LMF

LaminarMasterFlow
SYSTEM

Reference Book

This reference book is solely aimed to qualified employees, who have achieved the necessary knowledge with regard to language understanding and contents.

The separate manual includes all information relevant for the operator.

The following text is a translation of the source document from the German language.

*** VERSION 5.8 ***
State: 08/25/2011

Copyright

Service

If there are any questions exceeding the contents of the provided product information, you may contact us at the address indicated above.

Telephone: **0049 - 7157 / 5387-0**
Telefax: **0049 - 7157 / 5387-10**
Email: info@tetratec.de

In addition, you will find more information and data sheets of other products on our homepage: You are invited to visit www.tetratec.de.

Table of Contents

1 Introduction

1.1 Product Description

The LMF system consists of hardware and software.

1.1.1 Hardware

Vital components of the hardware are Controller S320 and one or several measuring sections.
The controller in its core consists of a very accurate floating point calculator in a standard switchboard installation rack. A very high flexibility is given by the modularity of the hardware and software.
The controller can be inserted in cases specific for application. To make easier the specific operation of the application, these cases can be equipped with additional buttons, displays or a PLC interface.
The measuring sections can also be embedded in the case according to size and number, be installed on a mounting plate or be supplied loosely. Measuring sections typically consist of an arrangement of volumes or flow elements and connected sensors and/or correcting elements.
For being able to communicate with the analog or digital sensors, final control elements or a PLC, the controller is equipped with plug-in cards according to the application. In addition to various plug-in cards for special jobs the following plug-in cards are used frequently:

Type100 cards	Two analogue-digital converters
Type200 cards	Two digital-analogue converters
Type310 card	An analogue-digital converter and a digital-analogue converter each, 14 bit each, cycle time only 10 ms, conversion time 3ms. Hence, particularly suitable for fast control.
Type400 card	Bus module for digital extension modules, e.g. for PLC interface
Type500 card	Two inputs for pulse transmitters
Type510 card	Two frequency counters
Type520 card	Two frequency generators with adjustable pulse-width modulation

For detailed information and other cards please see our homepage.

1.1.2 Software

The software is arranged hierarchically:
- Operating System
- Config (registration and, if necessary linearization of the plug-in cards and configuration of the serial interfaces)
- LMF software, application-parameterized
- Switchable parameter sets for different measuring tasks (program 0 to 9)

Originally there has been different software for different types of application. But over and over again there have been requests for measuring systems exceeding the limitations between the software packages. Thus these different software packages have been integrated in the LMF software version by version. The applications now result from the specific configuration of the software. The LMF software therefore includes the following applications:

LMF	LaminarMasterFlow	Originally for the evaluation of Laminar Flow Elements (LFE), in the meantime generally for the evaluation of primary elements for flow measurements, i.e., in addition to LFEs also orifices, nozzles, Pitot tubes, gas meters etc.. Combined with actuators also for the regulation of pressure and flow.
PCS	PressureControlSystem	For pressure control
LFC	LaminarFlowControl	Flow controller
LMS	LeakageMeasuringSystem	Leakage measuring in closed volumes
CVS CAL	Constant Volume Sampling Calibration	Calibration equipment for CVS devices

1.2 Intended Use

The devices of the series LMF are exclusively determined according to the sales confirmation

- for measuring and controlling of
  - Volume flows
  - Mass flows
  - Pressures
  - Temperatures
  - Humidity
- for the calibration of other devices measuring and controlling such parameters
- For metering of gaseous media
- For leak testing

In special cases sensors for linear measurement and power measurement can be integrated.

Approved as a medium are (according to the sales confirmation)

- Air
- Gases
  - Argon
  - Carbon dioxide
  - Carbon monoxide
  - Helium
  - Hydrogen
  - Nitrogen
  - Oxygen
  - Methane
  - Propane
  - N-butane
  - Natural gas
  - Laughing gas

Note:
The proper use is exclusively restricted to the application and the media specified in the sales confirmation. I.e., even the use for one of the purposes mentioned above and the operation with a medium mentioned above will be recognized as improper use, provided that the device has not been specified for that purpose!
Tests and an approval in written form will be required with changes by TetraTec Instruments GmbH.

When being used as a measuring unit in complex machines, a combination of machines, an assembly line or system, the signal outputs must exclusively be used for the information of a superior control (e.g. PLC).
When being used as an independent laboratory measuring instrument with control function the regulations and indications for emergency stop functions and for the recovery of voltage after power failure must be observed.

Intended use also includes

- observing of all notes of the operating instructions
- compliance of the inspection and maintenance work.

Another use or a use beyond that will be considered as not intended. TetraTec Instruments GmbH will not be responsible for any damages arising from that.

1.3 Warranty and Liability

Our "General Sales and Delivery Specifications" are valid in principle. They will be available for the operator by the conclusion of a contract at the latest. Warranty and liability claims in the case of damages to persons and property will be excluded, if they are caused by one or more of the following reasons:

- Improper use of the device
- Faulty installing, taking into operation, operating and maintaining of the device and of the accessories (sensors, LFE).
- Operating of the device with defect safety equipment or safety and protection devices being installed improperly or not operatively.
- Ignoring of the instructions of the operating instructions in regard of transport, storage, installation, starting, operation, maintenance and setting of the machine.
- Arbitrary structural changes of the device, arbitrary changing of the measuring section and of the measurement set-up.
- Inadequate monitoring of accessory parts being subject to wear.
- Repairs performed faulty.
- Disasters resulting from circumstances caused by a third party or force majeure.

2 Safety

It is absolutely necessary to get used to the safety instructions before the installation is started!

2.1 Basic Safety Instructions

The knowledge of the basic safety instructions and of the safety regulations is a basic requirement for save handling and trouble-free operation of this equipment.
The operating instructions, particularly the safety instructions, have to be observed by anyone working with the equipment.
Furthermore the rules and regulations for the prevention of accidents valid for the site have to be observed.

2.1.1 Responsibility of the Operator

- The operator is committed to ensure that only persons will be working with the equipment who have been informed about the basic regulations of safety of work and the prevention of accidents and who have been instructed in the handling of the equipment.
- The responsibility of the staff must be clearly determined for mounting, taking into operation, operating, setting and servicing.
- The safety-conscious working of the staff will be inspected regularly.
- The electrical operational safety has to be inspected and to be recorded regularly.
- The pneumatic equipment has to be inspected and to be recorded regularly.
- In the event of dangerous media (other gases as air) the test section design has to be checked for leakage and to be recorded regularly. The devices must only be operated in monitored atmosphere, if necessary (gas alarm units).
- Control periods must be determined by the operator in consideration of the relevant legal requirements.

2.1.1.1 Training of the Staff

- Only trained and introduced staff is allowed to work with the equipment.
- The staff must have read, understood and confirmed by signature the safety chapter and the warning notes included in the operating instructions.
- Staff to be trained must only work with the equipment while being supervised by an experienced person.

2.1.1.2 Informal Safety Measures

- The operating instructions have to be kept at the location of the equipment all the time.
- The generally accepted and local regulations for the prevention of accidents and for environmental protection have to be provided and be observed as an amendment for the operating instructions.
- All instructions for safety and danger of the equipment and of the measuring section have to be kept legibly.

2.1.2 Responsibility of the Staff

All persons having been ordered to work on the equipment will be responsible before starting work:

- to observe the basic regulations of the safety of work and the prevention of accidents.
- to read the safety chapter and the warning notes of the operating instructions and to confirm having read and understood them by their signature.

2.1.3 Inevitable Remaining Dangers by the Equipment

The devices of the series LMF have been constructed according to the state of the art and the recognized safety regulations. However, it is possible that danger for life and physical condition of the operator or a third person or damage of the equipment or other real values may occur during operation.
The devices must only be used

- for proper use
- and in a correct safety condition.

Malfunctions which may have impact on the safety must immediately be corrected.

2.1.3.1 Dangers by Electric Energy

- Only an electric specialist must be allowed to work on the power supply or on a control box.
- Check the electrical equipment of the machine regularly. Immediately remove loose connections and broken cables and replace them by new cables.
- All necessary repairs must be performed by a certified service engineer of TetraTec Instruments GmbH.
- If work is indispensable on live components, a second person should be consulted to switch off the main switch in case of emergency.
- To exclude fire risk or danger of an electric impact, protect the device from rain, moisture and excessive humidity.

2.1.3.2 Dangers by pressure

Insufficiently fixed or aged flexible tubing, pipes etc. may become loosely or may burst.
Possible consequences:

- Parts may fly or whirl around and may cause damages or injuries.
- Involuntary movements or distractions caused by frightening may cause damages to property, injuries etc.
- Strong noise development, thus reduction of the response time and risk of hearing damages.

2.1.3.3 Dangers by gases

(applies only if gaseous media other than air are used)

Gases have the following dangerous properties depending on the type of gas:

- Oxygen and laughing gas have a fire-supporting impact
- Laughing gas and xenon have a hallucinogenic or anesthetic to toxic impact according to their concentration
- Carbon monoxide is very toxic.
- Hydrogen, carbon monoxide and carbon hydrides as for example propane are combustible and may provide explosive mixtures when being mixed up with air.
- By admixing gases (except oxygen) to the breath air its oxygen concentration will decline, so that a suffocating effect with high concentrations will be initialized.

Hence:

- Avoid emission of gases.
- Examine measuring setup regularly for leakage.
- Discharge dispersing gases to exhaust gas system.
- Work in a well ventilated environment.
- Monitor atmosphere in the work space with gas alarm units.

2.1.4 Switch-on characteristics with running PLC

The device may be configured in such a way that it will run in the automatic test cycle mode when being turned on after a power supply failure and voltage has returned.
In this mode some of the digital control outputs are active!
The operator is responsible for the protection against a restart of the machines / assemblies controlled by the PLC, which may be immediately dangerous for persons and appliances!

2.2 Notes for set-up, installation and operation of the equipment

2.2.1 Set-up, Installation

The device must be set-up at a dry place free of dust and free of vibration. If existing, the case must not be opened at all. It usually contains no parts to be maintained by the operator. If this should be the case anyway, the corresponding indications of the operating instructions have to be observed.

The opening and vent holes of the case must not be covered. Sufficient aerial circulation has to be provided. If assembled in a switch cupboard / built-in cupboard the operating temperature limits must be observed.

With loosely delivered measurement value transducers and primary elements it must be observed that the installation is free of contamination and in correct positional arrangement at the measuring point. If necessary, sensitive readings recorders must be particularly protected against damage.

The sensors and primary elements must not be exchanged or be allocated wrongly at all.
The allocation to the suitable measuring channel as well as to the suitable device must be absolutely maintained. If the assembly is exchanged, the calibration of the devices will be invalid. If sensors of different types are exchanged, there will be a risk of damage up to a total breakdown.

If sensors are integrated in the device the dependency of position of the sensors must be observed, if necessary. This is particularly valid for oil-filled sensors with a small measuring range, e. g. differential pressure sensors of the series 3051. Here the device must only be inclined by the centre line which corresponds to the normal vector of the measuring diaphragm. The centre line itself must be kept horizontally. Devices, for which this factor has to be observed, are often equipped with a water level. In addition, a corresponding indication can be found in the operating instructions.

2.2.2 Operating Conditions, Ambient Conditions

Operating temperature: 5°C up to 40°C. With special applications differing temperature limits may be valid for external test section designs.
Ambient pressure atmospheric pressure
working pressure: See application-specific operating instructions.
humidity range: 0 ... 90% of relative humidity, not condensing!
Before the device is turned on it must be adapted to the room temperature, the device must not be with dew at all.

2.2.3 Electric power supply / electrical connection

2.2.3.1 OEM-device or Controller S320 delivered as a component

Controller S320 is supplied with 24 V. The 0V connection has to be connected with the protective earth conductor.

2.2.3.2 Devices with uniphase mains supply

110 - 230 VAC (50/60 Hz)
Only the provided power cords or power cords with equivalent test sign must be used. The power supply must comply with the currently valid specifications.

2.2.3.3 Devices with protective case

110 - 230 VAC (50/60 Hz)
The connector assembly set must only be installed by a qualified electrician.

2.2.3.4 Devices with control box

Monophase and multiphase devices with control box must only be installed by a qualified electrician.

2.2.4 Cleaning of the Device

Wipe with a moist but not watery cloth.

2.2.5 Calibration, Measuring Accuracy

The devices are delivered by TetraTec Instruments GmbH being calibrated and completely configured. Any change of the calibration coefficient or other scaling factors and constants used internally may make the calibration invalid or reduce the measuring accuracy.

2.2.6 Structural Changes on Devices and Measuring Sections

All measures of conversion require tests and written approval by TetraTec Instruments GmbH.

- ➢ No changes, attachments or conversions of the device or measuring section must be carried out without approval of the manufacturer.
- ➢ Only use original spare parts and wearing parts.
  If parts are supplied by third companies there is no guarantee of being constructed and manufactured appropriately for stress and safety or that they meet metrological requirements.
- The exchange of sensors and measuring sections must be coordinated with TetraTec Instruments GmbH, because possibly a new measurement may be necessary.
- Only sensors and measuring sections supplied and calibrated by TetraTec Instruments GmbH must be used.

2.2.7 Limit parameter access

It is possible to limit the parameter access in the editing mode.
The first paragraph of this chapter explains, according to which scheme the parameters are allocated to access levels defined by the factory. In the second paragraph there is information about the definition of own user groups and a documentation of the user groups preset by the factory and their passwords.

Note:
The operator or his system administrator is responsible for the changing of at least the passwords, keeping records of them and to keep this documentation at a save place.

Further information

- For the consequences of the restrictions of access in the editing mode see section
- Access restriction for TCP connection see section

2.2.7.1 Level allocation of the parameters

A set of levels is allocated to each particular parameter as a default setting. This is carried out by the attribute "level=n". Here "n" is a number the particular bits of which encode the respective level.

Examples

Term	**= binary**	**Explanation**
level=1	0001	parameter is only accessible in level 0
level=12	1100	parameter is accessible in levels 2 and 3
level=9	1001	parameter is accessible in levels 0 and 3

2.2.7.2 Definition of users and their rights of access

Up to 10 users can be defined in the block S05XX. Each user has an indication (e. g. "tool setter"), a password, and a number of levels, to which access is possible for him. Just like the allocation of parameters to levels the allocation of users to levels is carried out by indicating a number, the particular bits of which indicate whether the user has access to the parameters in this level or not.

