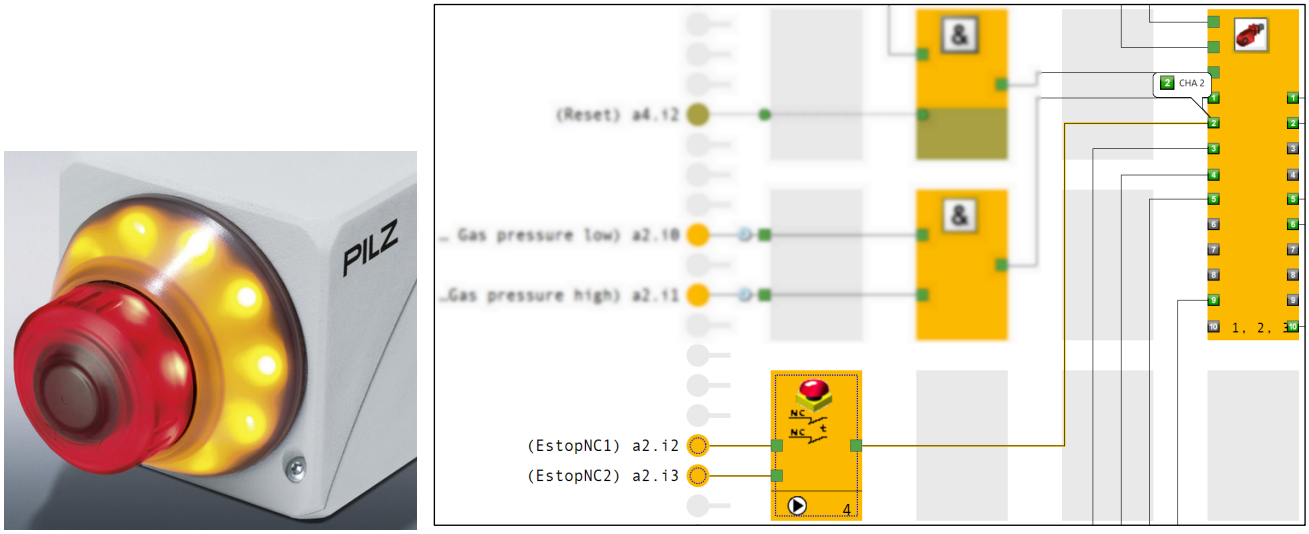

Figure 29: PNOZmulti program – Element 'Emergency stop'

- **Maximum temperature** on safety chain ignition and operation (*CHAi*):
  Result of temperature monitoring connected to *CHAi*.
  Result comes from the module program of the analogue input module, which is explained in Chapter 5.3.2 Temperature monitoring [📖 30].
  – *CHAi* must be TRUE each step from ignition up to operation.

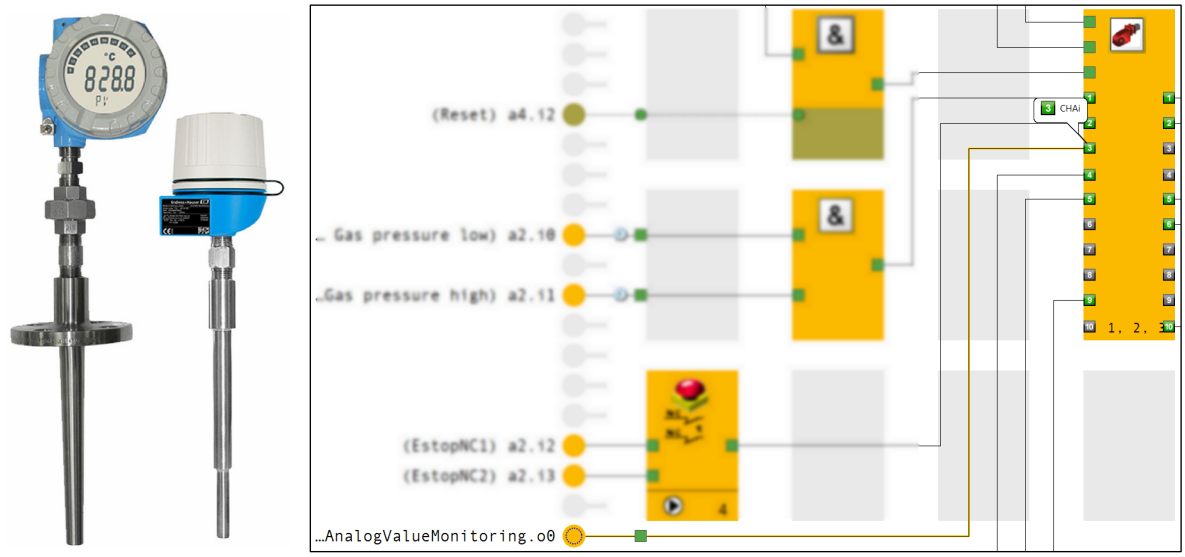

Figure 30: PNOZmulti program – Function 'Maximum temperature'
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- **Air pressure switch** and **Air flow switch** on combustion monitoring input (*AirP*):
  Logical AND operation of **[2-04]** air pressure low and **[2-05]** air flow.
  – The result is connected to *AirP*.

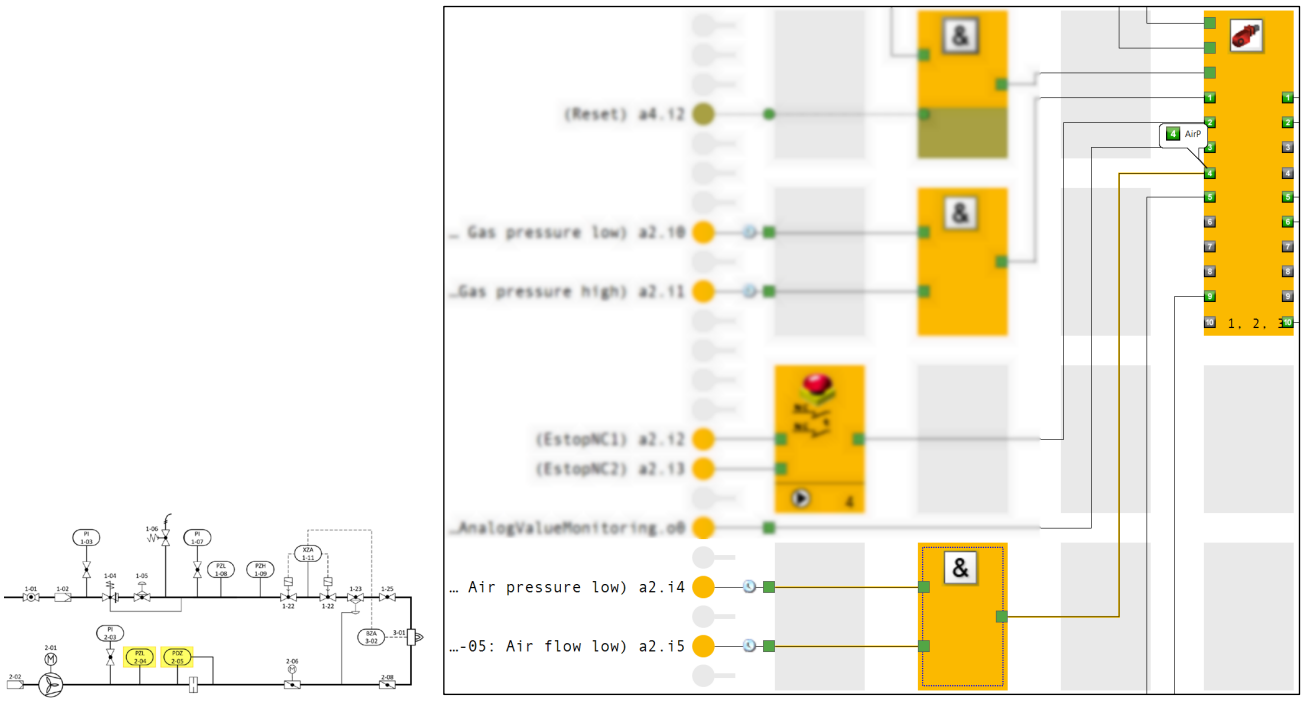


Figure 31: PNOZmulti program – Functions 'Air pressure switch' and 'Air flow switch'

- **Flame signal** on flame monitoring input (*FLAM*):
  The relay contact of the external flame monitor **[3-02]** switches a 24 VDC signal to the input *FLAM* (high at flame present).

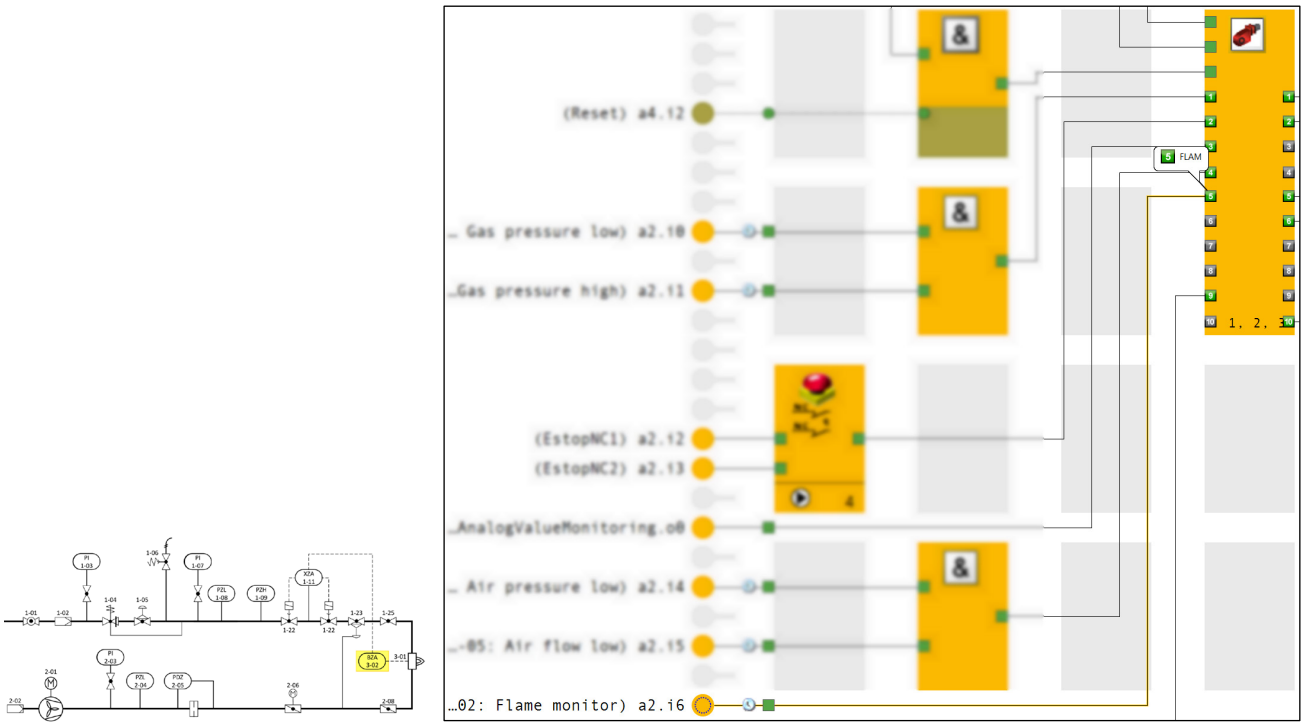


Figure 32: PNOZmulti program – Function 'Flame signal'

- **Air pressure** switch for **Tightness control** (*GP*):
  The air pressure switch for the tightness control `[1-11]` must be connected to input *GP*.

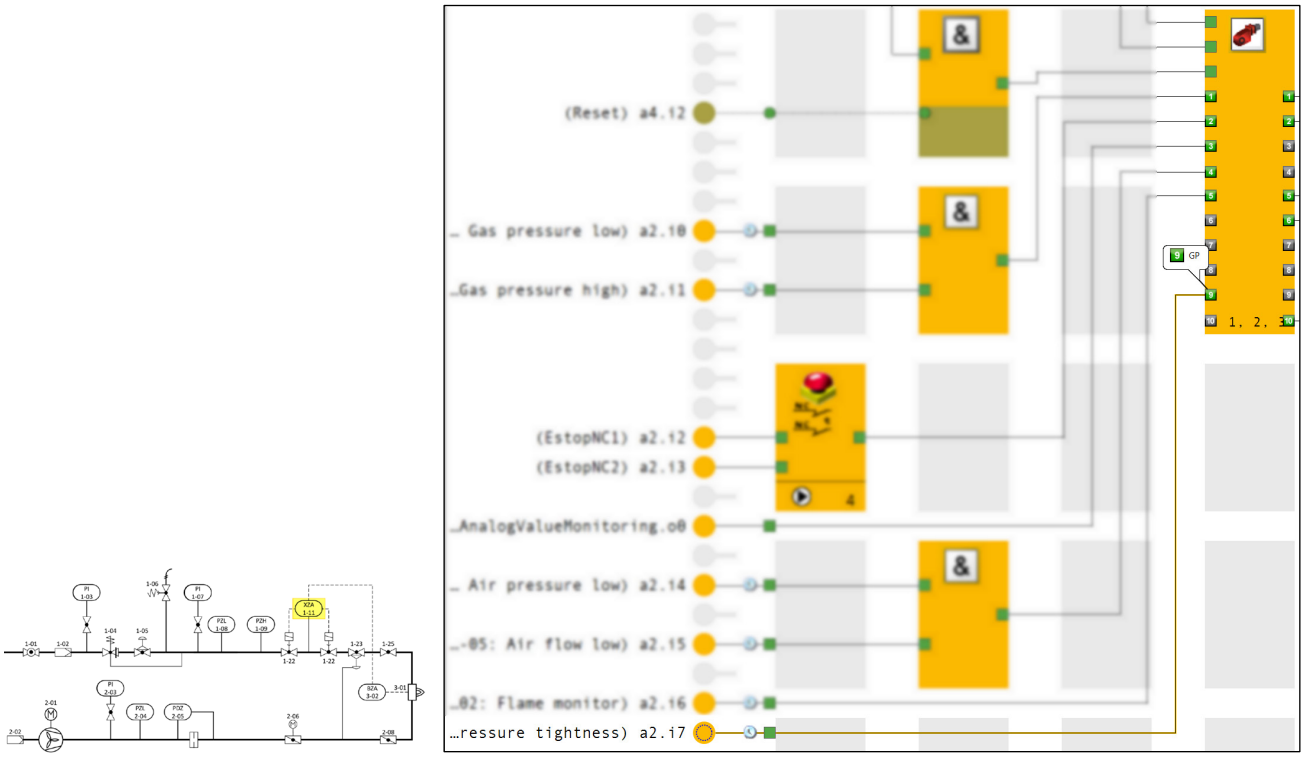


Figure 33: PNOZmulti program – Function 'Air pressure tightness control'

5.3.1.2 Output interface

- Outputs for **Safety valves** (*SV1* and *SV2*):
  If the safety valves `[1-22]` are to be driven by 24 VDC, the outputs *SV1* and *SV2* must be connected to semiconductor outputs. The advanced fault detection option is not necessary, as the safety valves are inherently safe if they are according to EN 161.

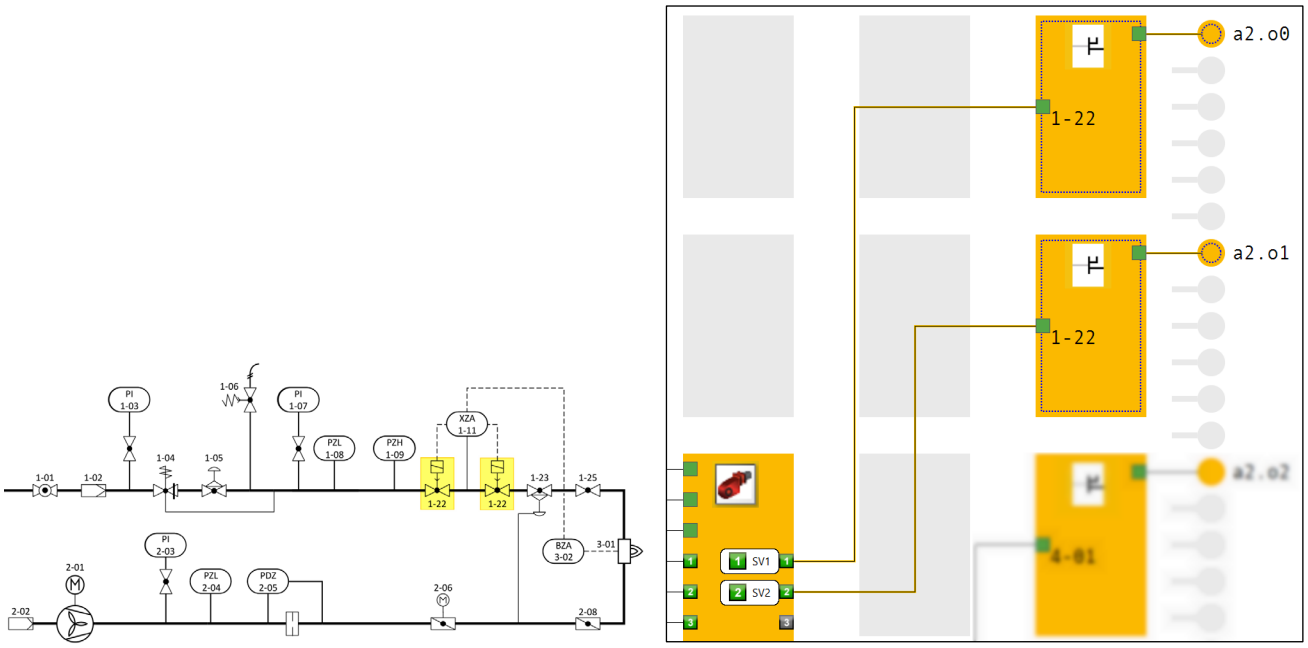
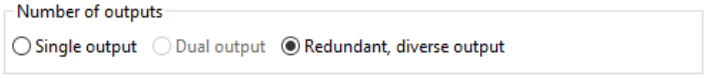


Figure 34: PNOZmulti program – Elements 'Semiconductor output' for Safety valves

If the safety valves `[1-22]` are to be driven by 115/230 VAC, the outputs *SV1* and *SV2* must be connected to relay outputs. A feedback loop monitoring is not necessary, as the safety valves are inherently safe if they are according to EN 161.
If the safety valves are in continuous operation, 2 diverse relay outputs must be used per valve. For this reason, the option "*Redundant, diverse outputs*" must be selected at the setting of the number of outputs to meet the according requirement of the EN 50156.



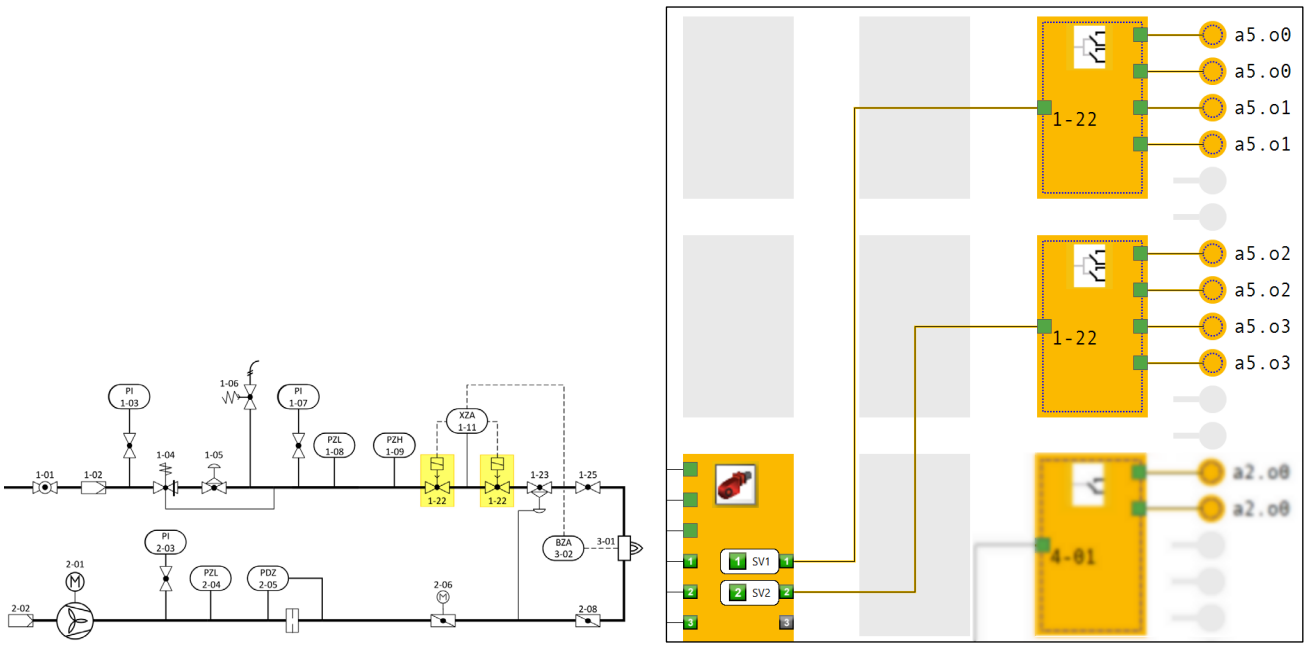


Figure 35: PNOZmulti program – Elements 'Relay Output' for Safety valves

- Output for **Ignition transformer** (*IGNT*):
  If the ignition transformer is driven by 24 VDC, the output *IGNT* must be connected to a semiconductor output. The advanced fault detection option is not necessary.

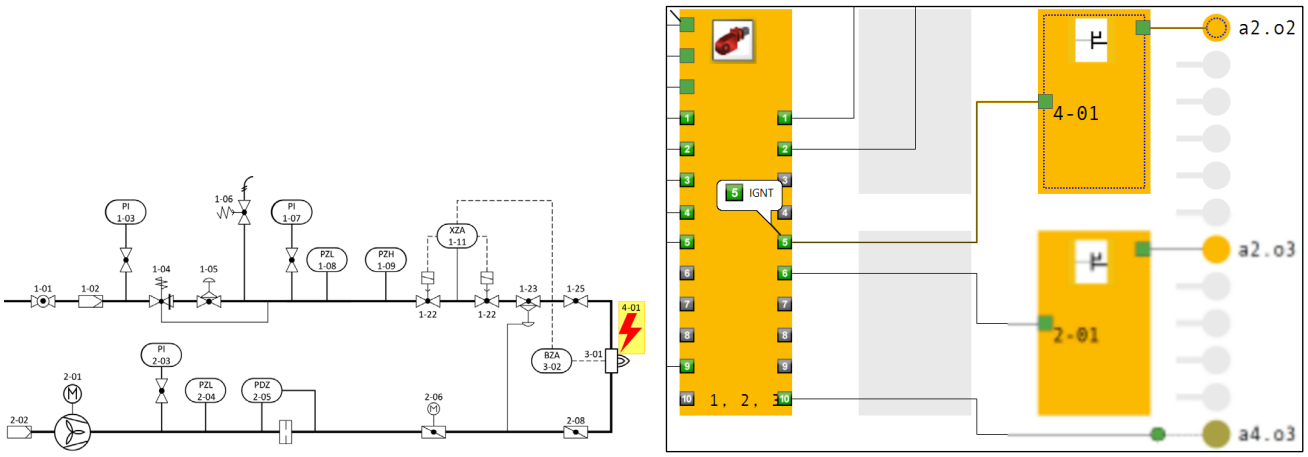


Figure 36: PNOZmulti program – Element 'Semiconductor Output' for Ignition transformer

If the ignition transformer is driven by 115/230 VAC, the output *IGNT* must be connected to a relay output.

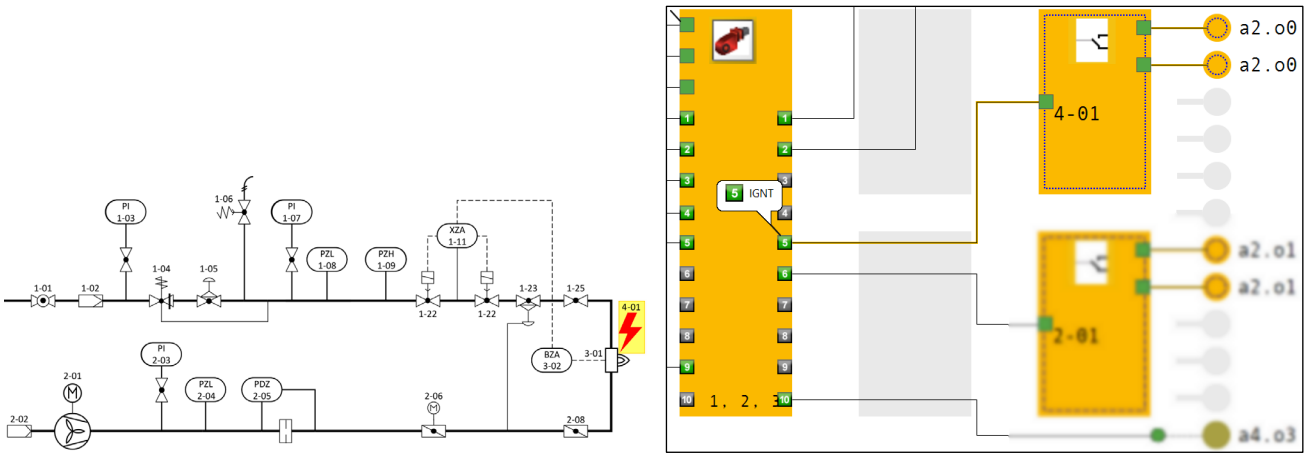


Figure 37: PNOZmulti program – Element 'Relay Output' for Ignition transformer

- Output for **Combustion air ventilator** (*BLOW*):
  If the contactor for the combustion air ventilator is driven by 24 VDC, the output *BLOW* must be connected to a semiconductor output. The advanced fault detection option is not necessary.

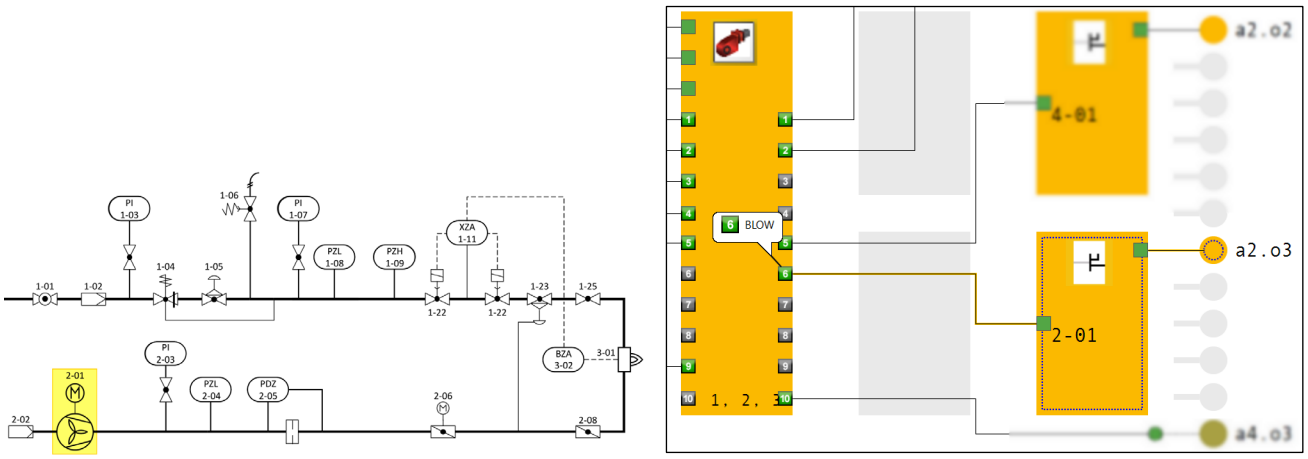


Figure 38: PNOZmulti program – Element 'Semiconductor Output' for Combustion air ventilator

If the contactor for the combustion air ventilator is driven by 115/230 VAC, the output *BLOW* must be connected to a relay output.

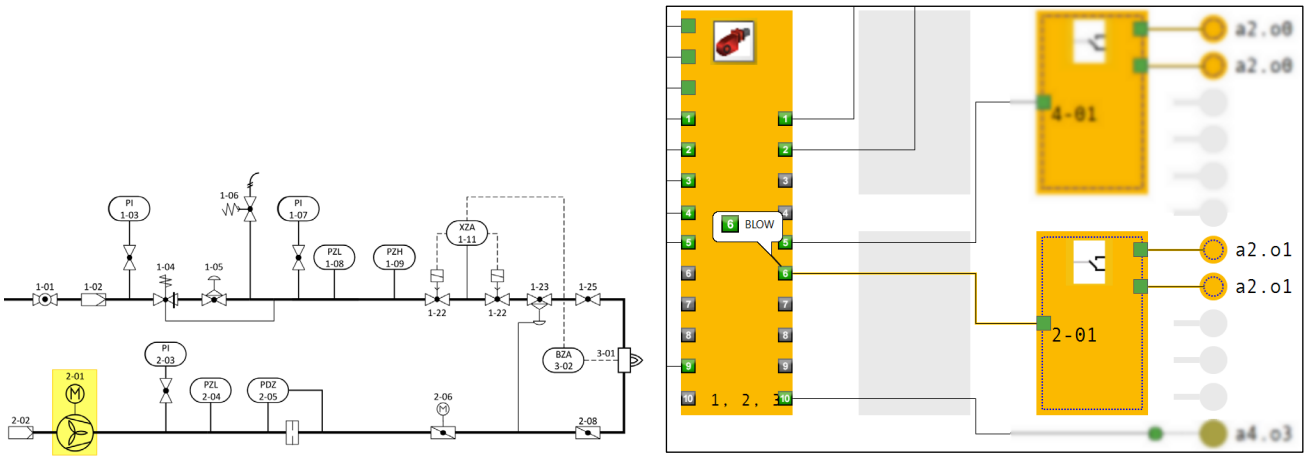


Figure 39: PNOZmulti program – Element 'Relay Output' for Combustion air ventilator

- **Control enable signal** (*CONT*) to higher level controller:
  The signal which enables to modulating control of the burner, as soon as the burner is in operation is not a safety related signal. It can be communicated to a higher-level controller via fieldbus.

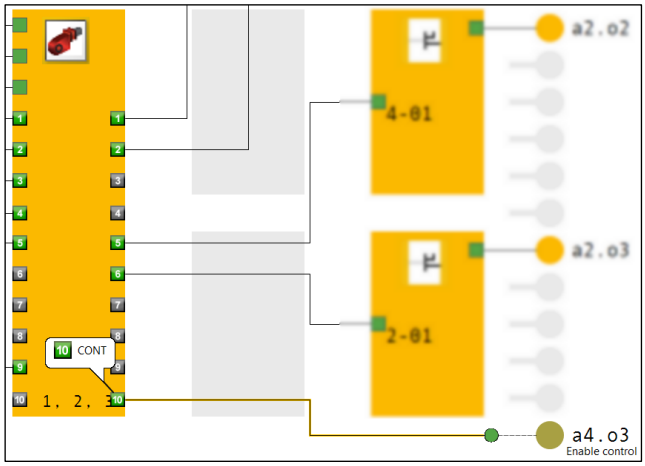


Figure 40: PNOZmulti program – Control enable signal (CONT) to higher level controller

5.3.2 Temperature monitoring

The temperature monitoring connected to the safety chain ignition and operation (*CHAi*) as mentioned in Chapter 5.3.1 Burner software element [🕮 23] is explained in detail here.