Example

S0500="Egon" S0501=1 S0502=1234	These parameters define a user named "Egon" (this name has to be selected when entering the editing mode). The user's password is "1234" and he has access to all parameters which are visible in level 0 (since 1 = 0001 binary).
S0500="Egon" S0501=7 S0502=1234	As above, but user “Egon” has only access to parameters of the levels 0, 1 and 2 (since 7 = 0111 binary).

Further information

- For block S05XX see section

Standard settings

Four users are defined as a default, and exactly one level is allocated to each of them. The appropriate four levels are arranged hierarchically in ascending order (i.e., the superior levels include all parameters of the lower levels respectively). The password is the number of the level respectively:

Name	Password	Access to parameter
"Level 0"	0	PX500 up to PX523
"Level 1"	1	PX400 up to PX499 and PX500 up to PX523 and PX701 up to PX722
"Level 2"	2	M0000 up to M0999 and PX000 up to PX999 and S0000 up to S0013 and S0100 up to S0311
"TetraTec"	3	C0000 up to C0199 and D0000 up to D1999 and E0000 up to E9999 and I0200 up to I0209 and M0000 up to M0999 and PX000 up to PX999 and S0000 up to S9999

Note

It goes without saying that the level “TetraTec” is only left for authorized staff (i.e., with the exception of changing passwords by the operator or his system administrator only employees of TetraTec Instruments GmbH), since the changing of basic parameters may result in considerable negative consequences.

3 Components of a LMF System

3.1 Overview

According to the application different components are used, i.e., your system must not be equipped necessarily with all described components. The following table gives an overview of the components and their main operational areas.

Evaluation electronic	Heart of the evaluation electronic is controller S320 with various interface cards. For a description see chapters 1.1.1 and 4.
Interfaces	The evaluation electronic can display the computed values by digital and analog interfaces. Analog outputs are also used fort he activation of actuators, e.g., of proportional valves.
Protective cabinets	Depending on the desired protective class different protective cabinets are available. Depending on the size of the measuring section the protective cabinet can also accommodate sensors or even the complete measuring section in addition to the evaluation electronic and the power pack.
Primary elements	Primary elements is the generic term for LFEs, orifices, Pitot tubes, etc., which are used for flow measurement. Important sub-groups are: • Active pressure transmitter • Counter • Thermal mass flow meter sensors The most current primary elements are described in detail in the following paragraph.
Differential pressure sensors	Differential pressure sensors are used, for example, for the measurement of the active pressure of active pressure transmitters.
Absolute pressure sensors	The absolute pressure of a gas is required for all sorts of calculations, e.g., for the calculation of the standard volume flow or mass flow by a active pressure transmitter. If only the absolute pressure is required on a measuring point, this absolute pressure can be measured immediately with an absolute pressure sensor.
Relative pressure sensors	It turned out as an advantage to use only an absolute pressure sensor for the ambient pressure in the case of several measuring points, and to equip all the other measuring points with relative pressure sensors. At the same time the ambient pressure serves as the reference pressure to which all measuring points can be equally adjusted (nullification of the relative pressure sensors). Then the absolute pressures on the measuring points are determined arithmetically.
Temperature sensors	Just as the absolute pressure the temperature is also required for various calculations.
Humidity sensors	Indeed, air humidity influences the viscosity of air not as much as temperature or pressure, nevertheless, it is an important measured variable in the case of high requirements of the measuring accuracy. For applications with pure gases or dry compressed air it is possible to calculate with a fixed value.
Port directional control valves	Port directional control valves are used in most different types and sizes and for the most different purposes. The valve arrangements for leak testing devices and for the nullification of the pressure sensors of active pressure transmitters (option) are to be highlighted.
Actuators	Typical actuators for our applications are proportional valves or electronic pressure control valves. They are used as final control elements for flow controls or pressure controls.
Cable sets and assembly material	It has lately been increasingly implemented that the measuring sections are delivered completely mounted on mounting plates or in cabinets, what makes final assembly easier as well as leakproofness and functionality will be better guaranteed. The LMF system is always delivered including all necessary cables or mating plugs.

3.2 Primary elements

The primary element most often used by us is the LFE, since among other things its linear behaviour allows a high accuracy over a wide span. Other primary elements like orifices, accutubes, critical nozzles, gas meters or mass flow meters have other advantages according to the measuring problem, which shall be briefly characterized here.

3.2.1 Active pressure transmitter

3.2.1.1 LFE

Mode of operation
The volumetric flow rate through the LFE generates a laminar flow in the capillaries or gaps of the LFE. The pressure drop of the laminar flow section is proportional to the product of the current volume flow and the current viscosity.

Accuracy
With LFE as a primary element the LMF system works with a typical measuring accuracy of 0.5 to 1% or better, referred to the measurement value of the current volume flow in the measuring range of 1:10 (1:50 optionally). This accuracy is also reached with variable line pressure or variable temperature, provided that the sensors for temperature and absolute pressure are integrated.
The system is applicable with slightly diminished accuracy with a span of up to 1:20 (1:100 optionally). For the improvement of the measuring accuracy system-related non-linearities of the LFE as well as of the sensors are compensated arithmetically.

Conditions of use
Since the capillaries of the LFE are easily choked by condensates or particles, LFEs can only be operated reasonably with well filtered gases (or air).
In addition, there can be a temperature restriction by the materials used. E.g., the LFEs of the series 50MK10 are limited to 70°C, since the capillaries are poured in with epoxy resin.
LFEs which do not intake atmospherically are operated in closed line systems.

3.2.1.2 Orifices, nozzles operated undercritically

Mode of operation
A constriction causes an acceleration of the flowing medium and results in a pressure drop which can be measured between face and back as differential pressure (active pressure). The active pressure behaves proportionally tot the square of the flow or vice versa: The flow is proportional to the square root of the measured active pressure.
The pressure drop remains as a result of the turbulences.

Accuracy
As a result of the very non-linear characteristic curve a good accuracy can only be guaranteed by a very limited span.

Conditions of use
In the case of adequate opening diameter relatively insensitive against fouling. All components consisting of heatable material can also be manufactured by this simple set-up. Another advantage is the small installation length, especially for the orifices. Here an easy removal is often possible.
Orifices and nozzles are operated in closed line systems.

3.2.1.3 Venturi tubes

For mode of operation, accuracy and conditions of use the same is valid in principle compared with orifices, however, the active pressure is measured between the inlet and the narrowest point of the venture tube. The soft cross-sectional extension after the constriction has the effect of transforming the flow energy to pressure energy, whereby the remaining pressure drop is clearly less than the active pressure. A disadvantage is the clearly bigger installation length and higher manufacturing costs according to the type of the toroid and conical segments.

3.2.1.4 Pitot tubes, Pitot crosses and similar

For mode of operation and accuracy the same is valid in principle compared with orifices, with the exception that the acceleration is not caused by constriction but by displacement of the probes.
The operational field differs basically in the fact that the use is not bound to lines, i.e., it can be used outside in principle (e.g., as a speedometer aboard an airplane).

3.2.2 Counter

Counters are incremental or frequency transmitters. A common feature of all counters is, that there will be no valid measurement value as long as a minimum number of pulses has not been entered. Hence, it cannot be avoided that when the measurement starts a measurement result cannot be displayed and that any measurement result is a gliding and delayed average.

3.2.2.1 Turbine wheel gas meter

Mode of operation
A turbine wheel is rotationally moved by the flow. The rotating speed soon reaches a balance with the flow speed. The rotations are counted.

3.2.2.2 Drum gas meter, rotary piston gas meter, bellows gas meter, experimental gas meter

The counters of the enumerated models measure the flowing volume. The medium fills one or several measuring chambers alternately and thus drives a speedometer. As a rule, the speedometer supplies only one pulse per each rotation, however, there are also types with a finer resolution.

3.2.3 Miscellaneous

3.2.3.1 Mass flow sensors

Mass flow sensors measure the transmission of heat which is performed by the flowing medium. In addition, a defined surface (or also a wire) is kept on a constant temperature in the middle of the pipe. The electric power required for that is used as a measure for the transmission of heat and thus for the mass flow.
An advantage is the small pressure loss combined with high accuracy and small installation length. Main disadvantage is slowness, since a measurement is only valid in thermal balance.

3.2.3.2 Overcritical nozzles

With overcritical nozzles the flow in the constriction is limited by the speed of sound. Hence, an overcritical nozzle can be used very well for generating a certain flow which basically depends on the geometry of the nozzle, speed of sound (depending on temperature) and tightness (depending on pressure) before the entry into the nozzle. Typical applications are test leaks and regulation tasks. Nozzles can be arranged as nozzle galleries in combination with valves. Therefore different flows can be switched by the combination of different nozzles.

4 Operational Controls

There is a distinction to be made between the operational controls, displays and interfaces of the controller and the additional operational controls, displays and interfaces of an application which accommodates a controller. The function of the operational controls and displays of the controller is independent of being used for a primary installation in a control box as a switchboard installation device, or of being integrated in an application with an own case.

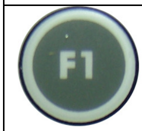
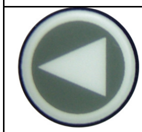
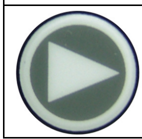
The number and type of the additional operational controls, displays and interfaces as well as the version of the case corresponds with the respective customer requirements and , hence, is documented in the part of the documentation specific for application. Hence, only one example can be shown at this point.

4.1 Front panel operational controls of Controller S320

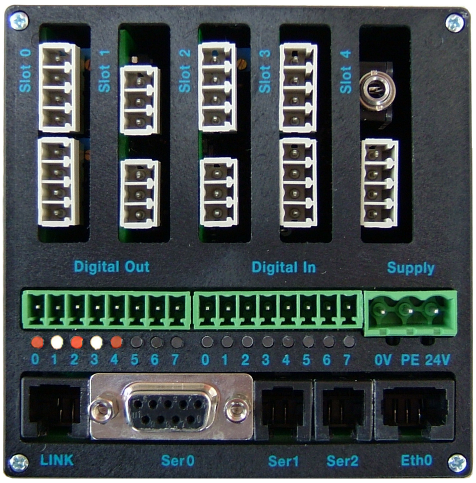
Controller S320 with its display lines and buttons is the core-piece of the LMF.

Display lines
Each of the three display lines consists of a 6-figure display for numerical values and a smaller 4-figure display for text. This text usually indicates the measuring circuit, unit or a designation of the measurement value. In applications with two measuring circuits the first line is usually allocated to the first measuring circuit, and the second one to the second measuring circuit.

Buttons

	Button	Meaning
	F1	Short keystroke in the standard mode: Scrolling of different measurement values and operands of measuring circuit 0. Short keystroke in the test mode: Scrolling of different measurement values or analog initial values of all measuring circuits. Long keystroke in the standard mode: Switching over to he editing mode. Short keystroke in the editing mode: Display next parameter. Keeping F3 simultaneously pressed: Return to the standard mode again, but changes will be rejected.
	F2	Short keystroke in the standard mode: Scrolling of different measurement values and operands of measuring circuit 1. Short keystroke in the test mode: Reduction of the displayed places in the second display line (raw value). Long keystroke: Return to the standard mode again, but changes will be taken over.
	F3	Long keystroke in the standard mode: Switching over to the test mode. Short keystroke in the editing mode: Display previous parameter. Keeping F1 simultaneously pressed: Return to the standard mode again, but changes will be rejected.
	Arrow left	In the test mode on inputs: Restores the factory settings of the sensor after nullification. Reducing of an analog initial value (provided it is just displayed). Otherwise: Reduces the displayed value (provided it can be edited).
	Arrow right	Long keystroke in the test mode: Nullification of the displayed measurement value. Otherwise: Raises the displayed value (provided it can be edited).

4.2 Interfaces of Controller S320



Interfaces of the controller
(Example, assembly with interface cards, specific for order)

Slots for interface cards
The controller is equipped with 5 slots for interface cards. The designation of the slots is imprinted. The slots are marked with „Slot 0“ to „Slot 4“ from the left to the right. The interface cards for analog-digital conversion (and vice versa) usually operate two analog devices each (sensors or actors), i.e., they usually have 2 ports. The upper port has the designation „Port0“, the lower one „Port1“. If cables are provided for the connection of the analogous devices, the connectors wear an adhesive label with an abbreviation for the indication of slot and port according to the pattern „Sl<slot number>/<port number>“.
Example: „Sl3/1“ stands for slot 3, port 1, this means the fourth column below.

Integrated digital contacts
8 outputs and inputs are available in each case, which are normally used for additional operational controls as, e.g., buttons and their lighting. As integrated digital contacts they are not isolated by optoelectronic coupler. If isolated or additional digital contacts are required, digital expansion modules are required which can be activated by a type 400 card.
Carrying capacity of each connection max. 24V/500mA

Supply
Power supply of the controller.
From the left to the right: 0V, PE, 24V

Link
Serial program interface. Connection of a laptop or PC with a serial 1:1 cable (9-pole). It is used by the S320 terminal program to transfer, e.g., the control program, the operating system or the configuration file.

Ser0
Serial RS232 interface for the exchange of ASCII data, e.g., for the query or changing of parameters, for the query of measurement values or for remote control commands.

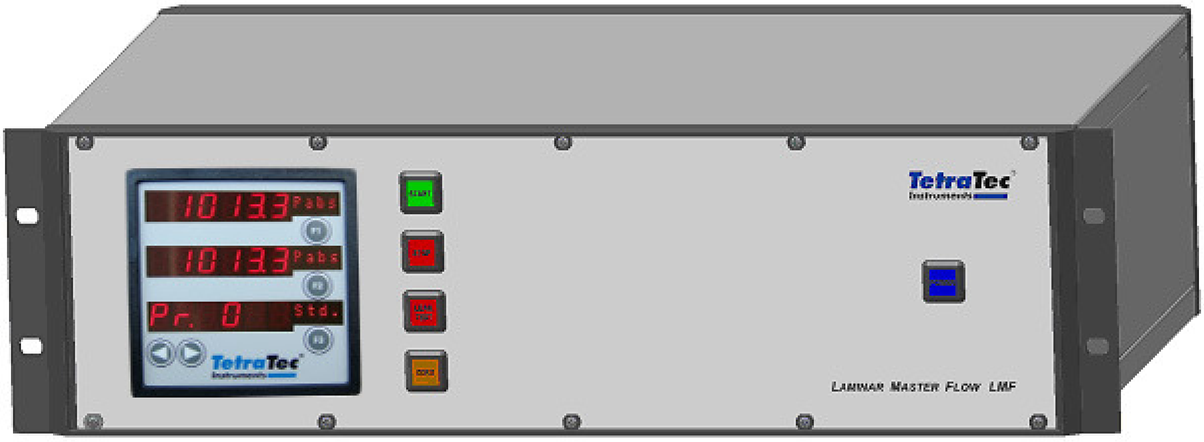
Ser1
Serial RS485 interfaces, is normally used fort he interlinking of several controllers.

Ser2
Serial RS485 interfaces, is normally used for the connection of serial sensors.

Eth0
Ethernet interface (TCP/IP).

4.3 Additional front panel operational controls with installation in a recumbent 19“ cabinet

Note:
It only can be an example here. The real application may have less or more operational controls or the operational controls may look differently. Completely different cases can be used, even several controllers S320 can be accommodated in one case. The display corresponds with the most current configuration.



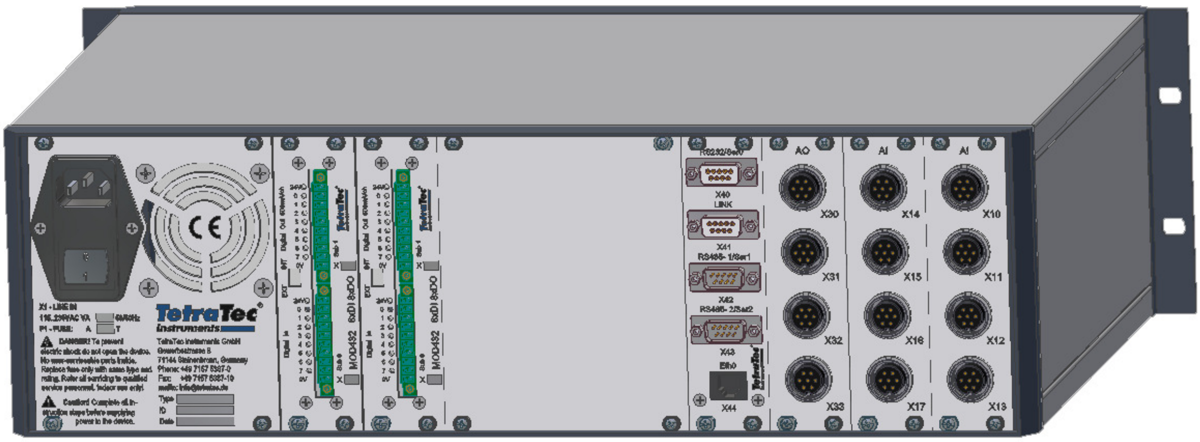
LMF front side (example)

Buttons

	Button	Meaning
	POWER	For turning on and off of the device (main switch must be turned on). POWER separates the device not completely from the power grid; in addition the main switch (usually on the back side) must be used or the mains plug must be removed.
	START	Starts, e.g., a mean taking measurement according to the application.
	STOP	Quits a started application prematurely (e.g. a mean taking measurement or a leak test). Quits the display of the results after untimely or automatic abnormal termination of a measurement. Moreover, it is equivalent to the keyboard shortcut „F1+F3“ in the controller, i.e., for returning from the test mode or editing mode to the standard mode.
	LEAK TEST	Starts a leak test (optionally).
	ZERO	Starts a nullification of the sensors released for that. Identical function as remote control command „ZERO“.

4.4 Back side interfaces with installation in a recumbent 19“ cabinet

Note:
It only can be an example here. The real application may have another number and other types of interfaces. The interfaces can be partly arranged differently. In addition, pneumatic interfaces are also possible. Completely different cases can be used. The display corresponds with a largely equipped configuration.



LMF back side (example)

Interfaces of the example from the left to the right

Mains connection	With main switch, fuse holder, fan and nameplate (serial number). The main switch separates the device bipolar from the power grid. Before a power cord is connected, compare the indication of the voltage on the name plate with the local mains voltage.
Digital interfaces	Opto-isolated interfaces for digital inputs and outputs, alternatively supplied internally or externally. According to the type of the digital expansion module 16 outputs, 16 inputs, or 8 outputs and 8 inputs are available. Digital interfaces of this kind are used, e.g., for the connection of a manual remote control, for the activation of valves, etc., or fort he analysis of switches, or they are part of a PLC interface, which, e.g., can be lead out as 39 or 40 pole connector with the installation in an IP54 protective case.
Serial interfaces	Here the serial interfaces and the Ethernet interface of the controller are lead outside. The RS485 interfaces are additionally terminated. The serial interfaces can also be installed on the front panel, if required, but will not be available on the backside any more than.
Analog outputs	Analog outputs are indicated by the designation „AO“. They are used, e.g., as an analog measurement value output or fort he activation of actuators with an analog input signal, e.g. of servo valves.
Analog inputs	Analog inputs are indicated by the designation „AI“. They are required for the connection of external analog sensors.

5 Interfaces for Remote Control

The Controller S320 included in the LMF uses two logical interfaces (“Link“ and “Comm“) for the communication with terminal programs.
The interface “Comm“ allows a complete remote control. It is possible to query and change parameters, query information or trigger actions. The command HELP displays an overview of the available commands. Any commercial terminal program can be used for that (ASCII mode), e.g., the terminal program Telnet which is included in the scope of supply with Microsoft Windows.
The interface “Link“ supports the additional options of the terminal program S 320 provided with the CD for programming and start of operation.

Physically the connection with these interfaces can be established by the Ethernet connection (TCP/IP) or both RS232 connections. The RS232 connection for the interface “Comm“ is normally indicated as „serial“.
If the Ethernet connection is used, both interfaces “ Comm“ and “Link“ are identified by the IP address of the controller and different port numbers.

Example
telnet <IP address or name> <port number>

IP address and port numbers can be set with the interface “Link“ by using the appropriate RS232 connection for this purpose.

Notes
- The RS485 connections are for a cross linking of several controllers or for the connection of serial sensors in one device. As a final user you normally are not faced with that, except with Comm commands with a RS232 connection, where the device address must be prefixed.
- In special cases only the required connections are lead through possibly.

5.1 Set up RS232 interface

The serial interface is preset, the settings can be seen in the configuration file. However, the settings are also accessible as a parameter, i.e., they may be changed with the front panel operational controls or with an existing serial connection.

5.1.1 Default settings in the configuration file:

Baud rate:
The transmission rate of the RS 232 interface
Default setting: 9600 Bauds.

Parity:
Setting of the parity bit.
Default setting: NONE (no parity bit)

Stop bits:
Number of stop bits of the RS 232 transmitter
Default setting: 1 stop bit
(the receiver is always set to 1 stop bit)

Handshake:
Setting of the handshake process:
Default setting: none
neither RTS/CTS (only hardware handshake),
nor XON/XOFF (software handshake)

Other settings are possible, if requested.
The settings are saved in the parameters S0006 to S0009, see chapter 9.7.1

5.1.2 Interface settings in the terminal program

If the terminal program S320 is used, the entries will be saved, so it is not necessary to care about it afterwards.

- Open the menu „Connect“ and click on „Comm Settings“.
  The window „Global Settings“ appears with the opened tab „Comm“.
- Enter the interface you are using, e.g., „com1“, in the left field
- If you also want to use the link connection, please repeat the settings in the tab „Link“.

Note

If you want to use both interfaces at the same time, you will need a second Comm interface or a USB serial adapter. In this case you certainly enter this other serial interface of your computer in the tab „Link“. However, if you only have one interface or only one cable, you can use the interfaces alternately only. Enter this interface in both tabs then.

- Close the window „Global Settings“ with „OK“.

5.1.3 Test function of the serial interface

- ✓ You will need a serial 1:1 cable with control wire with a 9-pole D Sub jack and a 9-pole D Sub connector (included in delivery).
- Connect the serial interface of the LMF with the serial interface of your computer.
- If you use a general terminal program, establish the connection with the serial interface of your computer.

- or -

- If you use the terminal program S320, change to tab „CommMsg“ and click on the button „Connect Comm“ in the launch-pad.

- Press the enter key of your computer.
  The connection works properly if you receive the response „Press help for details“.

5.1.4 Test function of the link interface

You will need

- ✓ a computer with the installed terminal program S320
- ✓ if you want to connect an OEM controller directly: a provided link cable

- or -

- ✓ if you want to connect a LMF with protective case: a serial 1:1 cable with control wire with a 9-pole D Sub jack and a 9-pole D Sub connector (included in delivery).

- Connect the link interface of the LMF with the serial interface of your computer.
- Click on „Connect Link“ in the Launch-pad of the terminal program S 320.
  The connection works properly if the successful setup of the link connection is displayed in the footer of the terminal program.

5.2 Set up network interface

You will need

- ✓ a computer with the installed terminal program S320
- ✓ a working link connection
- ✓ a released IP address

5.2.1 Enter IP address

Tip:

Consult your network administrator for the assignment of the IP address. He can also assign a memorable computer name to the address what makes the access more comfortable later.

- Make sure that the option „Network enabled“ is active.
- To open the input mask for the IP address, click on the entry „Network Configuration“ in the menu „System“.
- Overwrite the Default IP address and customize the Netmask, if necessary.

5.2.2 Adjust port number

It is advisable to maintain the default port number. It is user-designed and it is saved in the parameter S0020. You can read and overwrite this parameter like any other parameter.

5.2.3 Set IP address and port number in the terminal program

The terminal program must know the IP address (or, instead, the name of the computer of the LMF) and the port number. With Telnet these entries are attached simply at the end with the program request by command.
If the terminal program S320 is used, the entries will be saved, so it is not necessary to care about it afterwards.

- Open the menu „Connect" and click on „Comm Settings".
  The window „Global Settings" appears with the opened tab „Comm".
- Enter the IP address or the computer name of the LMF and the port number in the right field.
- If you also want to use the link connection, repeat the settings in the tab „Link".
- Close the window „Global Settings" with „OK".

5.2.4 Test connection

- If a general terminal program is used, establish the connection by IP address and port number.

- or -

- If the terminal program S320 is used, change to tab „CommMsg" and click on the button „Connect Comm" in the launch-pad.

- Press the enter key of your computer.
  The connection works properly if you receive the response „Press help for details".

5.2.5 Restrictions of access

By using a network there will be the problem that there are clearly more computers by which an access is possible compared to the access of other interfaces (e.g., RS232). Normally physical access to the device is not necessary any more. Even access by Internet is possible, for example.

To limit the number of computers, by which an access is possible, two string parameters with access lists exist for each network connection. These two string parameters are indicated as „Allow" and „Deny" for the following explanation. Each of these parameters contain an access list for the particular connection, e.g.

S00	Allow	for COMM connection by TCP
S0021	Deny	

S9308	Allow	for protocol printout, if S9300=8 (passive output by TCP)
S9309	Deny	

S9501	Allow	for virtual inputs and outputs
S9502	Deny	

Basic principles of the TCP/IP network protocol are necessary for the understanding of the access lists.

The following is valid, in principle: Only accesses of IP numbers or computer names can be configured. An access is allowed if and only if the Allow list allows access or if the Deny list does not deny it. If both lists are used, the Allow list has higher priority.

Each of both string parameters may contain a list of IP numbers, or computer names as a substitute. The use of computer names only works properly if a valid DNS server is entered in the network configuration of the controller, which can break down the used computer names. In addition, for each specification the entry of a net mask is still possible. Several computers are separated by semicolons, the (optional) net mask is separated by a slash. A preceding exclamation mark negates the comparison.

Examples for the syntax of the access lists:

```
# A computer specified by its IP number
192.168.28.13

# Other display with explicit net mask
192.168.28.13/32
```

```
# A computer specified by the name
frodo.example.org

# A complete class C network
192.168.28.0/24

# All computers except a class C network
!192.168.28.0/24

# Two computers
192.168.28.13;192.168.28.55

# Two computers and one class C network
192.168.28.13;frodo.example.org;192.168.0.0/24
```

Examples for the use of the access lists
To allow access by the com connection for exactly one single computer, this computer must be included in the suitable Allow list. The corresponding Deny list must include all the other computers:

```
S00=192.168.28.13   #Allow list for COMM connection
S0021=0.0.0.0/0     #Deny list for COMM connection
```

An alternative configuration is possible with the help of the negation operator:

```
S00=””              # Allow list is empty
S0021=!192.168.28.13    # Deny list includes all computers but one
```

Access for a local network, as well as for another computer:

```
S00=192.168.28.0/24;myhost.lan  # Allow list
S0021=0.0.0.0/0                     # Deny list
```

Access for all computers with the exception of computer public.example.org:

```
S00=””                  # Allow list is empty
S0021=public.example.org    # Deny list
```

The examples are also applicable for the other type of connections mentioned above.

5.3 Query and change of parameters

Note
While the LMF is in the editing mode, no values can be changed by the interface “Comm“. If values have been changed by the interface “Comm“, which still have not been acknowledged by „EXIT“ or „SAVE“, these values cannot be changed in the editing mode using the keyboard.

5.3.1 Physical units

Many of the parameters represent physical values. If, in addition, there are several units (e.g., PSI and mbar as an unit for pressure), the unit can be selected in the editing mode. However, this does not apply for a query or change by remote control. Here the indication of the units is abandoned. This is why the values are always applied in SI units. The only exception: mA is used instead of ampere. Hence, with the input of a parameter value the previous conversion to SI units (with the exception mA instead of A) has to be regarded. The input of physical units is not allowed.

5.3.2 Query parameters

Any parameter may be queried by simply entering its name. A list of parameters may be queried by replacing single digits in the name by the question mark.

Example:
```
p000?
```

Output of the controller:
```
P0000=0
P0001=1
P0003=2
P0004=1
```

If parameters have been changed, but none of the commands TEMP or SAVE have been used up to now to make effective the parameters, the currently valid value, followed by a ‚#’ sign, and the new value will be displayed.

Example:
```
p0000
```

Output of the controller:
```
P0000=0 # 1
```

5.3.2.1 Query measurement values and arithmetic values

The measurement values and arithmetic values are saved in the R parameters. They can be queried as well as any other parameter.
In addition, there is the option to use the command „RPAR“ which makes available substantially more information.
See also chapter 5.5.29.

Note
The R parameters belong to the parameters which cannot be changed.

5.3.3 Change parameters

Most parameters can be changed by entering an equals sign and a value after the parameter name.