- The temperature monitoring is realized in the module program of the failsafe analogue input module 'PNOZ m EF 4AI'. It consists of:
  - Range monitoring of analogue signal according to NE43
  - Plausibility check of both redundant signals
  - Scaling
  - Threshold value monitoring
  - Result as output to main program

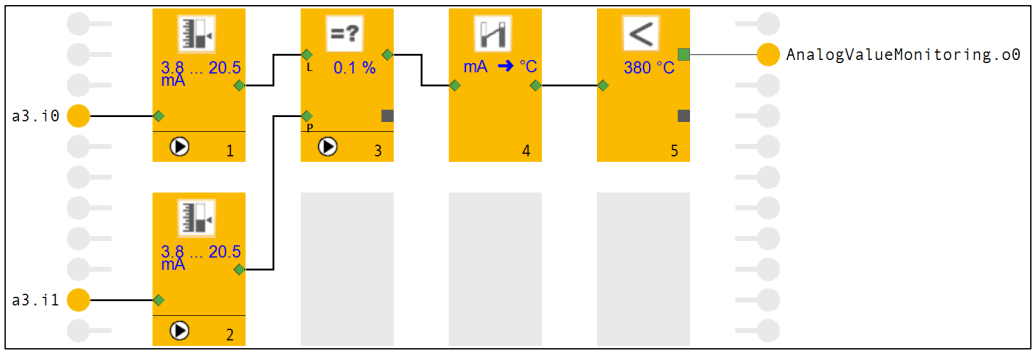


Figure 41: PNOZmulti program – Elements for analogue value monitoring

- **Range monitoring** of analogue signal **according to NE43**:
  - The settings of the range monitoring of analogue signal are made according to NE43:
    - Measuring range of 3.8 ... 20.5 mA
      (with accepted under- and overshoot)
    - Open circuit recognized by current < 3.6 mA
    - Short circuit recognized by current > 21 mA
    - Transmitter error signalized by transmitter
      by means of output current < 3.6 mA (failure information)
    - Transmitter error signalized by transmitter
      by means of output current > 21 mA (failure information)
  - The settings are made accordingly:

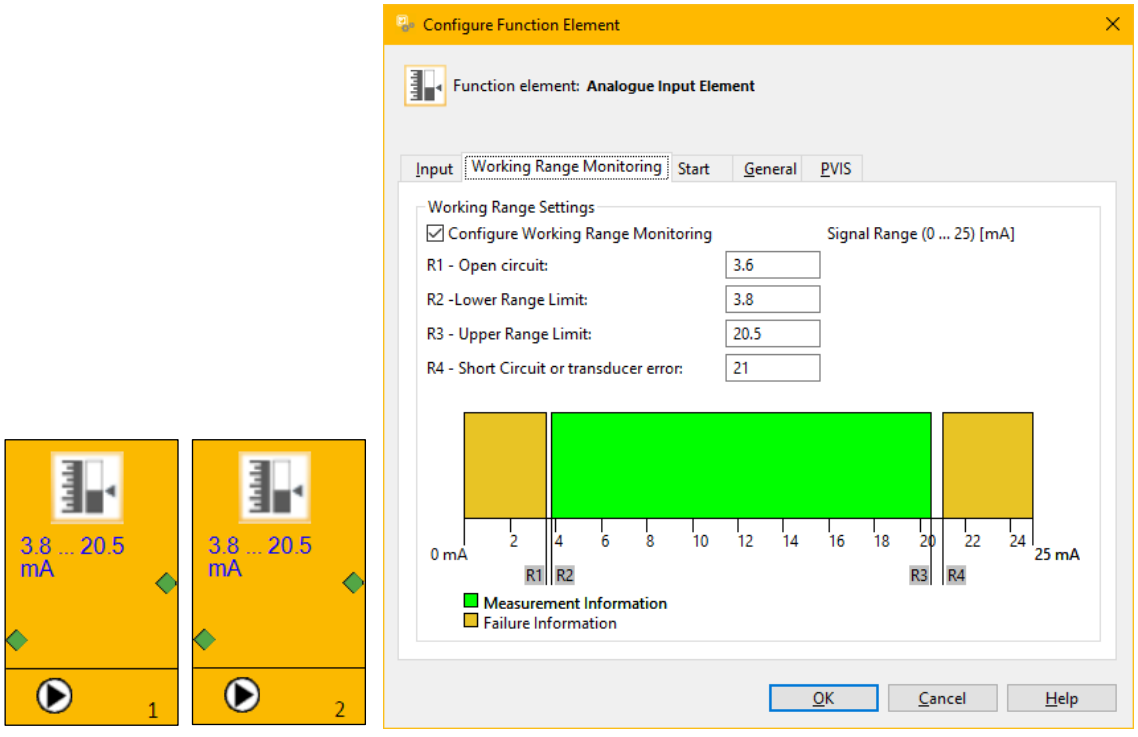


Figure 42: PNOZmulti Analogue Input element – Range monitoring according to NE43

- **Plausibility** check:
  To be able to reach SIL 3 the measuring values of the redundant temperature measurement must be compared. A maximal allowed tolerance is 0.1 % (exemplary value) is set.

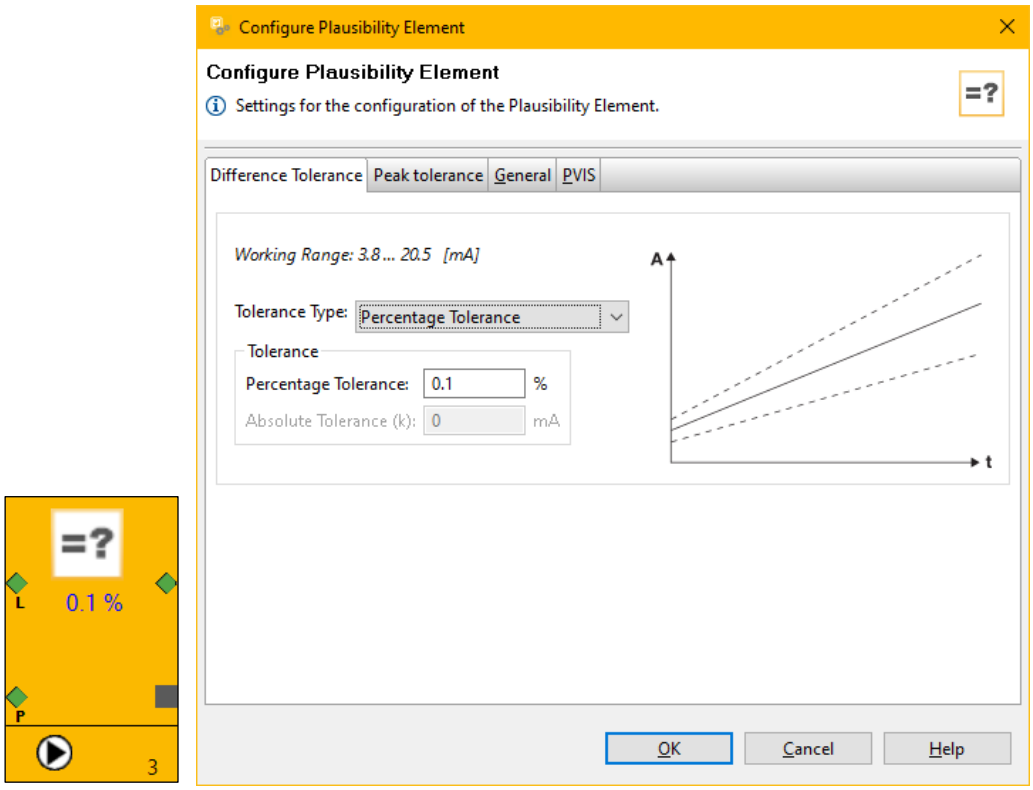


Figure 43: PNOZmulti Plausibility element – Plausibility check

- **Scaling**:
  Scaling of the 4 ... 20 mA signal to 0 ... 800 °C (exemplary value).
  The scaling must correspond to the actual measuring range of the transmitter.

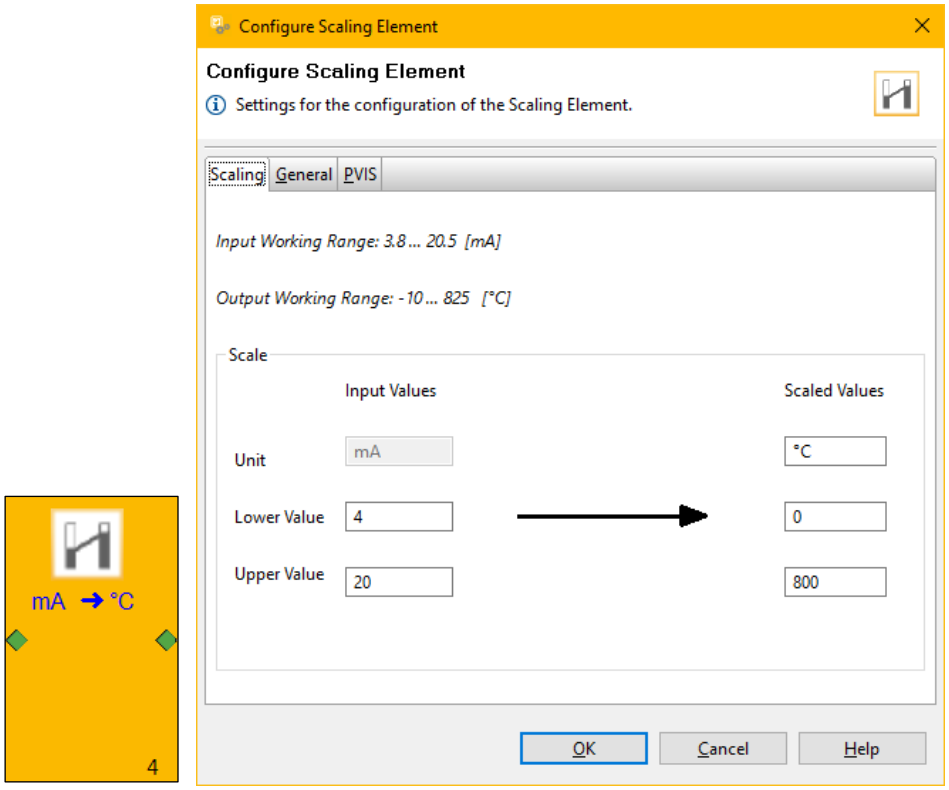


Figure 44: PNOZmulti Scaling element – Settings

- **Treshold value** for analogue value **monitoring**:
  - A FALSE signal (safety chain interrupted) is set, when temperature > 400 °C (exemplary value).
  - A TRUE signal is set, when temperature < 380 °C (exemplary value).
    This signal is connected to the safety chain for ignition and operation (*CHAi*) in the main program.

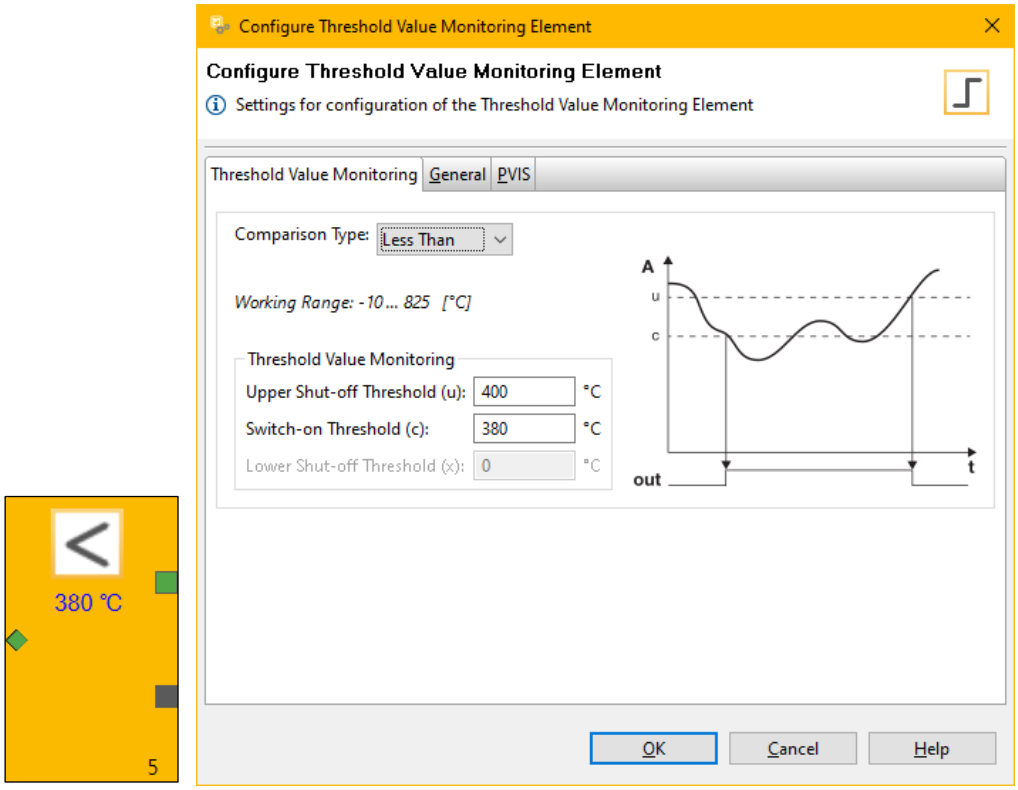


Figure 45: PNOZmulti Treshold Value Monitoring element – Settings

5.4 Resulting burner sequence

- **Resulting steps**, configured step times are exemplary:
  - After the start signal (*Start* := high) starting conditions are checked (step 1).
  - Combustion air blower (*BLOW*) is started (step 2).
  - During pre-purge (steps 5...9), tightness control is taking place (steps 5...8):
    - Open safety valve 2 (*SV2*) for venting for the specified time (step 5),
    - Close safety valve 2 (*SV2*) and check if pressure remains low (step 6).
      » If not, safety valve 1 (*SV1*) is leaking.
    - Open safety valve 1 (*SV1*) for filling for the specified time (step 7),
    - Close safety valve 1 (*SV1*) and check if pressure remains high (step 8).
      » If not, safety valve 2 (*SV2*) is leaking.
  - When tightness control is finished: Remaining pre-purge (step 9).
  - Pre-ignition: Activate ignition (*IGNT*) to build the spark (step 12).
  - Open safety valves *SV1* and *SV2* for ignition and wait for elapsing of the safety time (step 15).
  - Let flame stabilize (step 16).
  - Now we are in operation (step 18).
  - After the stop signal (*Stop* := high), safety valves *SV1* and *SV2* are closed and the flame is burning out (step 20).
  - Post-purging (step 21).
  - Combustion air blower (*BLOW*) is switched off (step 22).
  - Ready for *Start* again.

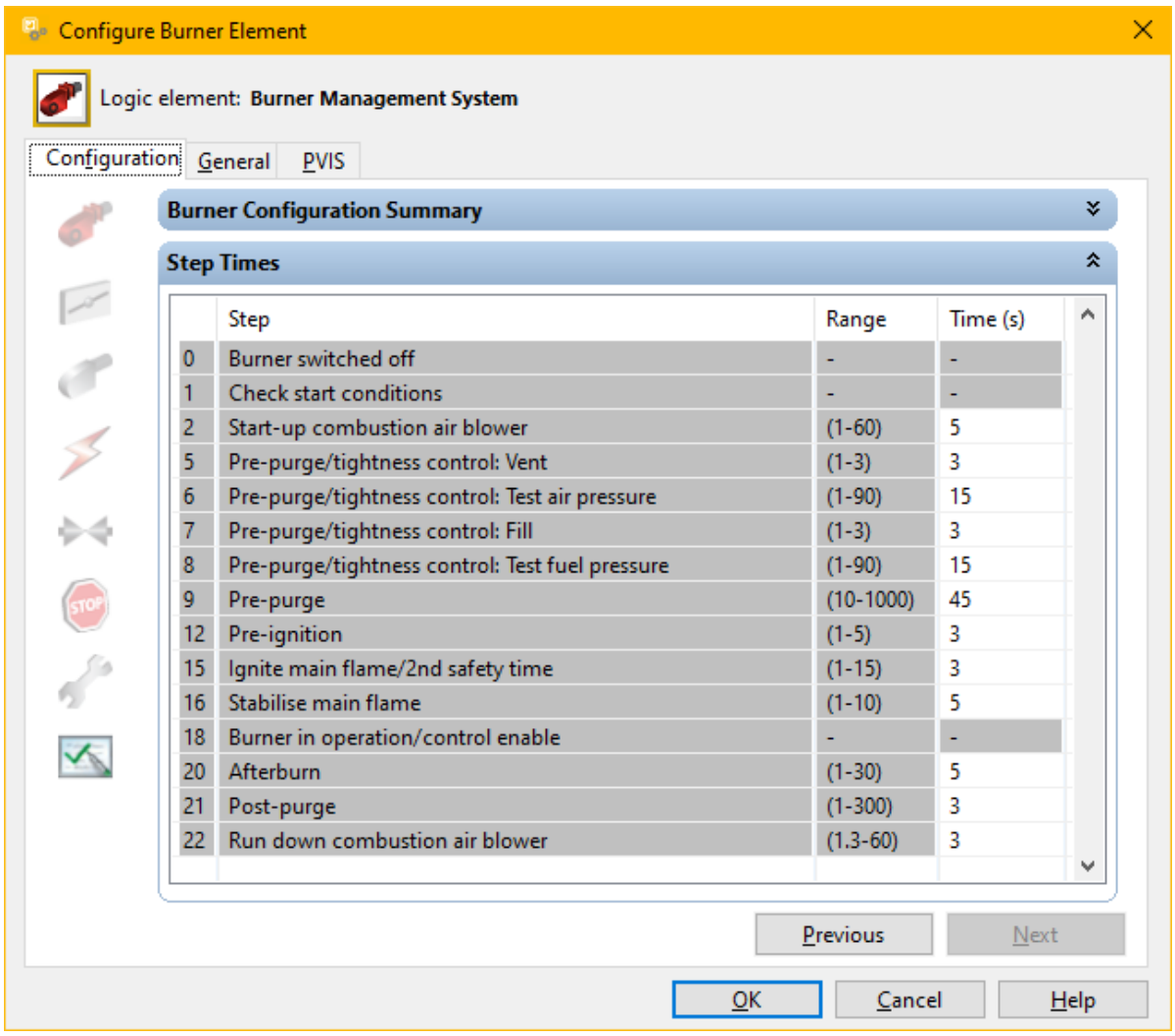


Figure 46: PNOZmulti Burner element – Resulting steps (Configured step times are exemplary!)

- Sequence and **monitoring of inputs**:
  - Safety chain 1 and 2 (*CHA1/2*) must remain high after *Start* (step 1) until run down (step 22).
  - Safety chain ignition and operation (*CHAi*) must remain high from pre-ignition (step 12) up to burner in operation (step 18), during other steps this monitoring is deactivated.
  - It is monitored, that the combustion air supply (*AirP*) is low directly after start (step 1) and gets/remains high during pre-purge, ignition, operation, afterburn and post-purge (step 5…21), during other steps the monitoring is deactivated.
  - The flame signal (*FLAM*) must be low at *Start* (step 1…2) and during pre-purge (step 5…9). During the ignition process (step 12…15) and during afterburn (step 20) the monitoring is deactivated, during post-purge and run-down (step 21…22) the signal must be low. During stabilizing of the flame (step 16) and during operation (step 18) the flame signal (*FLAM*) must be high.
  - During testing air pressure in the tightness control (step 6) the pressure (*GP*) must remain low and during testing fuel pressure in the tightness control (step 8) the pressure (*GP*) must remain high, during other steps the monitoring is deactivated.
  - Any deviation of low/high will lead to a safety shutdown.

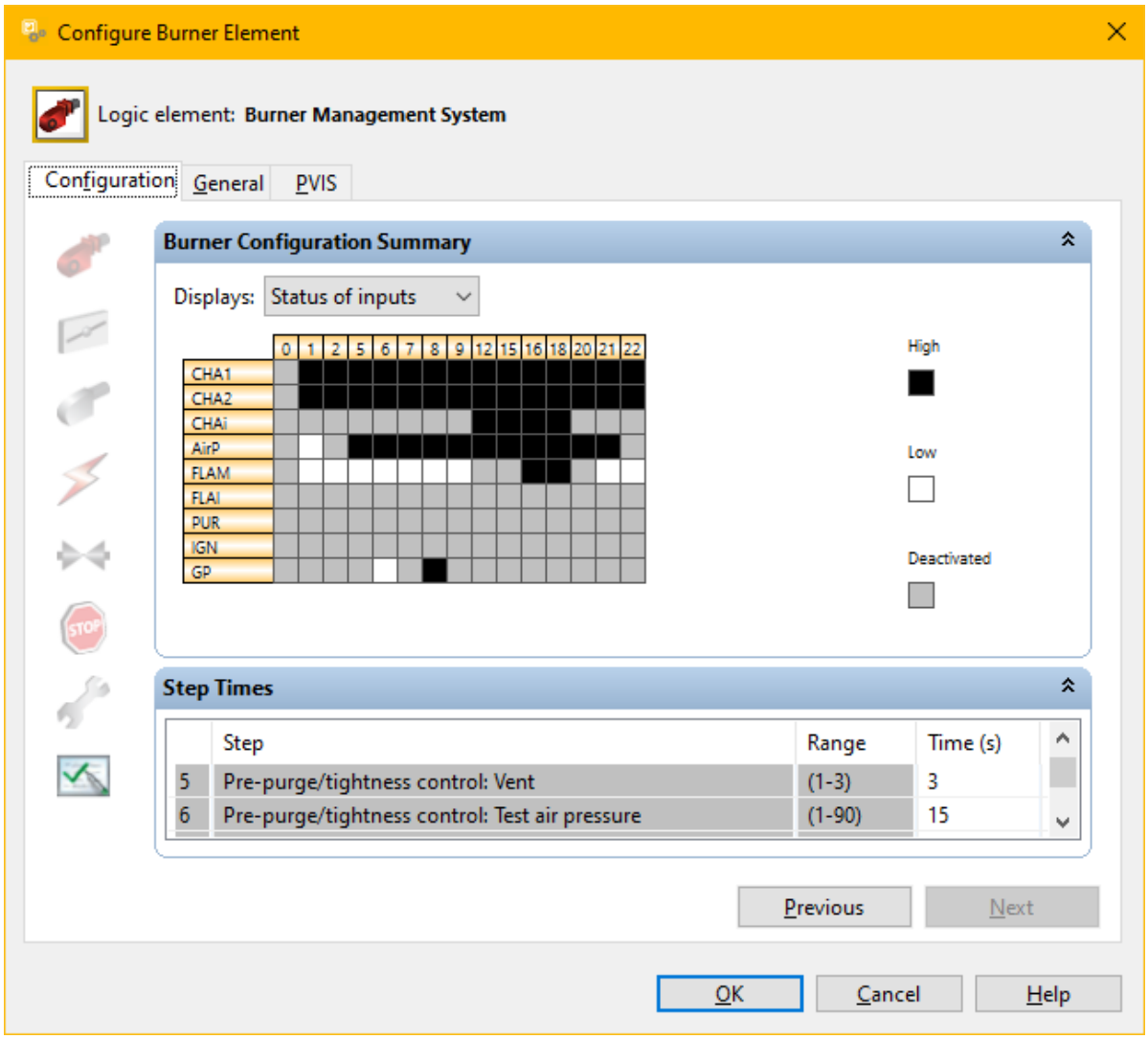


Figure 47: PNOZmulti Burner element – Sequence and monitoring of inputs

- Sequence and **control of outputs**:
  - The tightness control (step 5…8) runs during pre-purge (step 5…9).
    During tightness control, safety valve 2 (*SV2*) is opened (step 5) to vent the section between the safety valves (testing low pressure testing in step 6) and safety valve 1 (*SV1*) is opened (step 7) to fill the section between the safety valves (testing high pressure in step 8).
  - Both safety valves (*SV1* and *SV2*) are opened both during ignition and operation (step 15…18).
    The Ignition transformer (*IGNT*) is switched on during pre-ignition (step 12) and during igniting the main flame / 2nd safety time (step 15).
  - The combustion air blower (*BLOW*) is switched on at start (step 2) and remains on until post-purge (step 21).
  - The controller enable signal (*CONT*) is set during operation (step 18).

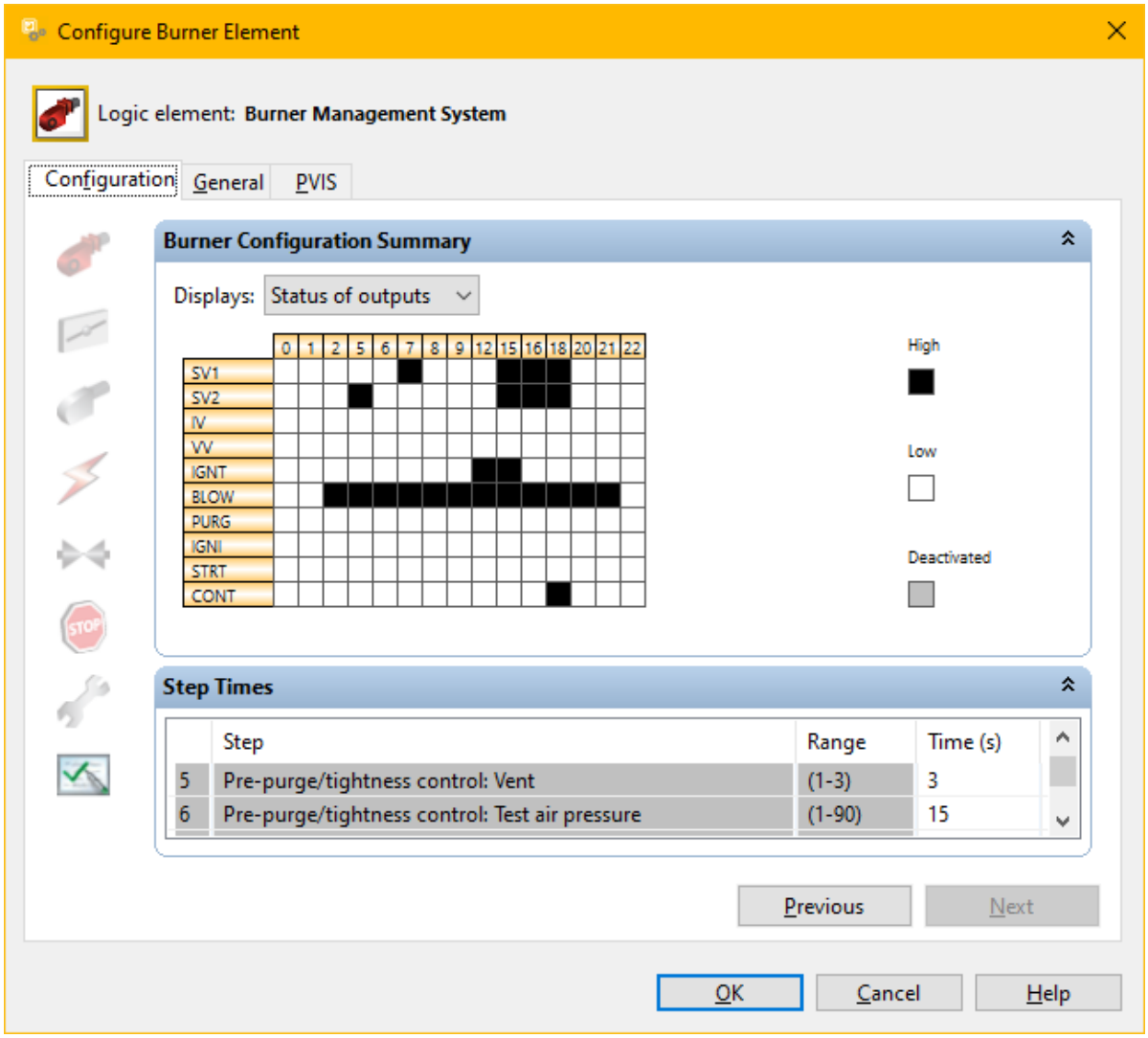


Figure 48: PNOZmulti Burner element – Sequence and control of outputs

5.5 Optional configurations

5.5.1 Indirect ignition

- When using an ignition burner to ignite the main flame (indirect ignition), following settings can be made (displayed below):
  - *"... Indirect Ignition, separate flame monitoring"*,
    when each main flame and ignition flame have their own flame monitoring or
  - *"... Indirect Ignition, joint flame monitoring"*,
    when both flames have one and the same flame monitoring.
- Additional steps in the sequence, when indirect ignition is set:
  - Ignite ignition flame / 1st safety time and
  - Stabilise ignition flame

  after Pre-Ignition and before Ignite main flame / 2nd safety time.