Example:
```
P0000=0
```

Output of the controller:
```
P0000=0
```

For the syntax of the indicated value see chapter 6.1

The allocated value must be within the valid limits of the respective parameter, otherwise „Range Error“ will be returned. Some parameters are only readable („Read-only“), trying to change them will result in the message „Access denied“ then.

Parameters which have been changed will not become effective immediately, but only if, in addition, TEMP or SAVE is entered.

Error messages with the entering of values

Conversion not possible	Appears if the number cannot be converted into the demanded figure format.
No match	Appears if an input is recognized as a parameter, but this parameter does not exist in the present configuration.
Value below minimum!	Appears if a value shall be allocated to a parameter which is below actual value range.
Value exceeds maximum!	Appears if a value shall be allocated to a parameter which is below actual value range.
Illegal Command	Appears if the input is not recognized as a command.

5.4 Virtual inputs and outputs

In addition to really existing digital inputs and outputs the application LMF also knows virtual ones which can be queried or set by a separate network interface.

The basic parameters for the connection are set in the parameter block S9500. The expressions which determine the values of the virtual outputs are in the parameter block S1300. Within control expressions the value of a virtual input can be read with the function NI.

Further information

- Control expressions see chapter 6.3
- Parameter block S1300 see chapter 9.7.6
- Parameter block S9500 see chapter 9.7.28

5.4.1 Communication

For communication with a remote station the system waits for an external starting of connection. Only one connection is possible at a time. The communication is carried out with readable (ASCII) strings, single lines are terminated with „Carriage Return“ and „Line Feed“. The system understands the following messages:

```
QUIT
NI number
```

QUIT quits the connection. With NI the system is informed of a change of the input signals. Each bit of the number indicated as a parameter corresponds to an input. The following figure formats are allowed:

- decimal: [0-9]+
- decimal: [0-9]+d
- hexadecimal: [0-9a-fA-F]+h
- dual; %[01]+
- octal: &[0-7]+
- hexadecimal: $[0-9a-fA-F]+

On the other hand, the controller also announces any change of the virtual outputs by this connection. The format in which the data are sent with a change of the outputs is configurable with parameter S9507. The definition of the format corresponds with the format used with the protocol pressure (S93XX), except that exactly one single integer argument is available, namely the current output state. The initial state is sent by the controller once immediately after the connection has been set up so that the remote station knows the initial state.

Further information

- Format strings see chapter 6.2

5.4.2 Timeouts

Connection errors (e.g. pulled network cable) may, for technical reasons, only be noticed if both systems exchange data. To make sure that such errors do not remain unnoticed, the configuration of timeouts is possible (and recommended).

If a reception time-out is configured, then the LMF assumes an error, if no command was received by the remote station for longer than the set time. The existing connection is cancelled and the system waits for a new connection. Attention: If a reception time-out is configured, the remote station must transmit data at regular intervals, otherwise the connection will be cancelled.

If a transmission time-out is configured, then the LMF itself sends data at least in configured intervals. Since the state of the outputs is ordinarily only transmitted if something has been changed, the current state will even be transmitted in the case of a transmission time-out if the time-out has run off.

A value of 0 for the respective time-out parameter switches off the time-out process.

5.4.3 Access control

Two other parameters permit the restriction of the access to the interface. See also chapter 5.2.5.

5.5 List of the remote control commands of the COMM interface

Note
The remote control commands will be valid no matter by which physical interface the logical COMM interface has been built up. If the RS485 interface has been used, the device address must precede the remote control commands.

5.5.1 CONTROL

The command CONTROL displays the parameters for a regulator. Two arguments are expected: The number of the program and the number of the regulator in the program (0 or 1).

Example:

```
control 0 0

----- Control #0/0 -----
P0400 - Mode             : 1 (manual)
P0401 - Hot edit         : FALSE
P0402 - T1               : +1.000000E-01
P0403 - TD               : +0.000000E+00
P0404 - TI               : +1.000000E+00
P0405 - VP               : +1.000000E+00
P0406 - Cor lower limit: +0.000000E+00
P0407 - Cor upper limit: +1.000000E+00
P0411 - Actual value     : R0000
P0412 - ActV error mode: 0 (error)
P0416 - Reset behavior : 0 (last value)
P0417 - Fixed reset val: +0.000000E+00
P0420 - SP scale enable: FALSE
P0421 - SP input         : -1 (fixed value)
P0422 - Fixed SP         : +0.000000E+00
P0425 - SP ramp          : 0 (disabled)
P0430 - Lin method       : 0 (none)
P0441 - SP disp unit     : 1 (%)
P0442 - SP disp digits : 3
```

The parameter number precedes the output of the single parameters in each case. Inactive parameters are not displayed.

In addition to the output of the regulator data the command also sets the active regulator for the commands CTD, CTI and CVP (see there).

5.5.2 CTD

Using the command CTD the D portion of a regulator can be changed. In contrast to the allocation to the parameter the CTD command changes the D portion with running regulator.

The active regulator is the one which has been responded by the command CONTROL at last.

5.5.3 CTI

The I portion of a regulator can be changed by the command CTI. In contrast to the allocation to the parameter the command CTI changes the D portion with running regulator.

The active regulator is the one which has been responded by the command CONTROL at last.

5.5.4 CVP

The V portion of a regulator can be changed by the command CVP. In contrast to the allocation to the parameter the command CVP changes the V portion with running regulator.

The active regulator is the one which has been responded by the command CONTROL at last.

5.5.5 DATE

The command DATE queries date and time of the controller, or sets them. Invoking without parameters returns the current values. Invoking with the entry of time and date as an argument sets the clock to the indicated value. The argument must have the format „dd.mm.yyyy hh:mm:ss“. The time will be saved fail-safe.

5.5.6 DEFAULTS

All parameters can be reset to the delivery state by the command DEFAULTS. The program requests for a second input for user settings not being deleted by mistake.

Example:
```
defaults
```

Output of the controller:
```
Please enter: "DEFAULTS 4c6a" within 15 seconds
```

Input:
```
defaults 4c6a
```

Output of the controller:
```
DEFAULTS: OK - will reboot in a moment
```

After having established the delivery state the device will be started again, so that changes become effective. With the first start the reset must be confirmed on the controller by pressing F1 additionally.

5.5.7 DISCARD

DISCARD discards all parameter changes, which have not yet been taken over by TEMP or SAVE.

5.5.8 DLIST

The command DLIST displays a display list. A numerical argument (the number of the desired display list) is expected.

Example:
```
dlist 0
```

Output of the controller:
```
--------- Display list 0 ---------
D0100 - Pages in list  : 11
D0101 - Mode           : 1 (row mode)
D0102 - Page #0        : 1
D0103 - Page #1        : 11
D0104 - Page #2        : 12
D0105 - Page #3        : 13
D0106 - Page #4        : 14
D0107 - Page #5        : 15
D0108 - Page #6        : 16
D0109 - Page #7        : 17
D0110 - Page #8        : 18
D0111 - Page #9        : 19
D0112 - Page #10       : 20
```

The parameter number precedes the output of the single parameters in each case. Inactive parameters are not displayed.

5.5.9 DMODE

DMODE displays an overview of the display lists used in the different modes.

Example:
```
dmode
```

Output of the controller:
```
--------- Display mode mapping ---------
Mode  0 (Conti):         0
Mode  1 (Poll):          1
Mode  2 (Meas):          2
Mode  3 (Fill):          3
Mode  4 (Calm):          4
Mode  5 (Cal):           1
Mode  6 (Vent):          1
Mode  7 (Wait):          1
Mode  8 (MeasResult):    1
Mode  9 (Zero):          0
Mode 10 (Leak):          0
Mode 11 (LeakResult):    0
```

5.5.10 DPAGE

With DPAGE single display pages can be displayed.

Example:
```
dpage 3
```

Output of the controller:
```
--------- Display page 3 ---------
D1030 - Upper row      : 10800 (R parameter in P0800)
D1031 - Middle row     : 10801 (R parameter in P0801)
D1032 - Bottom row     : 196 (R0196)
```

5.5.11 EDITMENU

The command EDITMENU starts the editing menu of the controller and corresponds with the keyboard shortcut “ F1 (long) ” there.

5.5.12 EVAL

With EVAL expressions can be tested as they are used in the parameter blocks S14XX or S18XX, for example.

Example:
```
eval meas & (measmode = 1)
```

Output of the controller:
```
meas & (measmode = 1) => Integer (0)
```

The command EVAL can also be used as a small electronic calculator.

Example:
```
eval 2.0 * 3.14
```

Output of the controller:
```
2.0 * 3.14 => Float (+6.280000E+00)
```

5.5.13 FACDBG

FACDBG serves for the control of debugging displays and it is not provided for being used by the final user.

5.5.14 GASMIX

The command GASMIX displays information of a gas mixture. As a parameter the number of the gas mixture (0 .. 9) has to be indicated.

Example:
```
gasmix 0
```

Output of the controller:
```
----- GasMix #0 -----
M0000 - Name            : "Gas mix 0"
M0001 - Count           : 2
M0010 - 0. Gas          : 1 (Air)
M0011 - 0. Frac         : +5.000000E+01
M0015 - 1. Gas          : 14 (N2O)
M0016 - 1. Frac         : +5.000000E+01
```

The parameter number precedes the output of the single parameters in each case. Inactive parameters are not displayed.

5.5.15 HELP

HELP displays a short overview of the available commands.

Example:
```
help
```

Output of the controller:
```
CONTROL prog c          Query controller data
CTD val                 Set TD for a controller
CTI val                 Set TI for a controller
CVP val                 Set VP for a controller
DATE [date/time]        Display or set time and date
                        Format is dd.mm.yyyy hh:mm:ss
DEFAULTS                Reset to manufacturer settings
DISCARD                 Discard modified parameters
DLIST n                 Show display list n
DMODE                   Print display mode mapping
DPAGE p                 Show display page p
EDITMENU                Enter the edit menu (hold F1)
EVAL                    Evaluate an expression
FACDBG                  Enable/disable debug facilities
GASMIX n                Display gasmix data
HELP                    Print command descriptions
INPUT n                 Display analog input data
IVALVE n                Display impulse valve data
LASTSTATES              Print last states
LEAK                    Start the leak test
LOGLEVEL                Set the log level
MEAS                    Start measurement
OUTPUT n                Display analog output data
PORTMAP port prog       Display analog output port mapping
PRIMARY n               Display primary element data
PROG [sec prog]         Query or set the running program
PROGMENU                Enter the prog menu (hold F2)
QUIT                    Terminate the network connection
RPAR n                  Display read parameter n
SAVE                    Save parameters
SCRIPTINFO              Script interpreter info
SISEND                  Send a command to a serial sensor
STOP                    Stop measurement/soft reset
TEMP                    Use modified parameters
TESTMENU                Enter the test menu (hold F3)
TIMESTAT                Print time statistics
```

```
VERS                    Print the software version number
ZERO                    Zero inputs
param                   Query parameter value (i.e. P1234)
param=value             Set parameter (i.e. P1234=1)
```

5.5.16 INPUT

INPUT displays information about an analog input. The number of the input (0 to 19) has to be indicated as a parameter. The data correspond with the parameters of an input of the S-parameter block S2XXX / S3XXX.

Example:
```
input 0
```

Output of the controller:
```
----- Input #0 -----
S2000 - Type            : 0 (internal AI)
S2001 - Lin method      : 0 (Polynom)
S2005 - Lin poly order : 1
S2010 - Lin factor #0   : -7.500000E+02
S2011 - Lin factor #1   : +1.875000E+02
S2020 - Lin X factor    : +1.000000E+00
S2021 - Lin Y factor    : +1.000000E+00
S2022 - Serial number   : ""
S2030 - Offs            : +0.000000E+00
S2031 - Offs method     : 0 (before linearization)
S2032 - Zero input      : 0 (no)
S2033 - Zero timeout    : +0.000000E+00
S2034 - Zero group      : 0
S2035 - 4 mA Check      : TRUE
S2036 - Range check     : 0 (no)
S2039 - Damping         : 1
S2050 - Port number     : 0
```

The parameter number precedes the output of the single parameters in each case. Inactive parameters are not displayed.

5.5.17 IVALVE

The command IVALVE displays information about an impulse valve. The number of the impulse valve (0 .. 9) has to be indicated as a parameter. The data correspond to a block of the parameter range S16XX.

Example:
```
ivalve 0
```

Output of the controller:
```
----- IValve #0 -----
S1600 - Open port       : 4
S1601 - Close port      : 5
S1602 - State expr      : "(STATE >= 2400) && (STATE < 2500)"
```

The parameter number precedes the output of the single parameters in each case. Inactive parameters are not displayed.

5.5.18 IZERO

IZERO zeros a single input. The number of the input must be entered as a parameter. The command is only permissible in the standard mode. A feedback is carried out only with severe syntax errors of the input.

Example:
```
izero 0
```

5.5.19 LASTSTATES

With LASTSTATES a list of the last 10 internal states can be displayed. This command is applicable sensefully only for troubleshooting and for developer purposes, and it should be used only by specialist staff.

5.5.20 LEAK

The command LEAK starts a leak testing. If the measuring section is equipped accordingly, shut-off valves are closed on the inputs and outputs of the measuring section and the pressure change will be measured for a configurable time.

5.5.21 LOGLEVEL

The output of messages can be queried or influenced by the command LOGLEVEL. This command is applicable sensefully only for troubleshooting and for developer purposes, and it should be used only by specialist staff.

5.5.22 MEAS

The command MEAS starts a mean-taking measurement.

5.5.23 OUTPUT

OUTPUT displays information about an analog output. The number of the output (0 .. 9) has to be indicated as a parameter. The data correspond to the parameters of an output of the S-parameter block S8XXX.

Example:
```
output 0
```

Output of the controller:
```
----- Output #0 -----
S8000 - Type            : 0 (internal AO)
S8001 - Lin method      : 0 (Polynom)
S8005 - Lin poly order  : 1
S8010 - Lin factor #0   : +0.000000E+00
S8011 - Lin factor #1   : +1.000000E+00
S8020 - Lin X factor    : +1.000000E+00
S8021 - Lin Y factor    : +1.000000E+00
S8022 - Serial number   : ""
S8050 - Port number     : 0
```

The parameter number precedes the output of the single parameters in each case. Inactive parameters are not displayed.

5.5.24 PORTMAP

The command PORTMAP displays information about the allocation of a R parameter to an output. The number of the table entry and the program are expected as a parameter. The data correspond to the parameters of the P-parameter block PX9XX.