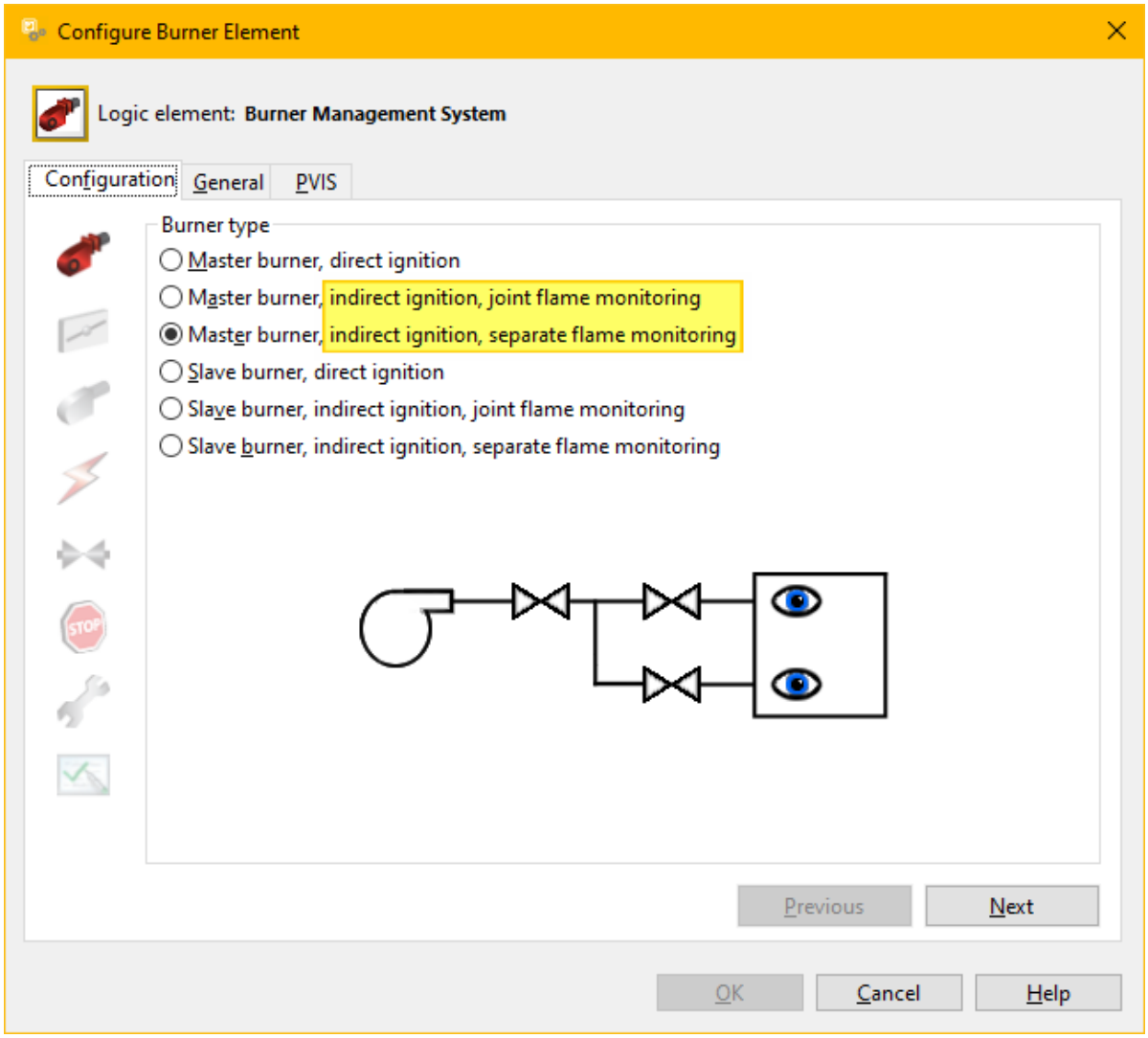


Figure 49: PNOZmulti Burner element – Setting indirect ignition

5.5.2 Slave burner

The sequence for the slave burner is a sequence without control and monitoring of the combustion air. The sequence therefore directly starts with the ignition.

- This setting is to be applied in multi burner applications, where a centralized control and monitoring of the combustion air is applied which is not part of the single burner sequence.
  - The OK signal of this centralized control and monitoring of the combustion air must be connected to *AirP*.

Same options are available as with the master burner: Direct ignition or indirect ignition with joint or separate flame monitoring.

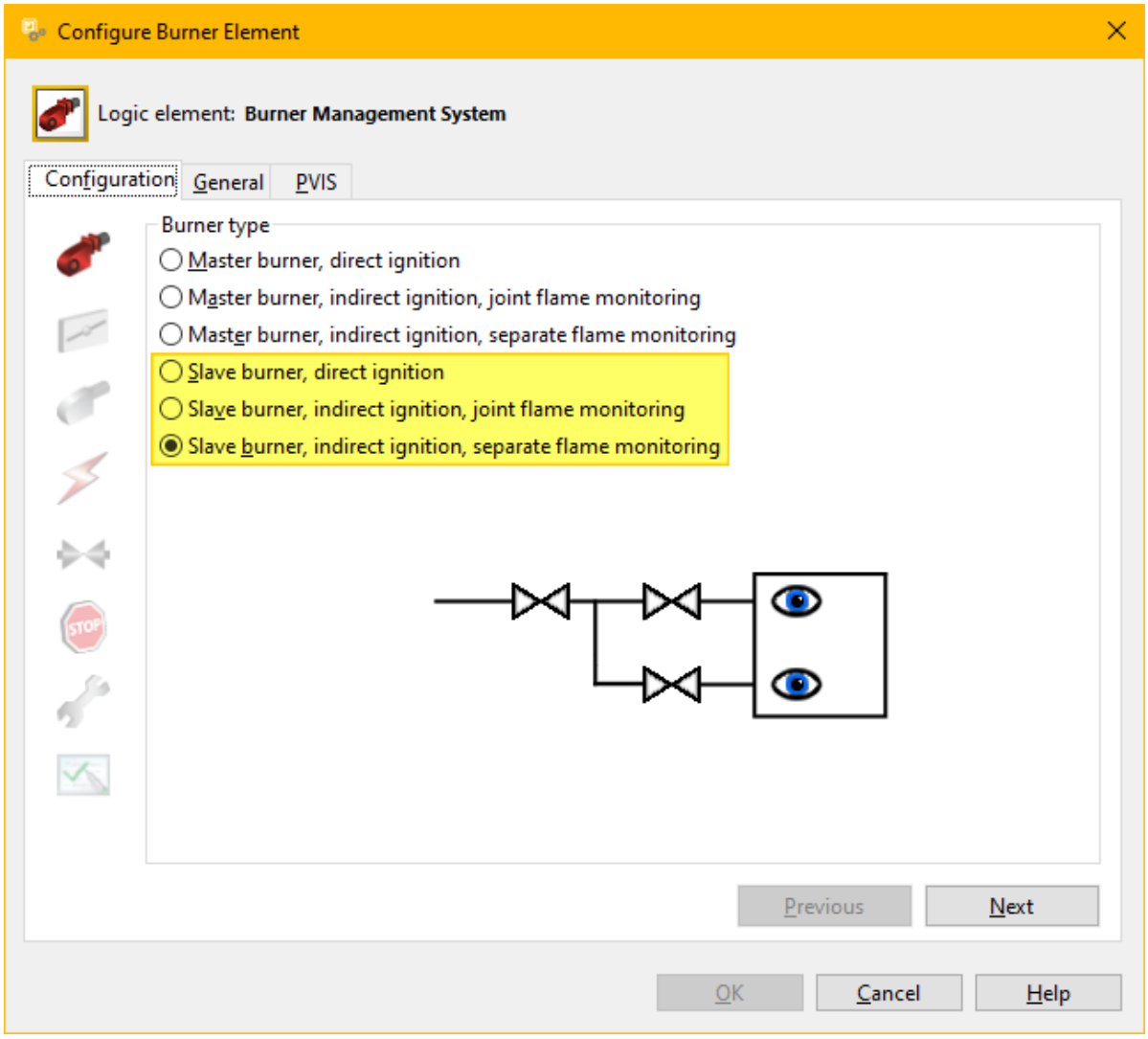


Figure 50: PNOZmulti Burner element – Slave burner

5.5.3 External electronic compound controller

When an external electronic compound controller is being used, the setting "*Cycle with compound controller*" must be made; see second option in Figure 21 PNOZmulti Burner element – Configuration of compound controller [🕮 17].

- When this setting is made, following inputs appear on the block:
  - *PUR*: Compound controller in pre-purge position
  - *IGN*: Compound controller in ignition position

Both inputs are monitored in the sequence. Debounce times can be set for these input signals.

- When this setting is made, following outputs appear on the block:
  - *PURG*: Compound controller to pre-purge position
  - *IGNI*: Compound controller to ignition position
- When this setting is made, following steps (marked yellow) are added to the sequence:

2	Start-up combustion air blower	(1-60)
3	Compound controller to prepurge position	(1.3-300)
5	Pre-purge/tightness control: Vent	(1-3)
6	Pre-purge/tightness control: Test air pressure	(1-90)
7	Pre-purge/tightness control: Fill	(1-3)
8	Pre-purge/tightness control: Test fuel pressure	(1-90)
9	Pre-purge	(10-1000)
10	Compound controller to ignition position	(1.3-300)
12	Pre-ignition	(1-5)
15	Ignite main flame/2nd safety time	(1-15)
16	Stabilise main flame	(1-10)

Figure 51: External Compound Controller – Overview of steps (table)

In step 3 the compound controller is given the time to move in the pre-purge position.
For this purpose, the output *PURG* is set in the steps 2...9 to ensure, that during pre-purge the compound control remains in the pre-purge-position.

- To monitor this, the input *PUR* must be TRUE during the steps 5...9. The input *PUR* must therefore be connected with the feedback signal from the compound controller which confirms that the compound controller is in the pre-purge position.
- For this feedback signal a debounce time can be configured in the 1st setting "*Debounce time for compound controller to pre-purge position*" in section "*Times*" in following Figure 52 [🕮 39].

In step 10 the compound controller is given the time to move in the ignition position. For this purpose, the output *IGNI* is set in the steps 10...16 to ensure, that during ignition the compound control remains in the ignition-position.

- To monitor this, the input *IGN* must be TRUE during the steps 12...16. The input *IGN* must therefore be connected with the feedback signal from the compound controller which confirms that the compound controller is in the ignition position.
- For this feedback signal a debounce time can be configured in the 2nd setting "*Debounce time for compound controller to ignition position*" in section "*Times*" in following Figure 52 [🕮 39].

- If a pneumatic or mechanic compound control is being used, the setting "*Cycle without compound controller*" must be made, as in these cases no interfaces are required.

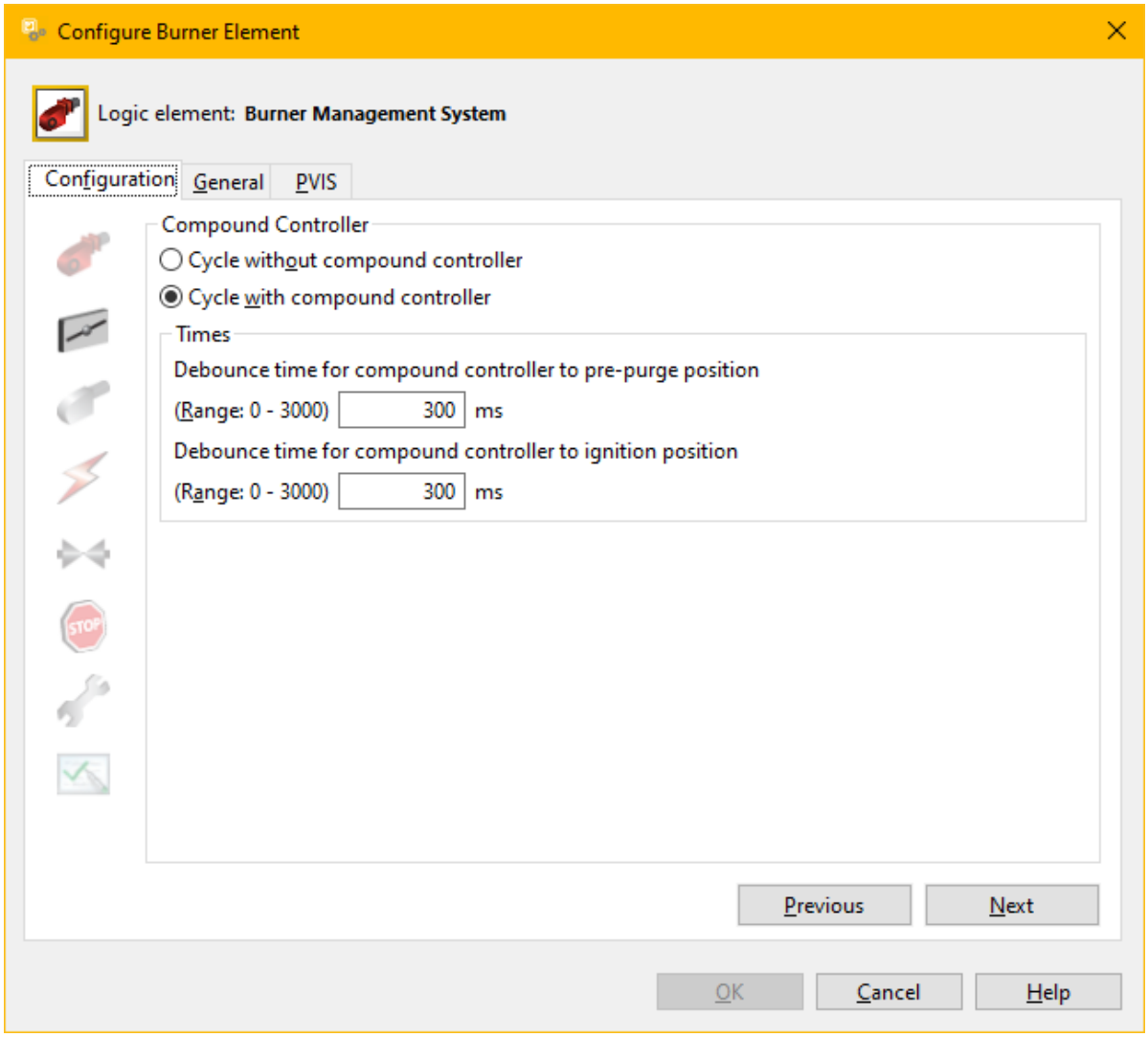


Figure 52: PNOZmulti Burner element – Settings compound controller

5.5.4 Tightness control

The venting during the venting phase of the tightness control can take place via a vent valve (displayed below) or via safety valve 2.

The option "*Continuous vent*" means, that no tightness control is taking place and instead the vent valve is kept open, if both safety valves are closed.
Eventual leaking gas will then not be detected but will escape through the vent valve.

The tightness control and continuous vent can also be deactivated.

- The tightness control can take place:
  - Prior to ignition (during pre-purge) or
  - after the regular shut down of the burner

In the last case, the tightness control will also take place prior to ignition (during pre-purge) during a restart after the burner has been shut down by a safety shutdown or a fault lockout.

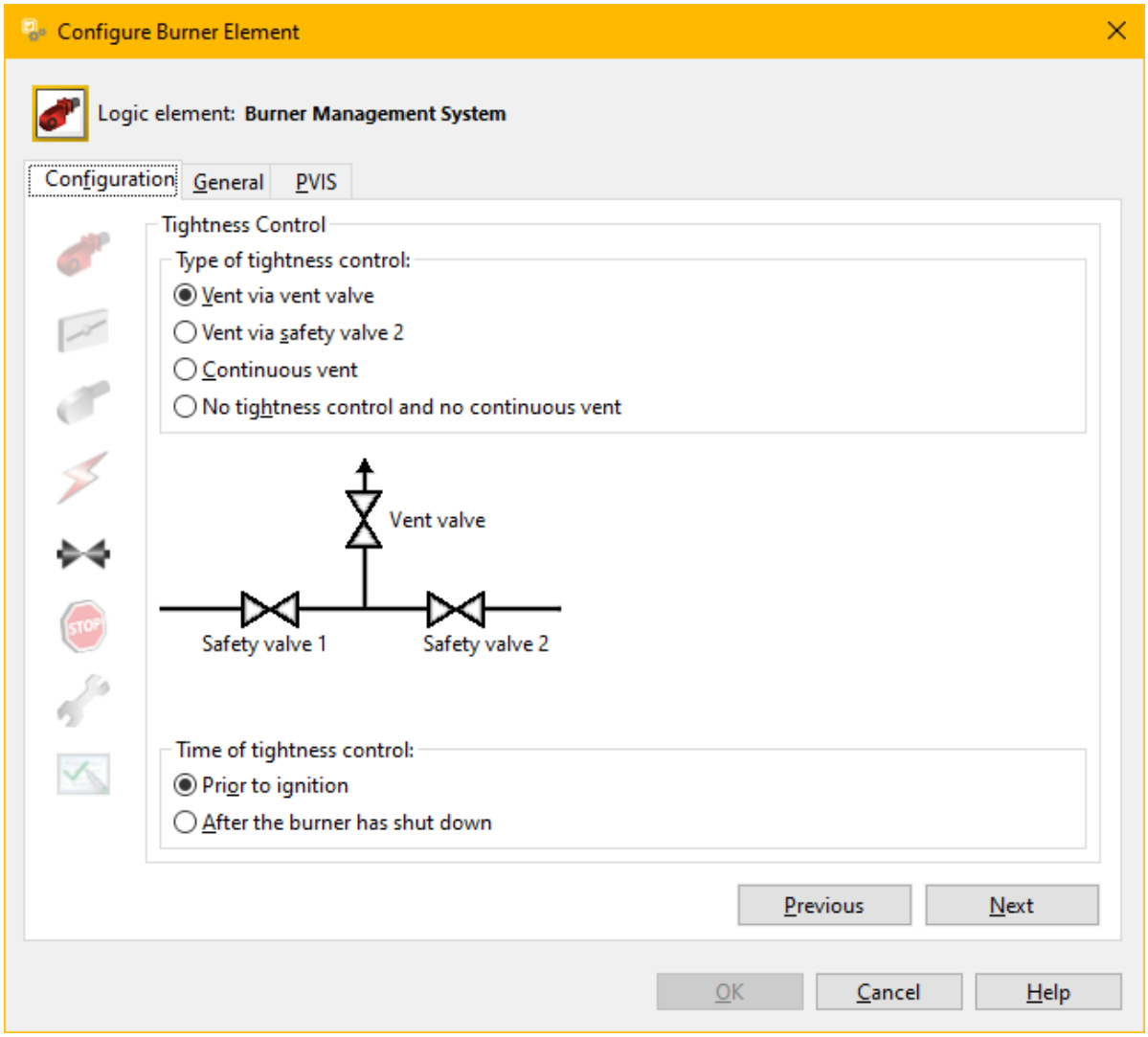


Figure 53: PNOZmulti Burner element – Tightness control

5.5.5 High temperature mode

- The high temperature mode can be set as follows (see below):

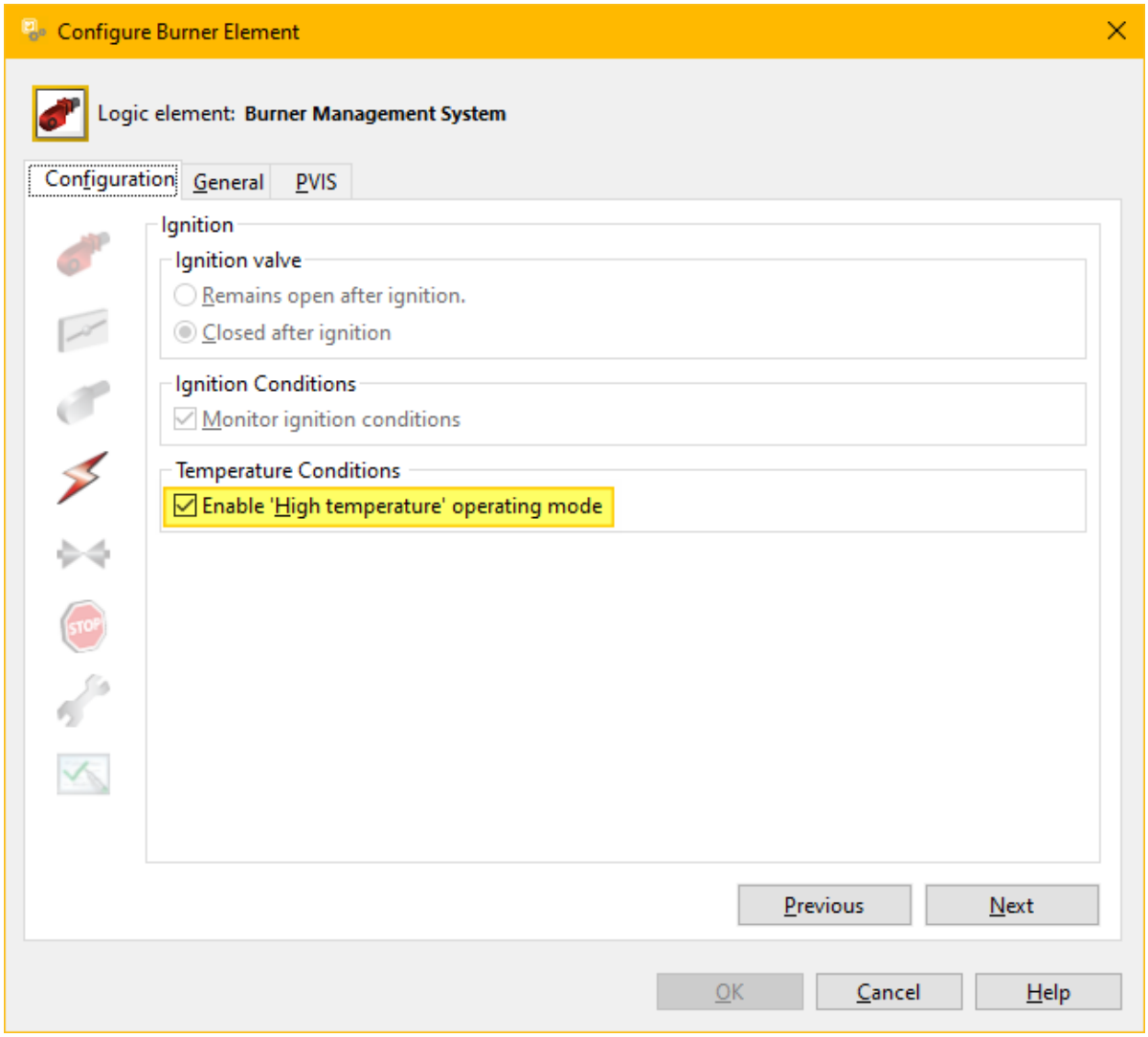


Figure 54: PNOZmulti Burner element – Setting high temperature mode

- If the high temperature mode is set, the input *HTmp* appears on the burner software element.

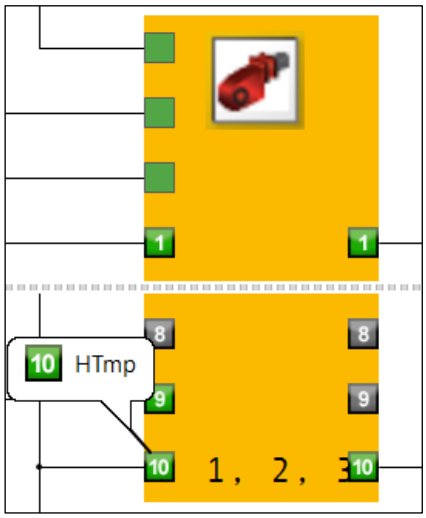


Figure 55: PNOZmulti Burner element – Input for high temperature mode

- If the signal at this input is high, following steps are no longer executed:
  - Pre-purge
  - All tightness control steps
  - Afterburn
  - Post-purge

If the input gets high during one of the above steps is active, then the sequence jumps to the next step normally active in high temperature mode, for example from "*Pre-purge/tightness control vent to Pre-ignition*".

- Also the flame monitoring is deactivated during high temperature mode.
- The high temperature mode is deactivated when the input *HTmp* is low.
- The input *HTmp* must be connected to the safety function monitoring the condition for the high temperature mode. For instance the coldest temperature in the fire chamber > 750 °C.

5.5.6 Restart behaviour after failure

Normally after a failure, a fault lockout is performed.

- For some failures (see options below), alternatively a safety shutdown with automatic restart can be configured.
- For these situations the time between failure and automatic restart can be configured.

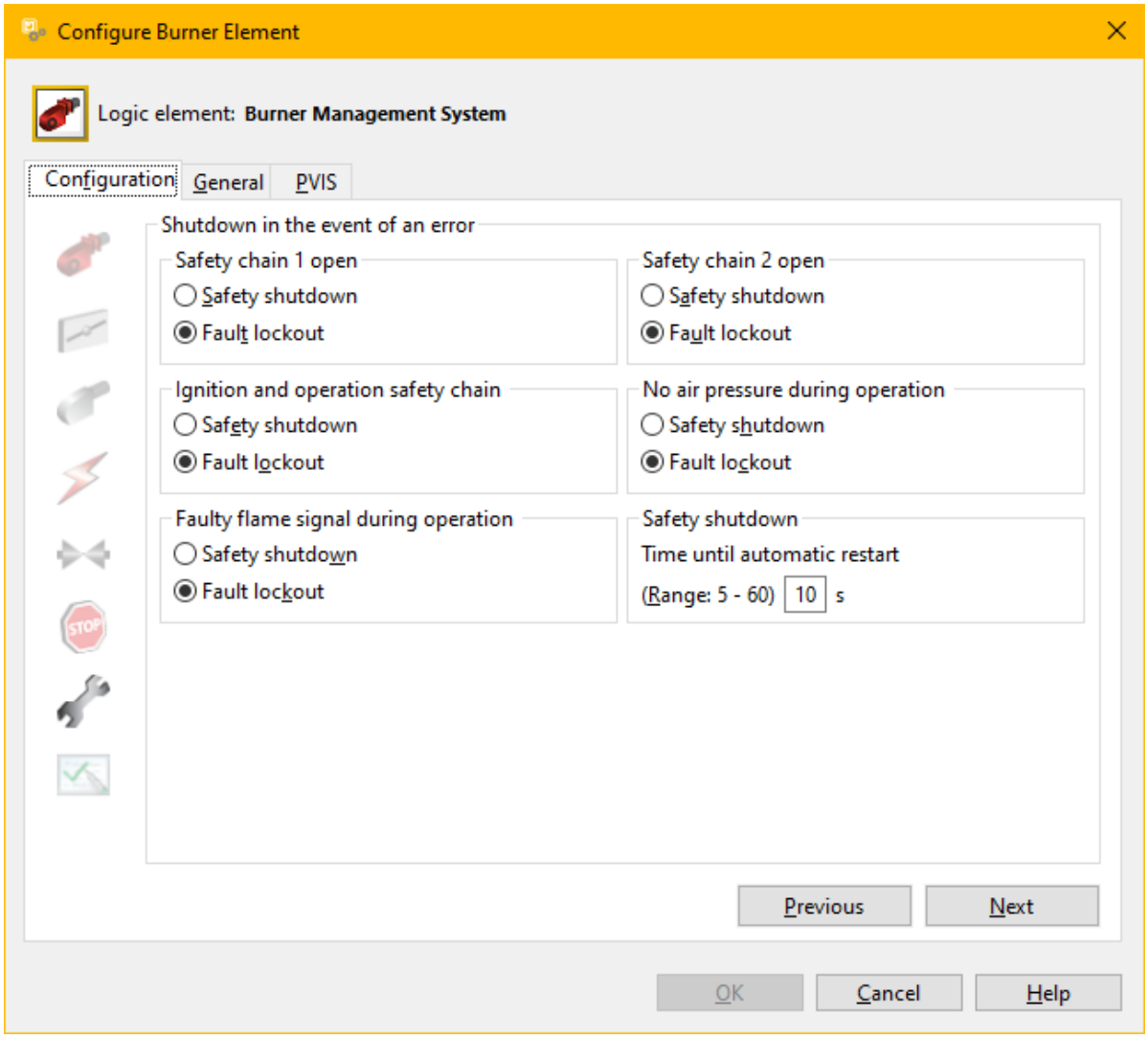


Figure 56: PNOZmulti Burner element – Restart behaviour

6 Appendix

6.1 Wiring diagram

The following circuit diagram shows the basic wiring of the devices with the terminals of the modules in order to be able to reconstruct the configuration.

- The operating manuals of the used Pilz devices are listed under:
  – Chapter 1.1Documentation from Pilz GmbH & Co. KG [📖 5]

- The wiring diagram contain are two hardware setups:
  1. PNOZmulti 2 system with semiconductor outputs (DO), wiring page 1-7
     Figure 18 Control hardware – PNOZmulti 2 system with semiconductor outputs (DO) [📖 15]
  2. PNOZmulti 2 system with relay outputs (DOR), wiring page 8-15
     Figure 19 Control hardware – PNOZmulti 2 system with relay outputs (DOR) [📖 15]

0	1	2	3	4	5	6	7	8	9

/2.0
-A1

Pilz
PNOZ m ES Profinet

PLC station ID

CPU: Name

PLC card is placed on rack ID

Position (slot / module)

Start address of PLC card

PILZ

/2.5
-A1.0

Pilz
PNOZ m B1 Burner

PLC station ID

CPU: Name

PLC card is placed on rack ID

Position (slot / module)

Start address of PLC card

PILZ

/3.0
-A1.1

Pilz
PNOZ m EF 8DI4DO

PLC station ID

CPU: Name

PLC card is placed on rack ID

Position (slot / module)

Start address of PLC card

PILZ

/3.5
-A1.2

Pilz
PNOZ m EF 4AI

PLC station ID

CPU: Name

PLC card is placed on rack ID

Position (slot / module)

Start address of PLC card

PILZ

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Rack overview PLC A1

Mounting place
+ AN_1006811_01

-A1
/1.0

Pilz
PNOZ m ES Profinet

X4:1 24V	/4.1	Power supply
X4:2 0V	/4.1	Power supply
X4:4 FE	/4.1	
X1:		
X2:		

PILZ

-A1.0
/1.1

Pilz
PNOZ m B1 Burner

0 X3:1 T0	/6.1	Testpulse T0
1 X3:2 T1	/6.2	Testpulse T1
2 X3:3 T2		
3 X3:4 T3		
X4:1 0V	/4.2	Power supply
X4:2 24V	/4.2	Power supply
X1:		
X2:		

PILZ

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PLC Overview A1.0

Mounting place
+ AN_1006811_01

-A1.1
/1.2

Pilz
PNOZ m EF 8DI4DO

0	X3:1 I0	/5.1	Gas pressure low	
1	X3:2 I1	/5.2	Gas pressure high	
2	X3:3 I2	/6.1	Emergency Stop Channel 1	
3	X3:4 I3	/6.2	Emergency Stop Channel 2	
4	X1:1 I4	/5.3	Air pressure low	
5	X1:2 I5	/5.5	Air flow low	
6	X1:3 I6	/5.7	Flame monitor	
7	X1:4 I7	/5.6	Pressure tightness control	
8	X2:1 O0	/7.0	Safety valve 1	
9	X2:2 O1	/7.2	Safety valve 2	
10	X2:3 O2	/7.4	Ignition transformer	
11	X2:4 O3	/7.3	Combustion air ventilator	
	X4:3 0V	/4.3	Power supply	
	X4:4 24V	/4.3	Power supply	

PILZ

-A1.2
/1.3

Pilz
PNOZ m EF 4AI

0	X1:1 I0+	/6.5	Maximum temperature measurement 1
0	X1:2 I0-	/6.5	
1	X1:3 I1+	/6.6	Maximum temperature measurement 2
1	X1:4 I1-	/6.6	
2	X2:1 I2+		
2	X2:2 I2-		
3	X2:3 I3+		
3	X2:4 I3-		
	X3:1 0V	/6.7	
	X3:2 24V	/6.7	Power supply sensor
	X4:1 0V		
	X4:2 24V		
	X4:3 0V	/4.4	Power supply
	X4:4 24V	/4.4	Power supply