Example:
```
portmap 0 0
```

Output of the controller:
```
----- PortMap #0 -----
P0900 - Port            : 0 (S80XX)
P0901 - R parameter     : R0000
P0902 - Output scale lo: +0.000000E+00
P0903 - Output scale hi: +1.000000E+00
P0904 - Error handling : 1 (use fixed value)
P0905 - Error value     : +0.000000E+00
```

The parameter number precedes the output of the single parameters in each case. Inactive parameters are not displayed.

5.5.25 PRIMARY

The command PRIMARY displays information about a primary element. The number of the primary element (0 .. 139) has to be indicated as a parameter. The data correspond to the parameters of a primary element of the parameter blocks S4XXX/S5XXX/S6XXX/S7XXX or EXXXX.

Example:
```
primary 1
```

Output of the controller:
```
----- Primary #1 -----
S4100 - Type           : 0 (standard LFE)
S4101 - Cal gas        : 1 (Air)
S4102 - Cal pressure   : +1.013207E+05
S4103 - Cal temperature: +2.942610E+02
S4104 - Cal humidity   : +0.000000E+00
S4105 - Lin poly order : 3
S4110 - Lin factor #0  : +0.000000E+00
S4111 - Lin factor #1  : +5.536489E-04
S4112 - Lin factor #2  : -5.144490E-07
S4113 - Lin factor #3  : +0.000000E+00
S4120 - Lin X factor   : +1.000000E-02
S4121 - Lin Y factor   : +6.000000E+04
S4122 - Serial number  : "752970-J9"
```

The parameter number precedes the output of the single parameters in each case. Inactive parameters are not displayed.

5.5.26 PROG

The command PROG is used to query or change the currently running program. The command always needs the number of a measuring circuit as an argument. If only the measuring circuit is indicated, then the program running in this measuring circuit will be displayed. If, in addition, a program number is indicated, then there will be a change to this program.

The command PROG only changes the currently running program. The running program is taken again from the parameter S100X with a soft reset (e.g., after entering TEMP), or with a restart.

5.5.27 PROGMENU

The command PROGMENU invokes the program menu of the controller. The command corresponds to the keyboard shortcut „ F2 (long) “.

5.5.28 QUIT

QUIT quits an existing network connection.

5.5.29 RPAR

The command RPAR displays information about a R parameter. In contrast to a query via RXXXX not only the value of the parameter is available, but also additional information, as for example the error code. The command needs the number of the R parameter as an argument.

Example:
```
rpar 1
```

Output of the controller:
```
----- R0001 -----
Error  = OK
Val    = +8.548035E+00 Pa
Val    = +8.548035E-02 mbar
Disp   =   0.085 mbar
Digits = 3
Unit   = 3
Desc   = "Pdif\4U"
```

The first value with the designation „Val“ is the value in SI units. The second one is the same value converted to the respective display unit. „Disp“ is the value which is displayed on the controller display. „Digits“ and „Unit“ are post comma places and unit.

5.5.30 SAVE

SAVE saves changes of parameters fail-safe. It has to be made sure that during the saving process (controller indicates SAVE in the right, upper display) the power supply is not interrupted.

5.5.31 SCRIPTINFO

SCRIPTINFO displays a list of the functions and variables applicable in expressions as a little memory.

Example:
```
scriptinfo
```

Output of the controller:
```
----- Script info -----
Node heap utilization: 384/384

Obj Name            Type
--------------------------
 V  FALSE           INT
 V  TRUE            INT
 V  CYCLE           FLOAT
 V  CYCLECOUNT      INT
 V  NOKLOCK         INT
 V  MEAS            INT
 V  MEASAVAIL       INT
 V  MEASMODE        INT
 V  MODE            INT
 V  STATE           INT
 F  PROG            INT
 F  RPAR            FLOAT
 F  DI              INT
 F  RES             INT
```

„V“ marks a variable and „F“ marks a function in the column „Obj“.

5.5.32 SISEND

By SISEND commands can be sent with the RS485 bus to which serial sensors are connected. This command is applicable sensefully only for troubleshooting and for developer purposes, and it should be used only by specialist staff.

5.5.33 STOP

Quits a started application prematurely (e.g., a measurement forming an average value or a density test).
Quits the display of the results after untimely or automatic abnormal termination of a measurement.

5.5.34 TEMP

With TEMP changes in parameters are temporarily taken over, i.e. up to the next restart of the controller.

5.5.35 TESTMENU

The command TESTMENU invokes the test mode of the controller. The command corresponds to the keyboard shortcut „F3 (long)"

5.5.36 TIMESTAT

The command TIMESTAT displays information about the time of the processing steps carried out in the controller. The outputs can only be used sensefully by developers.

5.5.37 VERS

VERS displays the state of the software version and an internal release number.

Example:
```
vers
```

Output of the controller:
```
Software Version: 5.000
SVN Revision:     854M
```

5.5.38 ZERO

The sequence for the nullification of the sensors is started by the command ZERO. There all sensors will be zeroed whose inputs are defined as zeroable. This property is saved in the parameters S2x32, where x stands for the number of the input.
Depending on the equipment of the measuring section defined working conditions can be produced, e.g., by the switching of the valves which separate the pressure sensors from the measuring section and which produce a pressure equalization. Parameter block S1800 defines which valves are switched in which operating conditions.

Up to the achievement of a pressure equalization incl. thermalization a stabilization period is necessary as a rule. Now it is possible to define up to three stabilization periods and up to three groups of sensors which are zeroed at the end of the respective stabilization period at the same time. The stabilization periods are saved in the parameters S1100, S1101 and S1102.

Each sensor input can be allocated to one of the groups. This allocation is saved in the parameters S2x34, where x stands for the number of the input again.

Notes for the sequence

- The stabilization periods should be selected in such a way that the assumption is right that the sensor will measure physically a zero value at the end of the stabilization period.
- A real sensor will transmit a signal other than zero (offset). It now depends on the setting of parameter S2x31 whether the offset will be calculated by the signal being really present at the input (e.g., of a tension), or by the physical value calculated by the linearization polynomial. As a rule the latter is to be preferred.
- After all stabilization periods have been terminated and all sensor groups have been zeroed, the previous operating conditions will be continued.
- The offset values are not stored fail-safe. To reach this, the command SAVE must be transmitted additionally. Nevertheless, this has to be used reluctantly, since the Flash ROM is not writeable infinitely.
- Each sensor can be aligned automatically regardless of remote control commands or function keys on the device in solid time intervals. The interval is saved in the parameter S2x33.

For further information and notes to requirements of the nullification see chapter 7.4.3.

6 Syntax

This chapter includes the syntax of
- figure formats for the input of numerical parameter values
- format strings, e.g., for protocol print functions (see chapter 9.7.27)
- control expressions

The special syntax of access lists for network connections is documented at an appropriate place, see chapter 5.2.5

6.1 Figure formats for the input of numerical parameter values

Figures in exponent notation	#.#######E## ±#.#######E±##	• Positive signs may be left out. • The number of digits of mantissa and exponent are variable. • The values can be also entered in fixed-point notation. • A decimal comma instead of a decimal point is not permissible.
Figures in fixed-point notation	#.####### ±#.#######	• Positive signs may be left out. • The number of the decimal and pre-comma places is variable. • If queried the display appears in exponent notation • A decimal comma instead of a decimal point is not permissible.
Integers	####### ±#######	• The number of the digits is variable.
Selection parameters	####### ±#######	• Selection parameters differ from the type „integer“ by the fact that only certain values are admitted.

6.2 Format strings for protocol printout functions

The format strings consist of a sequence of:

- placeholders with format specification,
- control characters, and
- normal signs.

The syntax %a$fw.ps is followed by a placeholder with format specification, where the following is valid:

- a is the number of the argument of S932X which should be inserted here.
- f are single signs which influence the output:
  - +: An algebraic sign is also displayed with positive figures.
  - -: The output is done left-aligned within the field width.
  - !: The output is done concentric within the field width.
  - 0: In the case of right-aligned output the left side is filled in with zeros.
- w is the total width in which the argument is formatted. w is optional.
- p is the accuracy. For floating point figures (s = e, E or f) the accuracy is the number of the decimal places. For integers (f = d) the accuracy is the number of the places. p is optional, if it is not indicated, then the point in front of it must also be cancelled. If no accuracy is indicated, then the default will be 6 for floating point figures and 0 for integers.
- s is the real format. ‚d’ is a decimal integer format, ‚x’ and ‚X’ are integers in the hexadecimal format, ‚f’ is floating point without exponent, ‚e’ and, ‚E’ are floating point with exponent and a precomma place in the mantissa.

Control characters

Control characters are initiated with a backslash. The following control characters are available:

- \t Tab character
- \\ Backslash
- \r Carriage Return
- \n Linefeed

Normal characters

All characters not recognized as control characters or as a format specification are copied 1:1 in the output.

Examples

- „%2$d“ displays the value of S9322 as an integer: „42“.
- „%2$0.4d“ displays the value of S9322 as an integer with 4 places and leading zeros: „0042“.
- „ %2 $ + 0.4d “ displays the value of S9322 as an integer with 4 places, leading zeros and an algebraic sign even with positive figures: „+042“.
- „ %2 $ + 010.4d “ displays the value of S9322 as an integer with 4 places, leading zeros, an algebraic sign even with positive figures, and a total width of 10 signs: „+042“.
- „ %2 $-+ 010.4d “ displays the value of S9322 as an integer with 4 places, leading zeros, an algebraic sign even with positive figures, and a total width of 10 signs left-aligned: „+042“.
- „%0 $.3f“ displays the value of S9320 as a floating point figure with 3 decimal places: „42.000“.
- „%0$E“ displays the value of S9320 as a floating point figure with 6 decimal places: „4.200000E01“.
- „%0 $.3e“ displays the value of S9320 as a floating point figure with 3 decimal places: „4.200E01“.

All 4 strings (S9301-S9304) are displayed.

6.3 Control expressions

To be able to customize the device easier to different application scenarios, expressions are used at many places for the determination of input or output signals. The calculation is carried out within these expressions and access to inputs or status variables used in the software is possible.

6.3.1 Operators and their priorities

Op	Name	Description	Prio
Id	Variable	Values of the variable at the analysis time	0
Id()	Function	All functions have exactly one parameter of the type INTEGER. The result can be of type INTEGER or FLOAT according to the function.	0
()	Clamping		0
-	Unary minus		0
+	Unary plus		0
!	Unary Boole NOT	Operand has to be of type INTEGER	0
~	Unary NOT	Operand has to be of type INTEGER	0
_	Debug output	The operator _ must be followed by an integer constant. During the analysis of the expression the integer constant and the value of the following partial expression will be displayed on the console. This allows for the test of more complex expressions.	0
*	Multiplication	Operands can be INTEGER or FLOAT. Result is of the same type as of operand.	1
/	Division	Operands can be INTEGER or FLOAT. Result is of the same type as of operand.	1
\	Modulo	Operands have to be of type INTEGER.	1
&	Binary AND	Operands are INTEGER	1

+	Addition	Operands can be INTEGER or FLOAT. Result is of the same type as of operand.	2
-	Subtraction	Operands can be INTEGER or FLOAT. Result is of the same type as of operand.	2
|	OR bit by bit	Operands have to be of type INTEGER.	2
^	XOR bit by bit	Operands have to be of type INTEGER.	2
=	Equal	Operates with INTEGER or FLOAT types as operands. The result is an INTEGER with the value 0 or 1.	3
!=, <>	Unequal	Operates with INTEGER or FLOAT types as operands. The result is an INTEGER with the value 0 or 1.	3
<	Less than	Operates with INTEGER or FLOAT types as operands. The result is an INTEGER with the value 0 or 1.	3
>	More than	Operates with INTEGER or FLOAT types as operands. The result is an INTEGER with the value 0 or 1.	3
>=	More than or equal	Operates with INTEGER or FLOAT types as operands. The result is an INTEGER with the value 0 or 1.	3
<=	Less than or equal	Operates with INTEGER or FLOAT types as operands. The result is an INTEGER with the value 0 or 1.	3
&&	Bool AND	Operands have to be of type INTEGER.	4
||	Boole OR	Operands have to be of type INTEGER.	5
^^	Boole XOR	Operands have to be of type INTEGER.	5
?:	Ternary operator (IF query)	The INTEGER expression on the left of ‚?’ is valued. If it is unequal to 0 (TRUE), then the result of the operator will be the left result expression, otherwise the right one. Example: DI(8) & 1? 5 : 0 If bit 0 of the digital input 8 is set, then the result is 5, otherwise 0.	6

Table 1. Operators and their priorities

6.3.2 Variables

Name	**Description**
CYCLE	FLOAT. Indicates the current cycle time (corresponds to S0301).
CYCLECOUNT	INTEGER. Includes a cycle counter.
FALSE	INTEGER constant. Always has the value 0.
MEAS	INTEGER. TRUE if a mean taking measurement runs.
MEASAVAIL	INTEGER. TRUE if a measurement result is available.
MEASMODE	INTEGER. Indicates the way of the measurement. 0 = mean taking measurement. 1 = leak test.
SPSCALMAX	INTEGER. State of the input CALMAX (see S1408) when the main cycle starts.
SPSCALMIN	INTEGER. State of the input CALMIN (see S1407) when the main cycle starts.
SPSDAVAIL	INTEGER. TRUE if it waits for the removal of the PLC start signal. The variable indicates the end of the cycle and thus the availability of the evaluation data. The signal is only taken away again when a new cycle has been started.
SPSEND	INTEGER. TRUE if it waits for the removal of the PLC start signal. The variable SPSEND is set inactive again, as soon as the PLC takes away the start signal. However, it waits in the state WAIT for at least one cycle.
SPSFAIL	INTEGER. TRUE if with the PLC program flow an error has occurred.
SPSIN0	INTEGER. State of the extension signal #0 (see S1411) when the main cycle starts.
SPSIN1	INTEGER. State of the extension signal #1 (see S1412) when the main cycle starts.

SPSIN2	INTEGER. State of the extension signal #2 (see S1413) when the main cycle starts.
SPSLDET	INTEGER. State of the input LDET (see S1409) when the main cycle starts.
SPSLOCK	INTEGER. TRUE if it waits for the error acknowledgement signal of the PLC.
SPSMODE	INTEGER. Program mode (corresponds to S0010).
SPSREADY	INTEGER. TRUE if the program waits for the START signal of the PLC.
SPSVDET	INTEGER. State of the input VDET (see S1410) when the main cycle starts.
SPSZERO	INTEGER. State of the input ZERO (see S1406) when the main cycle starts.
STATE	INTEGER. The state of the internal state machine.
STAUTH	INTEGER. Includes 1 during the password query, otherwise 0.
STCAL	INTEGER. Includes 1 during the calibration mode, otherwise 0.
STCALM	INTEGER. Includes 1 during the stabilization period, otherwise 0.
STEDIT	INTEGER. Includes 1 in the editing menu, otherwise 0.
STFILL	INTEGER. Includes 1 during the filling phase, otherwise 0.
STLDET	INTEGER. Includes 1 during the determination of the system leakage (LMS), otherwise 0.
STMEAS	INTEGER. Includes 1 during the measuring phase, otherwise 0.
STPFIL	INTEGER. Includes 1 during the prefilling period, otherwise 0.
STPOLL	INTEGER. Includes 1 during the polling phase, otherwise 0.
STPROG	INTEGER. Includes 1 in the program menu, otherwise 0.
STSAVE	INTEGER. Includes 1 during the saving, otherwise 0.
STTEMP	INTEGER. Includes 1 during the taking over of parameters, otherwise 0.
STVDET	INTEGER. Includes 1 during the determination of the test sample volume (LMS), otherwise 0.
STVENT	INTEGER. Includes 1 during the ventilation phase, otherwise 0.
STWAIT	INTEGER. Includes 1 during the waiting on PLC stop, otherwise 0.
STZERO	INTEGER. Includes 1 during the zero phase, otherwise 0.
TRUE	INTEGER constant. Always has the value 1.

Table 2. Variables

Note
The variables STxxx are set by the help of the state of the internal state machine and they do not only cover the real operation, but also initializations and transitional states.

6.3.3 Functions

Name	Description
DI	Reads a digital input. Result is an INTEGER. The current input value stands in bit 0, bit 1 indicates whether a change of state has occurred in the last cycle. So 0: Input is steady on OFF. 1: Input is steady on ON. 2: Input has changed from ON to OFF. 3: Input has changed from OFF to ON.
FF	Supplies the initial value of a flip flop (see S12nn). The parameter for the function is the number of the flip flop (0.. 9).
NI	Supplies the value of a virtual input. The bit definition corresponds to that of the function DI.
PROG	Returns the program running in a measuring circuit.
RES	Returns the evaluation of the test in the respective measuring circuit. Function result: 1 = NOTAVAIL, 8 = FAIL, 16 = OK, 32 = NOK, 64 = OFF.
RES0	Returns the individual value 0 of the test in the respective measuring circuit. Function result: 1 = NOTAVAIL, 2 = LOW, 4 = HIGH, 8 = FAIL, 16 = OK.
RES1	Returns the individual value 1 of the test in the respective measuring circuit. Function result: 1 = NOTAVAIL, 2 = LOW, 4 = HIGH, 8 = FAIL, 16 = OK.

RES2	Returns the individual value 2 of the test in the respective measuring circuit. Function result: 1 = NOTAVAIL, 2 = LOW, 4 = HIGH, 8 = FAIL, 16 = OK.
RES3	Returns the individual value 3 of the test in the respective measuring circuit. Function result: 1 = NOTAVAIL, 2 = LOW, 4 = HIGH, 8 = FAIL, 16 = OK.
RPAR	Reads out a R parameter and supplies the current value. The result is of the type FLOAT. Unknown R parameters or those with errors make 0.0.
SP0	Returns the sub program in measuring circuit 0. The number of the sub program parameter set is the parameter.
SP1	Returns the sub program in measuring circuit 1. The number of the sub program parameter set is the parameter.
SP2	Returns the sub program in measuring circuit 2. The number of the sub program parameter set is the parameter.
SPSOK	Returns TRUE if a test has been carried out in the measuring circuit and the result is OK.

Table 3. Functions

The command SCRIPTINFO includes a memory of the available variables and functions.

7 Operation modes

This chapter explains the most important operation modes except the PLC mode. The PLC operation mode is explained in an own chapter, see chapter 16.

7.1 STANDARD MODE

The standard mode is the mode which is active after the switch-on. It is also active if one of the other modes has been quit. As a rule the lower display line is used in the standard mode to display the current measuring program. Nevertheless, this can be initialized and, hence, deviations are possible in this item.
All arithmetic values and measurement values are continuously displayed in the standard mode. The displayed values can be toggled with the function keys „F1“, „F2“ and „F3“ starting from the default. The standard display setting is determined in the parameters and it can be changed in the editing mode.

7.1.1 Program selection

The LMF makes available up to 10 different measuring programs. They cannot be distinguished by the software, but they are alternative parameter sets with which, e.g., different sensor sets or measuring ranges are selected.

- To enter the program selection, press the function key „F2“ for approx. 3 seconds.
  The highest valid program number is displayed in the upper display line.
  The current program number is displayed in the middle display line, and the accompanying measuring circuit is displayed on the right of it.
  The lowest valid program number is displayed in the lower display line.
- Select the desired measuring circuit using the function keys „F1“ and „F3“ (provided that more than one measuring circuit exist).
- Select the desired program number using the function keys „<“ und „>“.

- To take over the changes with mains failure protection, press the function key „F2“ for 3 seconds.

-or-

- To reject the changes, press the key „STOP“ or press the function keys „F1“ and „F2“ at the same time for 3 seconds.

7.2 LEAK TESTING

This mode is intended as an accessory for the checking of the test section design for tightness. Leakage in the measuring system is the most frequent cause for faulty measurements and measuring deviations. With this function the test sample and the reference device can be checked for leakage by the pressure drop method.

- Fill the system with overpressure and vacuum and separate the pressure supply again.
- To activate the leakage test press the button "LEAK Test".

The parameters S8001 to S8007 (cf. Table 32) determine the display options and the test period. After the pressure drop measurement has been finished the measurement result appears on the LED displays:

P0:	Pressure at the beginning of the leak testing
P1:	Pressure at the end of the leak testing
Pmin:	the lowest pressure having appeared during the test
Pmax:	the highest pressure having appeared during the test
dpdt:	Pressure gradient during the test

The calculation of the result is done by the equation:

$$\text{Pressure drop / rise per time} = \frac{\text{Initial pressure - final pressure}}{\text{Measuring time}}$$

The result is treated with correct signs.

- To quit the leak testing press the button „STOP“ or press the function keys „F1“ and „F2“ at the same time and keep them pressed for 3 seconds.

7.3 MEASUREMENT by taking the mean

- To start a measurement by taking the mean, press the button „START“, or transmit the command „MEAS“ by remote control.
  The LMF starts with the cyclic recording of the measurement values and computed values. During the measurement both upper display lines continue to display the current measurement values (can be configured). The measuring time is displayed in the lower display line.
  At the end of the measuring time the results are displayed. For any flow rate and sensor value the minimum values and maximum values are also displayed in addition to average. As long as the results are displayed, the LMF carries out no measurements.

Note
The measurement can be finished prematurely by pressing the button „STOP“ or by pressing of the function keys „F1“ and „F3“ at the same time. Even in this case the results will also be displayed.

- To view the different averages of the sensor values and flow rates toggle them with the function key „F1“.
- To return to the standard mode again, press the button „STOP“ or press the function keys „F1“ and F3 “ at the same time.

Note:
With double section devices the measurement values and results are marked, in addition, with 0 for distance 0 and with 1 for distance 1. Limits as well as minima and maxima are always indicated with the accompanying physical value.

7.4 Special modes for the experienced user

7.4.1 Test mode

The test mode is for looking at the input signals and for editing the output signals. By the simultaneous display of the raw value and the value calculated out of it there is the possibility of a plausibility test.

- To activate the test mode, keep the function key „F3“ pressed for 3 seconds.
  In the upper display line the test mode is indicated.
  In the middle display line the current raw value of the input or output is indicated.
  In the lower display line the physical value calculated with the linearization polynomial is indicated.
- Select the desired input or output using the function keys „F1“ and „F3“.

Note
Only inputs which are active in the current program are displayed.

If you have selected an input:

- Press function key „F2“ to change the number of the displayed digits.

If you have selected an output:

- Set desired output signal using the arrow keys „<“ and „>“.

Note
In the test mode the arrow keys „<“ and „>“ have functions for the nullification of the inputs. Absolutely follow chapter 7.4.3 for this purpose!

- To take over the changes with mains failure protection, press the function key „F2“ for 3 seconds.

-or-

- To reject the changes, press the key „STOP“ or press the function keys „F1“ and „F2“ at the same time for 3 seconds.

7.4.2 Controller mode

The LMF may include up to two active controllers at the same time per program. Each controller can be switched in manual or automatic operation. The default mode of operation is determined in the parameters Px400 and Px450, but it can be switched. If the controller mode is activated, the last setting applies.

7.4.2.1 Overview automatic operation and manual operation

The following settings are possible with automatic operation
- Set value
- Also the controller parameters T1, TD, TI and VP with activated option „Hotedit“ (parameter Px401 or Px451).

The new settings will become active immediately.

The following settings are possible with manual operation
- optionally set value or control value
- the controller parameters T1, TD, TI and VP

The switching on and off of a controller is only possible with parameter Px400 or Px450.

7.4.2.2 Activate controller mode and select controller

- ➢ Press both arrow keys „<“ and „>“ simultaneously and keep them pressed for 3 seconds.
  The controlled variables of the first controller are indicated in the three lines of the display. The upper line displays the actual value, the middle line the set value and the lower line the control value.
- ➢ To indicate the desired controller, scroll forward the function key „F1“ or scroll backward the function key „F3“.

7.4.2.3 Adjust set value

The controller set value is saved in parameter Px422 or Px472 and it can be changed in the controller mode using the arrow keys.

Automatic operation
- ➢ Change the set value using the arrow keys „<“ and „>“.

Manual operation
- ➢ If the point flashing on the right is in the lowest line, press the function key „F2“ for a short moment.
  The flashing point jumps to the middle line, i.e. now the set value can be edited.
- ➢ Change the set value using the arrow keys „<“ and „>“.

7.4.2.4 Adjust control value (only manual operation)

- ➢ If the point flashing on the right is in the middle line, press the function key „F2“ for a short moment.
  The flashing point jumps to the lower line, i.e. now the control value can be edited.
- ➢ Change control value using the arrow keys „<“ and „>“.

7.4.2.5 Switch mode of operation

- ➢ Press the arrow keys „<“ and „>“ simultaneously.
  The menu „Mode“ is indicated.
  The current mode is indicated.
- ➢ Change mode using one of the arrow keys „<“ or „>“.

Now it is possible to leave the menu „Mode“ or immediately continue with the setting of the controller parameters.

- ➢ To take over the change with mains failure protection, keep the function key „F2“ pressed for 3 seconds.

-or-
- ➢ To reject the change, press the key „STOP“ or press the function keys „F1“ and „F2“ at the same time and keep them pressed for 3 seconds.

7.4.2.6 Adjust controller parameter

- If the menu „Mode“ is not already active, press the arrow keys „<“ and „>“ simultaneously.
- If the controller is in automatic operation, set the manual mode of operation with one of the arrow keys.
- Scroll with function keys „F1“ or „F3“ to the menus „T1“, TD, TI or „VP“.

The menus of the controller parameters indicate the value currently saved in the parameter in the middle line (see table below). This value can be changed proportionally. The proportional application of this value is indicated in the lower line.

- Set percentage with arrow keys „<“ and „>“.
- To take over the changes, press the function key „F2“ for 3 seconds.
  The parameter will be overwritten with mains failure protection, i.e., with the next opening of the menu the value is changed, and the lower line is set to 100% again.
- To reject the changes, press the key „STOP“ or press the function keys „F1“ and „F2“ at the same time for 3 seconds.

Overview of the controller parameters:

T1	Px402	Px452	Time constant
TD	Px403	Px453	Differential share
TI	Px404	Px454	Integral share
VP	Px405	Px455	Loop gain

7.4.2.7 Leave controller mode

- To take over changes of the set value and control value, press the function key "F2" for 3 seconds. The changes are valid up to the next switching off or restart of the software (no saving with mains failure protection)

-or-

- To reject the changes of the set value and control value, press the key „STOP“ or press the function keys „F1“ and „F2“ at the same time and keep them pressed for 3 seconds.

7.4.3 Nullification

Since the differential pressure sensors and relative pressure sensors may be dependent on position, a nullification must always be carried out when changing the place of installation for the differential pressure sensors or relative pressure sensors.
In addition, the nullification should be carried out in regular time intervals to compensate long-term drifts of the sensors.
The nullification applies to all sensor inputs which are released for a nullification. Each sensor input may be allocated to one of up to three groups. All sensors of the same group are matched at the same time.

The alignment of pressure sensors only makes sense in a state completely free of flow or free of pressure. If this operating condition is not automatically produced by valves, suitable operating conditions must be produced by adequate interventions. For example, it is recommended for differential pressure sensors to connect the pressure connections with each other. Effects as draft etc. will be avoided with that.

The nullification only makes sense with a thermally well-balanced device. I. e., after the device has been switched on there should be a waiting period of approx. 30 minutes, with a change of the ambient temperature caused by a change of location still clearly longer. Independent of that the waiting period of thermostat sensors may be up to 4 hours! In this case possibly leave the device or the sensor supply always switched on.

The nullification can be carried out for each sensor individually by hand or be started as an automatic cycle by remote control command (RS232, network or PLC) or by keystroke. The automatic function is documented in chapter 5.5.38

7.4.3.1 Manual nullification of individual sensors

The manual nullification is only possible in the test mode. The test mode is not accessible if the controller is set by S0010 to external control (e.g. PLC operation).

- If the controller is set to external control, activate the editing mode with the functional key "F1", scroll to parameter S0010, write down the original value and change the value according to the information of parameter S0010 (see chapter 9.7.1). Leave the editing mode by taking over the change (keep functional key "F2" pressed for 3 seconds).

- Activate the test mode using function key „F3“ and select the input of the sensor, which should be aligned to zero, using function key „F1“.

- To align the sensor to zero, keep right arrow key „>„ pressed for 3 seconds.
  If a nullification is released for the selected sensor, the LMF carries out a mean taking measurement and calculates an offset correction from it. The process for that is saved in parameter S2x31, and x stands for the number of the input.