PILZ

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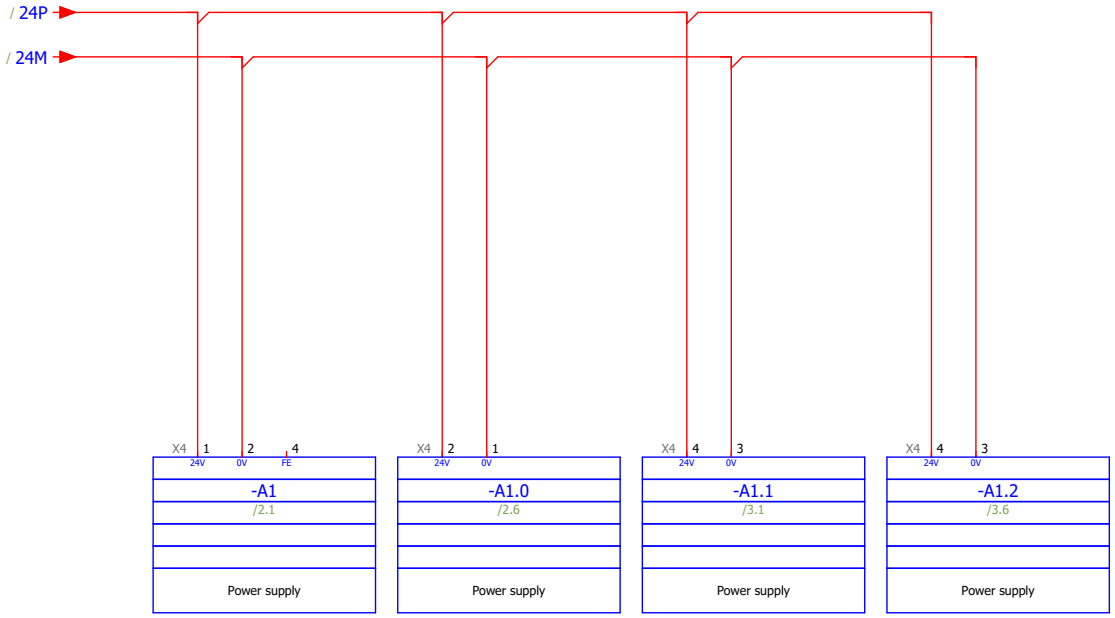
PLC Overview A1.1 A1.2

Mounting place
+ AN_1006811_01



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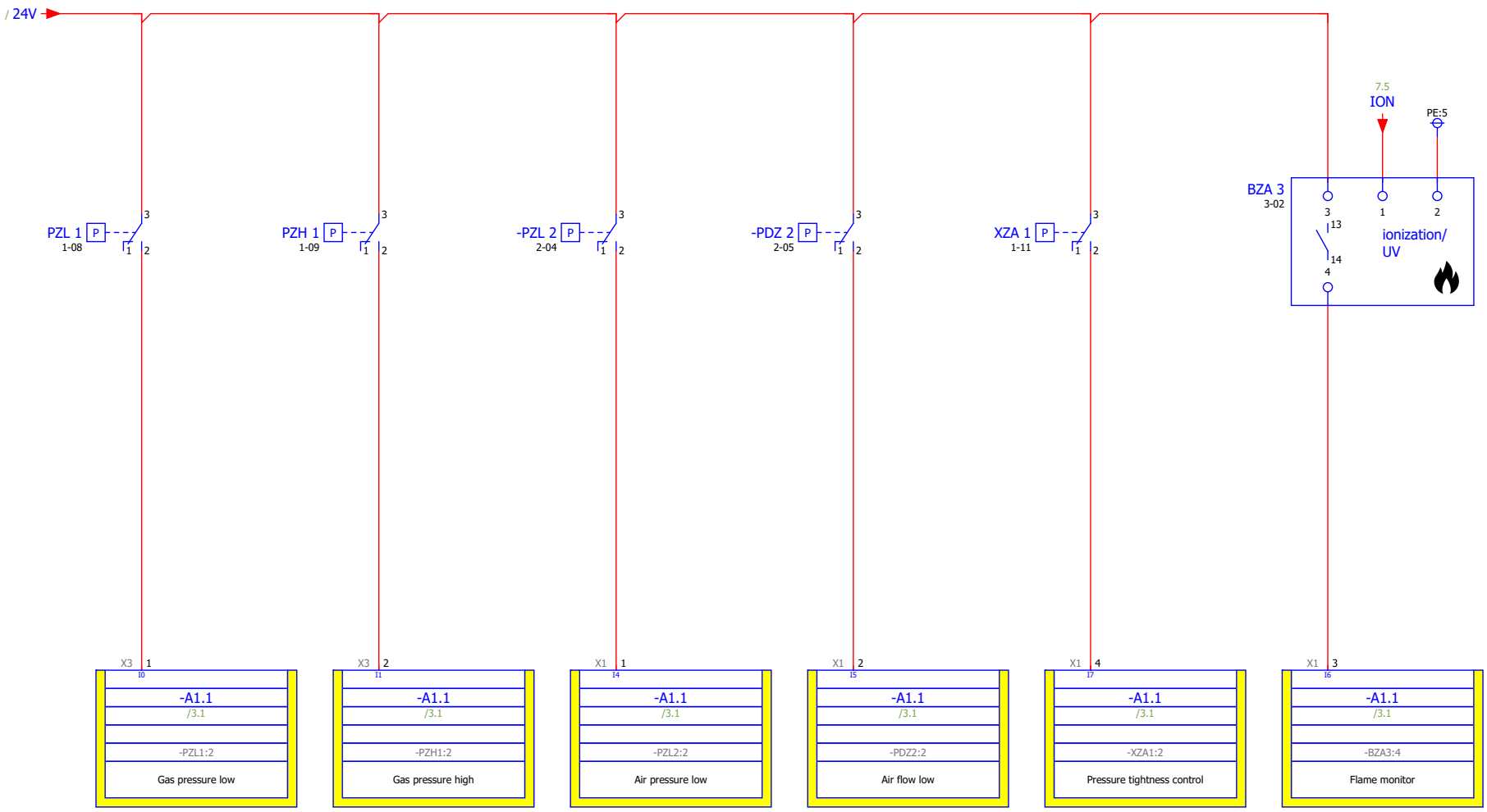
Power supply A1

Mounting place
+ AN_1006811_01



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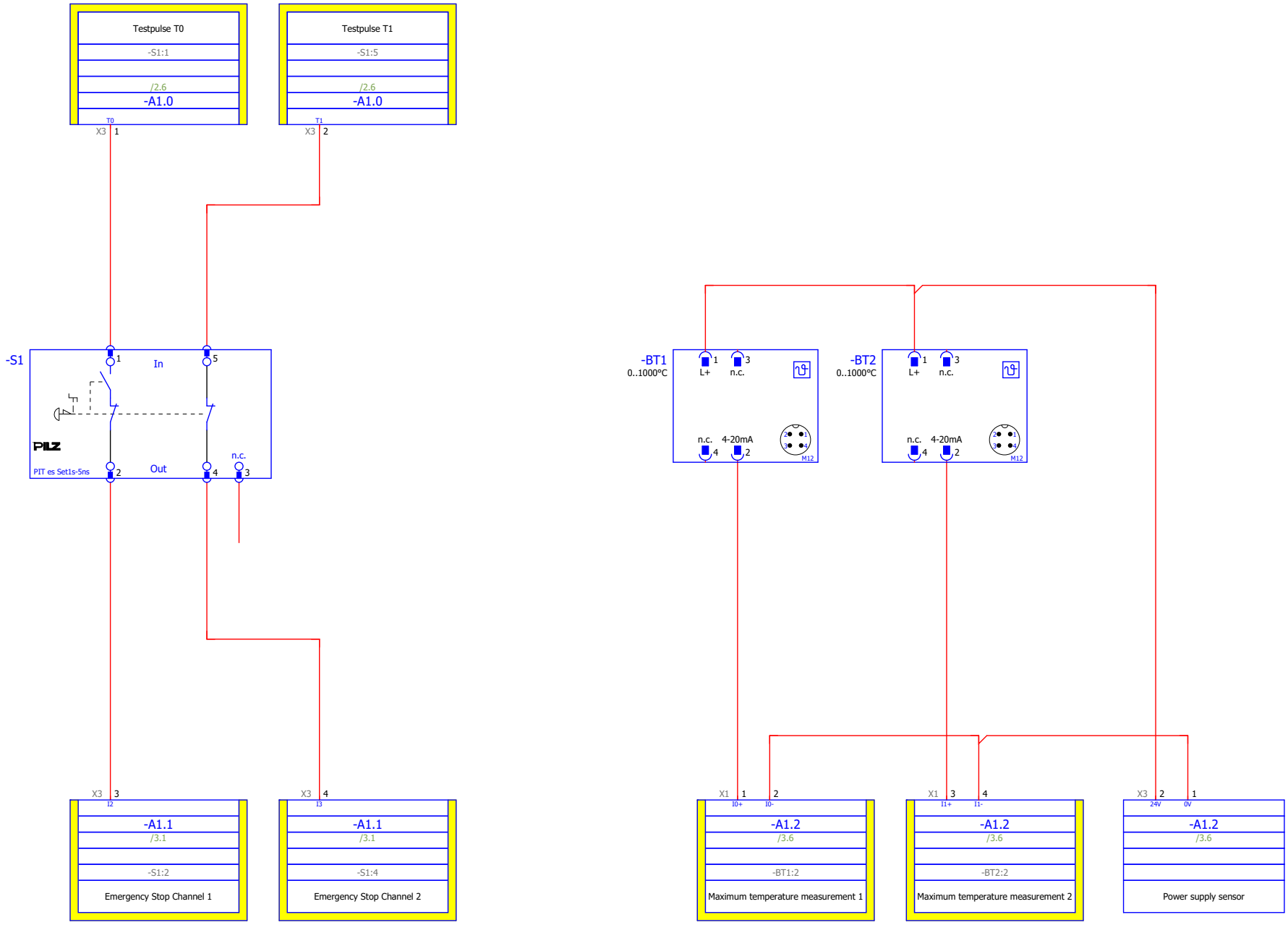
Inputs Pressure switches

Mounting place
+ AN_1006811_01



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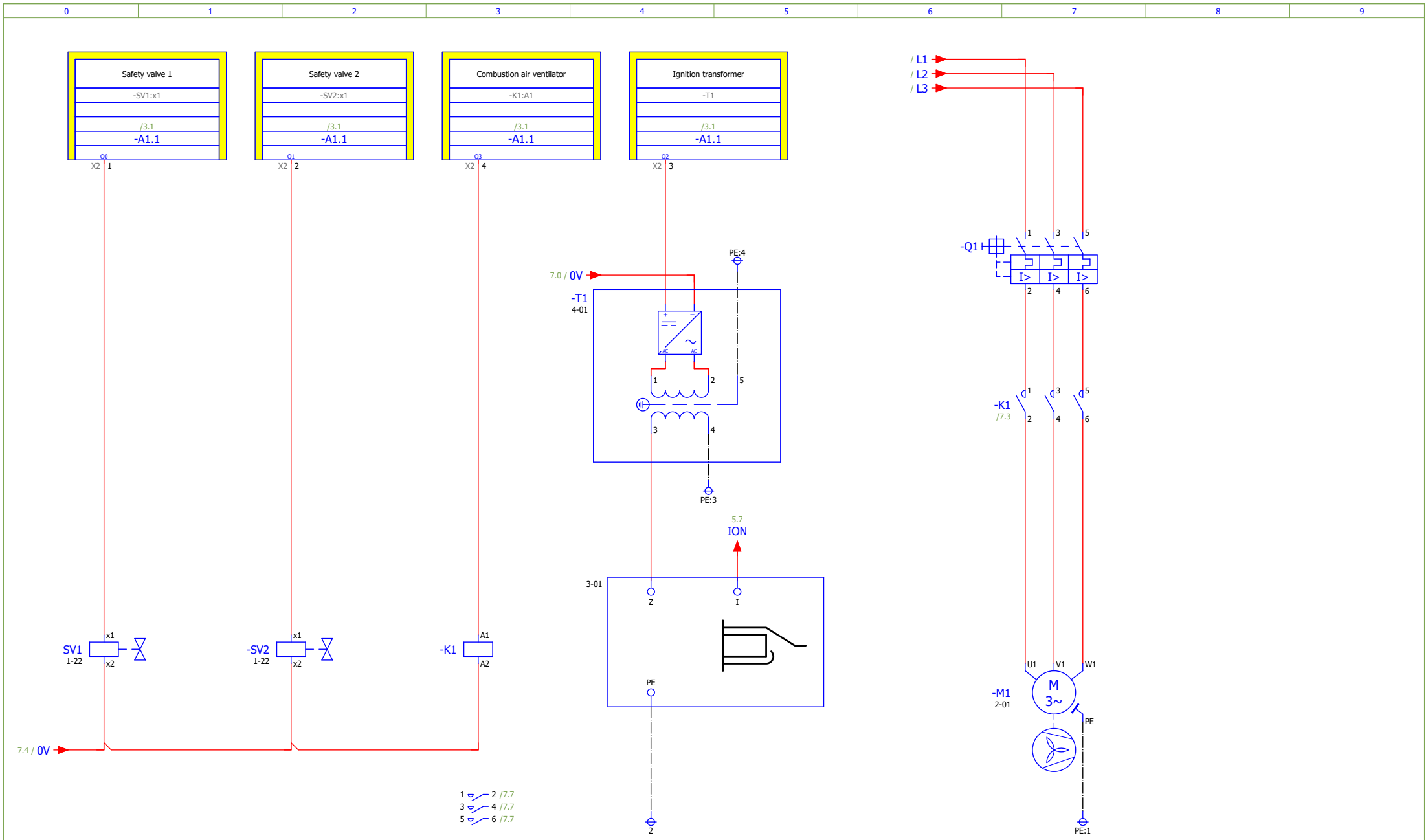
Inputs emergency stop +
max temp

Mounting place
+ AN_1006811_01

Page: 6 / 7



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PILZ

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Outputs

Mounting place
+ AN_1006811_01

Page: 7 / 7

0	1	2	3	4	5	6	7	8	9

/2.0 -A1	/2.5 -A1.0	/3.0 -A1.1	/3.5 -A1.2	/4.0 -A1.3
Pilz PNOZ m ES Profinet	**Pilz** PNOZ m B1 Burner	**Pilz** PNOZ m EF 4DI4DORD	**Pilz** PNOZ m EF 4DI4DOR	**Pilz** PNOZ m EF 4AI
PLC station ID	PLC station ID	PLC station ID	PLC station ID	PLC station ID
CPU: Name	CPU: Name	CPU: Name	CPU: Name	CPU: Name
PLC card is placed on rack ID	PLC card is placed on rack ID	PLC card is placed on rack ID	PLC card is placed on rack ID	PLC card is placed on rack ID
Position (slot / module)	Position (slot / module)	Position (slot / module)	Position (slot / module)	Position (slot / module)
Start address of PLC card	Start address of PLC card	Start address of PLC card	Start address of PLC card	Start address of PLC card
PILZ	PILZ	PILZ	PILZ	PILZ

Revision	30/11/2023	Date	28/11/2023			Mounting place
Name	PILZ	Name	PILZ	PILZ Pilz GmbH & Co. KG Felix-Wankel-Strasse 2 D-73760 Ostfildern	Rack overview PLC A1	+ AN_1006811_02
						Page: 1 / 8
		Dep.	CSI			

-A1
/1.0

Pilz
PNOZ m ES Profinet

X4:1 24V	/5.1	Power supply	
X4:2 0V	/5.1	Power supply	
X4:4 FE	/5.1		
X1:			
X2:			

PILZ

-A1.0
/1.1

Pilz
PNOZ m B1 Burner

0	X3:1 T0	/7.1	Testpulse T0
1	X3:2 T1	/7.2	Testpulse T1
2	X3:3 T2		
3	X3:4 T3		
	X4:1 0V	/5.2	Power supply
	X4:2 24V	/5.2	Power supply
	X1:		
	X2:		

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Revision	30/11/2023	Date	28/11/2023
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PLC Overview A1.0