- or -

- To restore the offset value of the original factory setting saved in the source text, keep the left arrow key „<„ pressed for 3 seconds.

Now it is possible to immediately align the next sensor to zero, or to leave the test menu by saving the changes (keep function key „F2“ pressed for 3 seconds).

- If you have changed the parameter S0010, restore the original value again.

7.4.4 Editing mode

In the editing mode there is access to the parameters which are defined in your application, as far as they are not classified as a "read-only". There is an overview of the parameter structure in chapter 8, detailed information about the meaning and about the range of adjustment of each parameter can be found in the list of parameters (chapter 9).

Editing mode and access by remote control are not possible simultaneously.

7.4.4.1 Read-only parameter

There are system parameters which must not be changed. There is no access to them in the editing mode. They can be queried at best by the terminal program, but it is not possible to change them.

7.4.4.2 User administration

Up to 10 access levels may be defined, where each level is allocated to one user group. An own password is allocated to each level. Beginning with version 5 it is not the case any more that users of a high level have also automatically access to the parameters which are accessible in a lower level. Just as for the quality „Read-only“ it can be determined for each parameter in which level access is possible or not. Particularly users of a high level have the advantage of finding a specific selection of relevant parameters for them and they need not search for thousands of parameters.
The user groups are defined in the parameter block S0500 (see chapter 9.7.3).

7.4.4.3 Activate and use editing mode

✓ You are in the standard mode

➢ Press the key F1 for 3 seconds.
  You are asked to set an access level.
➢ Set the access level using the arrow keys „<“ and „>“ and confirm the setting with function key „F2“.
  You are asked to set the password which corresponds to the level.
➢ Set the password using the arrow keys „<“ and „>“ and confirm the setting with function key „F2“.
  The first parameter is indicated.

In the upper line of the display the parameter identification is indicated, consisting of the initial letter and a four-digit number. In the middle line the value of the parameter is indicated.

➢ To indicate the desired parameter, scroll forward with function key „F1“ or scroll back with the function key „F3“.
➢ To change the value of the indicated parameter, use the arrow keys „<“ and „>“. Depending on the data format you will find some tips below (sections 7.4.4.4. to 7.4.4.7).

Now it is possible to change the next parameter or to leave the editing menu (section 7.4.4.8).

7.4.4.4 Editing figures in exponential form

As a default the arrow keys „<“ and „>“ have an effect on the smallest digit of the mantissa. By pressing function key „F2“ repeatedly it is possible to set the effect of the arrow keys on the exponent or on a certain digit of the mantissa. Thus a very comfortable setting is possible. Exponent and digits are periodically toggled. If you open a parameter, first of all no particular digit will be selected. With every keystroke of the function key „F2“ the digits are selected in the following order:

- Exponent
- 4th digit following the decimal point
- 3rd digit following the decimal point
- 2nd digit following the decimal point
- 1st digit following the decimal point
- Digit before the decimal point including sign
- No digit selected.

7.4.4.5 Editing of figures in fixed decimal point notation

Figures in fixed decimal point notation are always tied together with a physical unit. If the physical unit is changed, the value is converted accordingly, so that a comfortable input is possible.
For the qualities of the function key "F2" there is the same as with the figures in exponential form, but with the difference that the exponent is cancelled and instead the physical unit is changed (e.g., PSI instead of mbar).

7.4.4.6 Editing of integers

Only the arrow keys „<“ and „>“ are available. The values are incremented and decremented at increasing speed by pressing the key longer.

7.4.4.7 Editing of selection parameters

Selection parameters are non-numerical parameters with solid values which only can be advanced in turn (toggle parameter). The change is only possible by the arrow keys „<„ und „>„.

7.4.4.8 Leave editing mode

- To take over the change with mains failure protection, keep the function key „F2“ pressed for 3 seconds.
  The changed values are saved in the " persistent data area “ of the Flash ROM.

-or-

- To reject the change, press the key „STOP“ or press the function keys „F1“ and „F2“ at the same time and keep them pressed for 3 seconds.

8 Parameter Structure

8.1 Parameter structure and overview

The individual parameter names are built up of an identification letter and a four-digit number. According to their function they can be summarized in the following content units:

8.1.1 C parameter nozzle combinations

Cxxxx block Nozzle combinations

8.1.2 D Parameter display configurations

D00xx block Linkage program mode with display list
D01xx block Linkage of display pages to a display list
D1xxx block Definitions of the display pages

8.1.3 E parameter extension flow elements

E0000 block Linearization and type preselection flow elements
The data of 100 primary elements follow in a distance of 100 each up to the E9900 block, according to the same setup structure as the S4000 block

8.1.4 F parameter switch over vectors

F0000 block Switch over vectors for sub programs

8.1.5 I parameter initialization analog outputs

Ixxxx block Initial values of outputs

8.1.6 M-Parameter – gas mixtures

In the block M0000..M0999 up to 10 gas mixtures can be defined.

8.1.7 P-Parameter – measuring programs

10 different configurations of the measuring system can be deposited in the 10 measuring programs. For the measurement values and arithmetic values of the measuring program the type of gas, allocation of the primary elements and sensors, determination and scaling of the measuring ranges, notation in physical units and comma digits, limits, measuring times, display settings, scaling and allocation of the analog output it is determined here among other things:

X is the operation exponent for the measuring program from 0 to 9 here

8.1.7.1 Px000 block: Primary elements, basis description

Px010 block: Primary signal (differential pressure)
Px020 block: Test pressure absolute
Px030 block: Measuring temperature
Px040 block: Measuring humidity
Px050 block: Reference pressure absolute
Px060 block: Reference temperature
Px070 block: Reference humidity
Px075 block: Auxiliary input 0 Aux 0
Px080 block: Auxiliary input 1 Aux 1
Px085 block: Auxiliary input 2 Aux 2
Px090 block: Auxiliary input 3 Aux 3
Px095 block: Auxiliary input 4 Aux 4
Px100 block: Volume flow
Px120 block: Mass flow
Px130 block: Heating capacity
Px140 block: Tightness
Px160 block: Viscosity
Px180 block: Speed
Px300 block: Ratio formation
Px310 block: Functions
Px350 block: Computed R parameters
Px400 block: Control 1
Px450 block: Control 2
Px500 block: Limits
Px550 block: Automatic program toggle
Px700 block: Process times
Px800 block: Display options
Px900 block: Analog outputs

8.1.8 R parameter - read parameter, measurement results of the measuring programs

The read parameters are for the quick and direct query of the measurement and arithmetic results. An overview of all values can be found in the Ryxxx block. (Y: measuring circuit index)
Y here describes the desired measuring circuit (e. g.: 0 is the first distance and 1 is the second one with the double section device). xxx“ is the placeholder for the address of the value in the Ryxxx block. Measuring circuits are simultaneously active. A measuring program can be allocated to each measuring circuit.

8.1.8.1 Error codes with the output of R-parameters

The error codes described here appear with the indication of R parameters on the display (e. g. , in the standard mode), or by the query with the command „RPAR“. They have no importance for the query with R????.

There are two different error possibilities with the output of R parameters on the display:

- On the one hand, the number of the R parameter can be invalid. In this case „RXXXX“ is displayed on the left, and some question marks are displayed on the right.
- Secondly the R parameters themselves can be subject to errors, perhaps values could not be computed because of sensor errors, or the value is not available because the calculation has not been carried out. In this case the name and the unit of the R parameter is displayed on the right, but not the numerical value appears on the left, but one of the following texts.

Display	Internal Code	Meaning
noPort	ENOPORT	The input does not exist. This message may only appear with R parameters which represent direct analogous inputs.
noCALC	ENOTAVAIL	The value has not been computed or read.
S-OFF	EOFF	The sensor is switched off.
S-FAIL	EFAIL	Input values for the calculation are beyond the range of validity (violation of limits, division by 0...).
C-FAIL	EREL	A value which is required for the calculation has an error, as a result the value could not be determined.
ConFiG	ECONFIG	Due to errors in the parameters necessary for the calculation the value could not be computed.

The syntax of the responses corresponds with those of figures in exponential form or fixed decimal point numbers.

8.1.9 S-parameter - system parameter

In the system parameter range all basic and general settings and configurations are determined. It is structured as follows:

S0000 block: general parameters
S0350 block: error conditions of inputs and outputs
S0500 block: user administration
S1000 block: program preselection
S1100 block: nullification of stabilization times
S1200 block: flip-flops (flags)
S1300 block: virtual outputs
S1400 block: SPS control inputs
S1500 block: input and output allocations
S1600 block: impulse valves
S1800 block: digital outputs
S2000 block: analog input channels (linearization sensors)
S3000 block: analog input channels (linearization sensors)
S4000 block: linearization and type primary elements
S5000 block: linearization and type primary elements
S6000 block: linearization and type primary elements
S7000 block: linearization and type primary elements
S8000 block: linearization analog outputs
S9000 block: special functions
S9300 block: protocol printout
S9500 block: connection definition for virtual outputs

The behavior of the serial interface RS 232, the sensor element and primary element linearization data as well as special functions are saved in the system parameter range. The definition of the measuring circuits and their allocation to the measuring programs serves for simultaneous supply of results for parallel running measurements and their query of results.

8.1.10 U parameter - sub programs

Sub programs are managed in this parameter range.

9 List of Parameters

9.1 C parameter: nozzle combinations

The parameter block Cxxxx (C0000-C0199) includes 10 data sets for nozzle combinations with a distance of 20, which can be used for Px000 instead of a primary element. For that purpose a negative primary element number has to be indicated for Px000. -1 corresponds to the nozzle combination of C0000, -2 corresponds to C0020 etc. Only nozzles with the same type of evaluation (according to PTB or CFO calibration) can be combined respectively, calibration gas type, calibration conditions etc. must also correspond to each other.
In the following the data record is displayed exemplarily with C0000:

Parameter	Meaning	Values	Explanations		
C0000	Number of combined nozzles	0 .. 16	0	Nozzle combination invalid	
			1 .. 16	Combine N nozzles from C0001..C0016	
C0001	Nozzle #1	0 .. 139	Number of the nozzle data record from S4000-S7000 or Exxxx		
...					
C0016	Nozzle #16	0 .. 139	Number of the nozzle data record from S4000-S7000 or Exxxx		

Table 4. Cxxxx block: nozzle combinations

9.2 D parameter: display lists

The block Dxxxx defines the display options in the different modes of the program.

9.2.1 D0000-D0049 block: linkage program mode with display list

Parameter	Meaning	Values	Explanations	
D0000	Linkage mode #0 with a display list.	0 .. 49 [0]	The display list N is used in the program mode 0.	
...				
D0049	Linkage mode #49 with a display list.	0 .. 49 [0]	The display list N is used in the program mode 49.	

Table 5. D0000 block: linkage program mode with display list

Currently used program modes are:

Mode	Description
0	Continuous operation
1	Display of the measurement result during poll and in the standard mode
2	Display during measurement
3	Fill
4	Calm
5	Calibrate
6	Ventilate
7	Wait for SPS STOP
8	Display of the measurement result in the SPS mode (separate step)
9	Display during nullification
10	Display during the system leak test
11	Display of the results of the system leak test

9.2.2 D0100-D0499 block: linkage of display pages to a display list

Several display pages are summarized to a page list in block D0100-D0499. Each list may include up to 18 single pages which can be toggled with buttons. A maximum of 40 of such lists can be defined with a distance of 20. Here, as an example, the definition of list #0, display list #1 follows with D0120.

Parameter	**Meaning**	**Values**	**Explanations**	
D0100	Number of pages in list #0.	0 .. 18 [1]	N pages to be displayed starting from D0102.	
D0101	Display mode	0 .. 1 [0]	0: Display page-by-page. It is possible to toggle with F1 or F3. All displays are always switched to the new page. 1: Display line-by-line. Each display line uses a cutout from one page. F1 toggles the upper display to the following page, F2 the middle display, and F3 the lower display, regardless of the other displays. Scrolling back is not possible.	
D0102	Page #1	0 .. 99	Number of the first page in the list. The number refers to the page definitions in D1000-D1999.	
D0119	Page #18	0 .. 99	Number of page 18 in the list. The number refers to the page definitions in D1000-D1999.	

Table 6. D0100 block: linkage of display pages to a display list

9.2.3 D1000-D1999 block: definitions of the display pages

The block D1000-D1999 defines the individual display pages which are referred to in block D0100-D0499. Page #0 is defined in D1000-D1002, page #1in D1010-D1012 etc.

In addition to the display of certain predefined data there are two possibilities to indicate the value of R parameters on the display:

- display of a directly allocated parameter
- Display of the R parameter, which is saved in an allocated P parameter (see also chapter for that)

At this point it is a matter of determining whether a standard size or the value of a R parameter should be displayed, and whether the R parameter is allocated directly or indirectly, if necessary.

Parameter	**Meaning**	**Values**	**Explanations**	
D1000	Display value of upper display	-7 .. -1 0 .. 59999 [-1]	-7: Evaluation of measuring circuit 2 -6: Evaluation of measuring circuit 1 -5: Evaluation of measuring circuit 0 -4: Current time -3: Current date -2: Program no. of the measuring circuit -1: Empty display 0 .. 2999: R parameter number 3000 .. 9999: not covered 10000 .. 52999: P parameter no. which includes R parameters. There, the thousands digit indicates the measuring circuit. The ten thousands digit indicates, whether the R parameter itself should be used: 1xxxx: Use continuous value. 2xxxx: Use average. 3xxxx: Use sum. 4xxxx: Use minimum. 5xxxx: Use maximum.	
D1001	Display value of middle display	-7 .. -1 0 .. 59999 [-1]	As D1000	
D1002	Display value of lower display	-7 .. -1 0 .. 59999 [-1]	As D1000	

Table 7. D1000-D1999 block: definitions of the display lists

9.3 E parameter: extension primary elements

Parameter block Exxxx (E0000-E9999) includes the definitions of 100 additional primary elements (numbers 40-139). The individual elements are arranged in a distance of 100 and they are identically in their structure with the definitions in block S4000-S7000.

9.4 F parameters: switch over vectors

Switch over vectors are used if switchable sub programs are used, and the switch over is triggered by the value of a R parameter. Explanations of the sub programs and several options to determine their switch over behaviour can be found in section 9.9.