Mounting place
+ AN_1006811_02

-A1.1
/1.2

Pilz
PNOZ m EF 4DI4DORD

0	X3:1 I0	/6.1	Gas pressure low	
1	X3:2 I1	/6.2	Gas pressure high	
2	X3:3 I2	/7.1	Emergency Stop Channel 1	
3	X3:4 I3	/7.2	Emergency Stop Channel 2	
4	X1:1 13	/8.0	Safety valve 1 A	
4	X1:2 14	/8.0		
5	X1:3 23	/8.1	Safety valve 1 B	
5	X1:4 24	/8.2		
6	X2:1 33	/8.3	Safety valve 2 A	
6	X2:2 34	/8.3		
7	X2:3 43	/8.4	Safety valve 2 B	
7	X2:4 44	/8.4		

PILZ

-A1.2
/1.3

Pilz
PNOZ m EF 4DI4DOR

0	X3:1 I0	/6.3	Air pressure low
1	X3:2 I1	/6.5	Air flow low
2	X3:3 I2	/6.7	Flame monitor
3	X3:4 I3	/6.6	Pressure tightness control
4	X1:1 13	/8.5	Combustion air ventilator
4	X1:2 14	/8.5	
5	X1:3 23	/8.6	Ignition transformer
5	X1:4 24	/8.7	
6	X2:1 33		
6	X2:2 34		
7	X2:3 43		
7	X2:4 44		

PILZ

-A1.3
/1.4

Pilz
PNOZ m EF 4AI

0	X1:1 I0+	/7.5	Maximum temperature measurement 1
0	X1:2 I0-	/7.5	
1	X1:3 I1+	/7.6	Maximum temperature measurement 2
1	X1:4 I1-	/7.6	
2	X2:1 I2+		
2	X2:2 I2-		
3	X2:3 I3+		
3	X2:4 I3-		
	X3:1 0V	/7.7	
	X3:2 24V	/7.7	Power supply sensor
	X4:1 0V		
	X4:2 24V		
	X4:3 0V	/5.3	Power supply
	X4:4 24V	/5.3	Power supply

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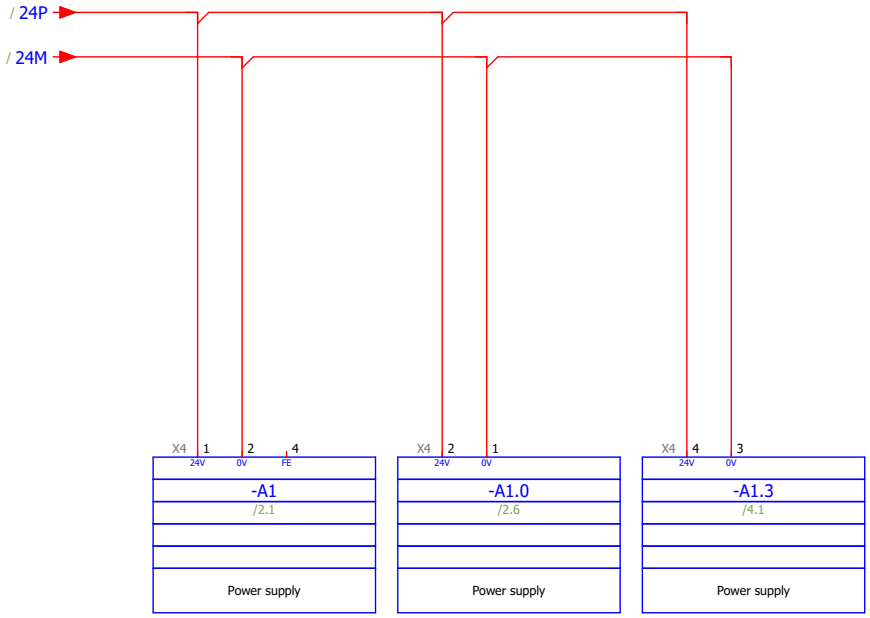
PLC Overview A1.3

Mounting place
+ AN_1006811_02



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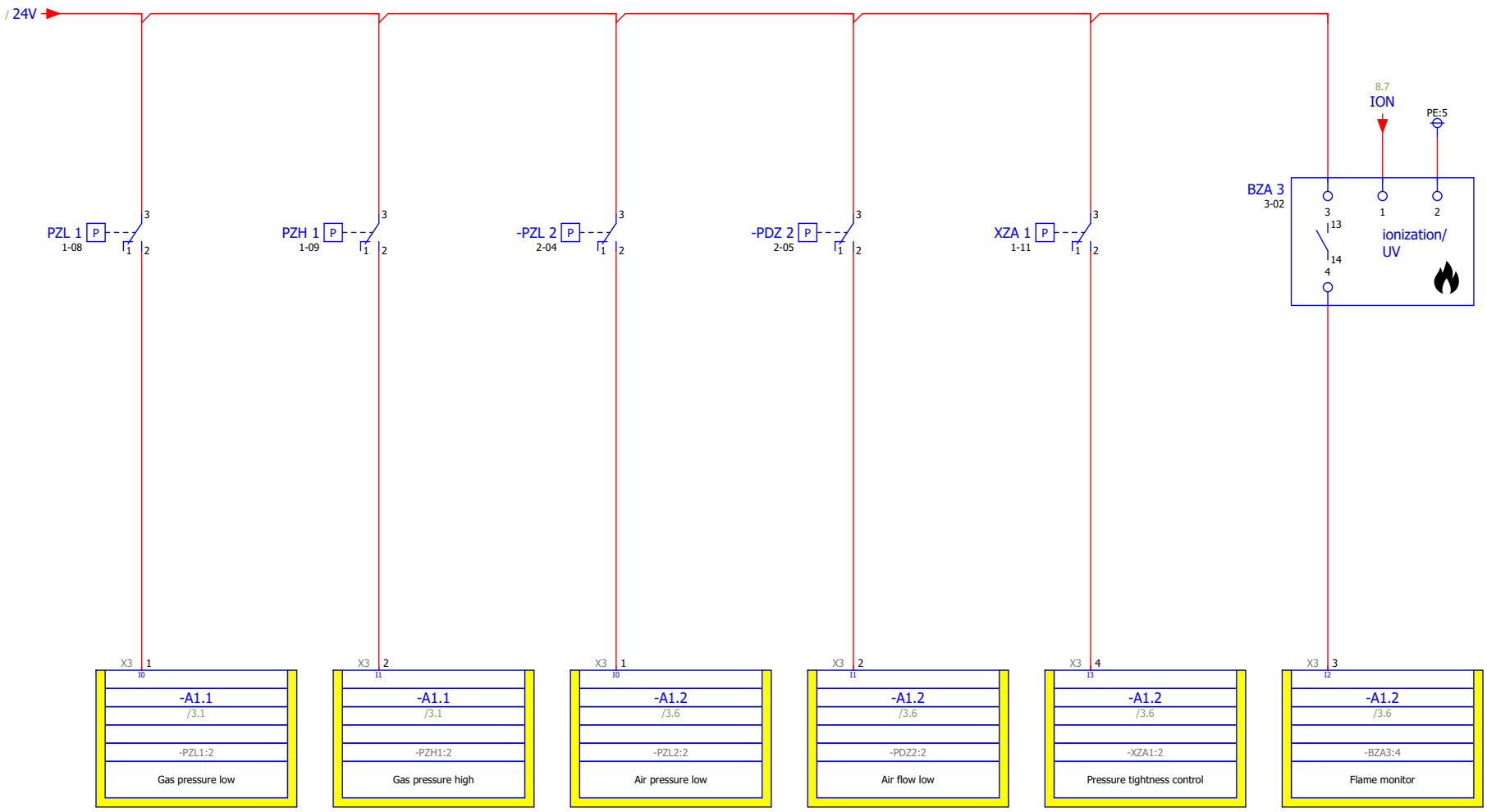
Power supply A1

Mounting place
+ AN_1006811_02



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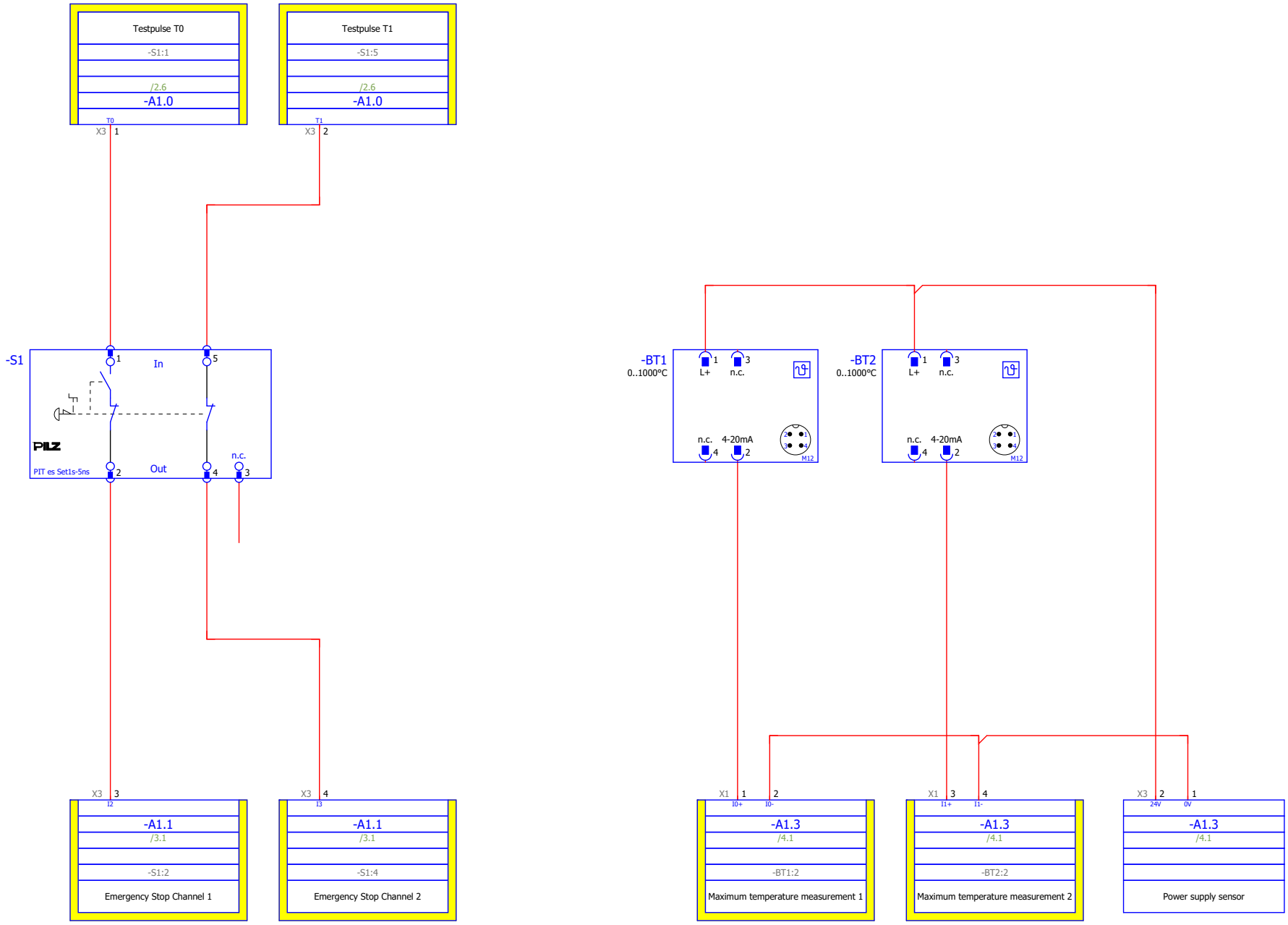
Inputs Pressure switches

Mounting place
+ AN_1006811_02



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Name	PILZ	Name	PILZ
		Dep.	CSI

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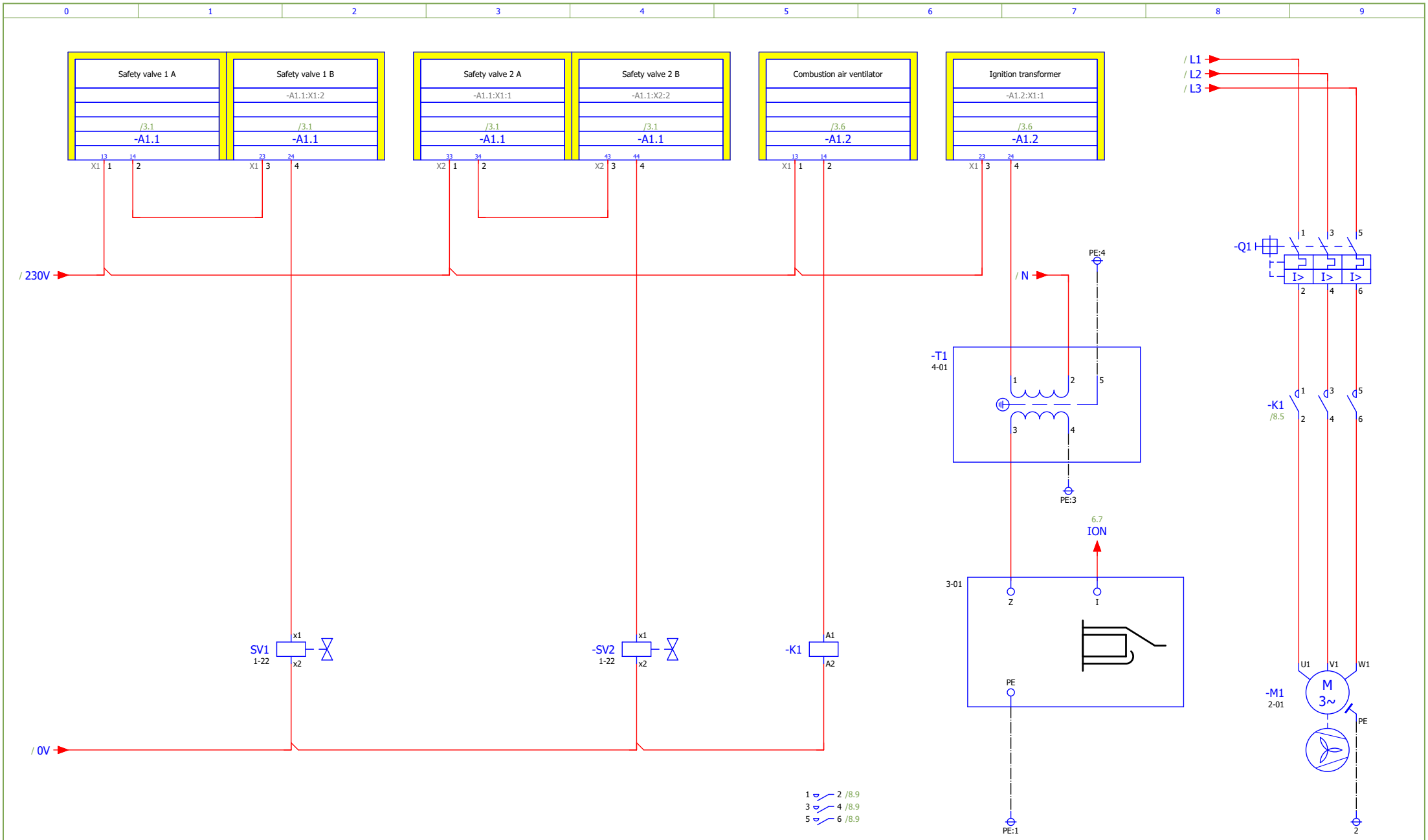
Inputs emergency stop +
max temp

Mounting place
+ AN_1006811_02

Page: 7 / 8



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Name	PILZ	Name	PILZ		
		Dep.	CSI		

PILZ

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Outputs

Mounting place
+ AN_1006811_02

Page: 8 / 8

7 Table of figures

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