The parameter block Fxxxx (F0000-F0499) includes 50 data sets with a distance of 10, one for a possible sub program respectively. In the following the data set of F0000 is described as an example:

Parameter	Meaning	Values	Explanations	
F0000	Number of the R parameter which shall be evaluated	0...2999		
F0001	Lower limit		Lower limit for the R parameter in F0000	
F0002	Upper limit		Upper limit for the R parameter in F0000	
F0003	Switch over target in the case of falling below a value	0...9	If the R parameter in F0000 falls below the lower limits in F0001, a switch over to the sub program indicated here is carried out.	
F0004	Switch over target in the case of exceeding	0...9	If the R parameter in F0000 exceeds the upper limits in F0002, a switch over to the sub program indicated here is carried out.	

Table 8. F0000 block: switch over vectors

9.5 I parameter: initial values of outputs

9.5.1 I0200 block: initial values of impulse valves

The block I010x describes how existing impulse valves should be set immediately after the program has been started.

Parameter	Meaning	Values	Explanations	
I0200	Initial value for impulse valve 0	0 .. 1 [0]	0: closed 1: open	*)
I0201	Initial value for impulse valve 1	0 .. 1 [0]	0: closed 1: open	*)
I0202	Initial value for impulse valve 2	0 .. 1 [0]	0: closed 1: open	*)
I0203	Initial value for impulse valve 3	0 .. 1 [0]	0: closed 1: open	*)
I0204	Initial value for impulse valve 4	0 .. 1 [0]	0: closed 1: open	*)
I0205	Initial value for impulse valve 5	0 .. 1 [0]	0: closed 1: open	*)
I0206	Initial value for impulse valve 6	0 .. 1 [0]	0: closed 1: open	*)
I0207	Initial value for impulse valve 7	0 .. 1 [0]	0: closed 1: open	*)
I0208	Initial value for impulse valve 8	0 .. 1 [0]	0: closed 1: open	*)
I0209	Initial value for impulse valve 9	0 .. 1 [0]	0: closed 1: open	*)

*) only if the impulse valve is available and defined in block S1600.

Table 9. I020x block: initial values of impulse valves

9.6 M parameter: gas mixtures

9.6.1 M0xxx block: definition of gas mixtures

The area M0xxx contains 10 definitions for gas mixtures in a distance of 100.

Parameter	Meaning	Values	Explanations	
M0000	Name of the mixture	String(63) „“	Name of the gas mixture	
M0001	Number of gases	1..10	Defines how many gas entries are valid beginning from M0010.	
M0010	Gas 0	1 .. 15	1: air 2: argon 3: carbon dioxide 4: carbon monoxide 5: helium 6: hydrogen 7: nitrogen 8: oxygen 9: methane 10: propane 11: n butane 12: natural gas H 13: natural gas L 14: laughing gas 15: water vapour	
M0011	Proportion gas 0	1E-3 .. 1E6	Molar proportion of gas 0.	
M0015	Gas 1	1 .. 15	As M0010	
M0016	Proportion gas 1	1E-3 .. 1E6	Molar proportion of gas 1.	
M0020	Gas 2	1 .. 15	As M0010	
M0021	Proportion gas 2	1E-3 .. 1E6	Molar proportion gas 2.	
M0025	Gas 3	1 .. 15	As M0010	
M0026	Proportion gas 3	1E-3 .. 1E6	Molar proportion gas 3.	
M0030	Gas 4	1 .. 15	As M0010	
M0031	Proportion gas 4	1E-3 .. 1E6	Molar proportion gas 4.	
M0035	Gas 5	1 .. 15	As M0010	
M0036	Proportion gas 5	1E-3 .. 1E6	Molar proportion gas 5.	
M0040	Gas 6	1 .. 15	As M0010	
M0041	Proportion gas 6	1E-3 .. 1E6	Molar proportion gas 6.	
M0045	Gas 7	1 .. 15	as M0010	
M0046	Proportion gas 7	1E-3 .. 1E6	Molar proportion gas 7.	
M0050	Gas 8	1 .. 15	as M0010	
M0051	Proportion gas 8	1E-3 .. 1E6	Molar proportion gas 8.	
M0055	Gas 9	1 .. 15	as M0010	
M0056	Proportion gas 9	1E-3 .. 1E6	Molar proportion gas 9.	

Table 10. M0xxx block: gas mixtures

9.7 S parameter: system parameter

9.7.1 S0000 block: general parameters

Parameter	Meaning	Values	Explanations	
S0001	Step-by-step operation	0 .. 1 [0]	0: switched off 1: step operation active	
S0002	Display Initialization	0 .. 1 [0]	0: switched off 1: display is initialized again in each cycle	
S0003	Watchdog	0 .. 1 [0]	0: do not use watchdog 1: activate watchdog	
S0005	Bus address RS 485 cross linking	0 .. 99 [00]	Bus address for several users	
S0006	Baud rate of the serial interface (Ser0)	0 .. 8 [4]	0: 300 Baud 1: 600 2: 1200 3: 4800 4: 9600 5: 19200 6: 38400 7: 57600 8: 115200	
S0007	Serial output Feedback with commands (echo)	0 .. 1 [1]	0: no feedback 1: feedback	
S0008	Serial output String blockmark	0 .. 2 [0]	0: CRLF 1: CR 2: LF 3: ETX	
S0009	Handshake RTS/CTS	0 .. 1 [0]	0: off (no handshake) 1: on (handshake RTS/CTS)	
S0010	Mode (mode of operation)	0 .. 31	Bit-encoded value for adjusting the mode of operation. Bit 0: 1=complete cycle, 0=sub-cycle Bit 1: 1=external check, 0=keys Bit 2: 1=external program selection Bit 3: 1=stop interrupts measurement, 0=stop quits measurement Bit 4: 1=error with measurement quits a test with several cycles, 0=all cycles are carried out Current values: 0: standard mode 9: LMS with manual control 15: PLC cycle	
S0011	Number of flows	1...999		
S0012	Program step, if S0011> 1	0,1	0: no program step 1: program step	
S0013	Counter NOK Lockout active with n x NOK	0 .. 10 [0]	0: n = 0, not active 1: n = 1, active with 1 x NOK 2: .. etc. up to 10: n = 10, active at 10 x NOK	*)
S0014	Determination system leakage (LMS cycle): number of flows whose result is ignored	0 .. 100 [0]	Total number of the flows is determined by S0014 + S0015.	
S0015	Determination system leakage (LMS cycle): number of flows whose result is evaluated	1 .. 100 [1]	Total number of the flows is determined by S0014 + S0015.	

S0016	Save system leakage continuously after determination	0 .. 1 [1]	0: Take over only temporarily. 1: Save continuously.	
S0017	Determination of the test sample volume (LMS cycle): number of flows whose result is ignored	0 .. 100 [0]	Total number of the flows is determined by S0017 + S0018.	
S0018	Determination of the test sample volume (LMS cycle): number of flows whose result is evaluated	1 .. 100 [1]	Total number of the flows is determined by S0017 + S0018.	
S0019	Save test sample volume continuously after determination	0 .. 1 [1]	0: Take over only temporarily. 1: Save continuously.	
S0020	TCP connection	0..65535 [54491]	0: none 1..65535: TCP port number	
S0021	List of permitted remote stations	String(63) [„“]	These remote stations are permitted to establish a connection.	
S0022	List of unpermitted remote stations	String(63) [„“]	These remote stations are not permitted to provide a connection.	
S0030	Time-out for DNS operations	0.0 .. 90.0 [1.0]	Time-out for DNS queries in seconds.	
S0080	Digital output port which is set active with a runtime error.	-1 .. 99	-1: switched off. Otherwise: The number of the digital output port (DOnn in the configuration) which is set active with runtime errors. Caution: This only works with runtime errors which appear after the reading of the parameters, i.e. not during the startup phase.	
S0081	Digital output port which is set inactive in the case of runtime errors.	-1 .. 99	-1: switched off. Otherwise: The number of the digital output port (DOnn in the configuration) which is set inactive with runtime errors. Caution: This only works with runtime errors which appear after the reading of the parameters, i.e. not during the startup phase.	
S0098	Number of active measuring circuits	1..3 [1]		
S0099	Number of device/series/project	String(63) [„“]	Readable only.	
S0101	Standard condition absolute pressure	[100000.0]	in Pascal	
S0102	Standard condition temperature	[293.15]	in Kelvin	
S0103	Standard condition humidity	[0.0]	0..1 r.F.	
S0301	Cycle time	0.02 .. 2.0 [0.02]	in seconds	
S0311	Display update	0.02 .. 5.0 [0.3]	display only each n seconds	

*) only with PLC operation

Table 11. S0000 block: general parameters

Further information

- Restriction of access for TCP connection see chapter 5.2.5

9.7.1.1 Several test flows with one test sample

Optionally several measurements can be carried out with one test sample (without deadaptation, without interruption of the control, if available), where the following cycle is kept (shift and intermediate steps are not listed):

- Select program
- Fill
- Calm
- Measure
- Distinction of cases:
  - the flow which has been just carried out was not the last flow: back to „fill“, then next flow.
  - the flow which has been just carried out pass was the last flow: go on with „ventilation“.
- Ventilation

9.7.1.2 Automatic program step:

If by S0011> 1 several flows are initialized, there is optionally the possibility to increase the program with each flow by 1:
- 1st Cycle: start routine, as specified by S1400-S1402.
- 2nd Cycle: start routine + 1.
- etc.

The program step is limited by the parameters S1010 (the lowest valid program number of measuring circuit 0) and S1020 (the highest valid program number of measuring circuit 3). By exceeding the highest program number there is a program step to the lowest program number (cyclic behavior).

9.7.2 S0350 block: error conditions of inputs and outputs

Block S0350 configures by which conditions error flags are set for inputs or outputs. For this purpose inputs and outputs are split in groups: Analogous inputs, analogous outputs, type 400 cards (digital inputs and outputs) and serial sensors. As soon as there are errors in a group for an adjustable time, an error flag will be set. This error flag is reset as soon as no error occurs any more for a period of time which is also adjustable. The error flag is made available to the Script Interpreter by the variable FAULT and it can be used, for example, to signal the error condition by a digital output.

Parameter	Meaning	Values	Explanations	
S0350	error handling analogous inputs on / off	0 .. 1 [0]	0: switched off 1: error analysis active	
S0351	time until error occurs	0.02 .. 60.0 [2.0]	time in seconds for which an error must permanently be present until the mistake flag is set.	
S0352	time until reset of error flag	0.02 .. 60.0 [2.0]	time in seconds, which must pass without errors after activation of the error flag, until the error flag is being reset again.	

According to this example block S036n contains parameters for analogous outputs, block S037n parameters for type 400 cards, and block S038n parameters for serial sensors.
Further notes:
- At present, only a responding of the 4-20mA supervision is evaluated as an error with analogous inputs. In addition, S2n35 / S3n35 must be activated.
- Errors with analogous outputs are only returned by type 200 cards in the 4-20mA operation.
- The query cycle of the serial sensors depends on the type and on the number of the configured sensors. An error is triggered when there was no last query, or if with the last query an error occurred. The error is triggered in each cycle as long as the sensor has been queried successfully.

9.7.3 S0500 block: user administration

Parameter	Meaning	Values	Explanations	
S0500	Description user 0	String(63) [„“]	Name of the user group	
S0501	group affiliation user 0	0 .. $7FFFFFFF	Bit-encoded, each set bit activates the affiliation to a group.	
S0502	Password user 0	0 .. 9999	Password to be entered	

The parameters S0510-S0599 contain other 9 user definitions of the same scheme.

Further information

- For examples and default settings see paragraph 2.2.7.2
- For consequences of the user-specific restrictions of access in the editing menu see paragraph 7.4.4.2.

9.7.4 S1000 block: preselection of program

A measuring section with a set of sensors for the analysis of a flow element is indicated as measuring circuit. The LaminarMaster may compute simultaneously up to three measuring circuits being active at the same time.
A program in which the definition of the measuring section is determined can be allocated to each measuring circuit. The analogous output can also be allocated to an active measuring circuit. The detailed settings of the analogous output are carried out in the measuring program (Px900).

Parameter	Meaning	Values	Explanations	
S1000	Measuring circuit 0 (single section)	0 .. 9	Allocation program 0 – 9	
S1001	Measuring circuit 1 (double section)	0 .. 9	Allocation program 0 – 9	*)
S1002	Measuring circuit 2 (triple section)	0 .. 9	Allocation program 0 – 9	*)
S1010	Lowest program number MK 0	0 .. 9	Allocation program 0 – 9	
S1011	Lowest program number MK 1	0 .. 9	Allocation program 0 – 9	*)
S1012	Lowest program number MK 2	0 .. 9	Allocation program 0 – 9	*)
S1020	Highest program number MK 0	0 .. 9	Allocation program 0 – 9	
S1021	Highest program number MK 1	0 .. 9	Allocation program 0 – 9	*)
S1022	Highest program number	0 .. 9	Allocation program 0 – 9	*)
S1030	Toggle program in the measuring circuit 0 automatically.	0 .. 3	0: No toggle. 1: Toggle to block Px550 2: Toggle to block Px560 3: Toggle to block Px550 and Px560	
S1031	Toggle program in the measuring circuit 1 automatically.	0 .. 3	0: No toggle. 1: Toggle to block Px550 2: Toggle to block Px560 3: Toggle to block Px550 and Px560	*)
S1032	Toggle program in the measuring circuit 2 automatically.	0 .. 3	0: No toggle. 1: Toggle to block Px550 2: Toggle to block Px560 3: Toggle to block Px550 and Px560	*)
S1035	Waiting time/stabilization time for automatic program toggle in measuring circuit 0.	0 .. 300	Time in seconds, until the next automatic toggle is possible.	
S1036	Waiting time/stabilization time for automatic program toggle in measuring circuit 1.	0 .. 300	Time in seconds, until the next automatic toggle is possible.	*)
S1037	Waiting time/stabilization time for automatic program toggle in measuring circuit 2.	0 .. 300	Time in seconds, until the next automatic toggle is possible.	*)

S1040	Carry out good/bad evaluation with block Px500 (limits) in the measuring circuit 0	0 .. 1	0: Off, no evaluation 1: On, carry out evaluation	
S1041	Carry out good/bad evaluation with block Px500 (limits) in measuring circuit 1	0 .. 1	0: Off, no evaluation 1: On, carry out evaluation	*)
S1042	Carry out good/bad evaluation with block Px500 (limits) in measuring circuit 2	0 .. 1	0: Off, no evaluation 1: On, carry out evaluation	*)

*) will only be evaluated if measuring circuit is active
**) only if available

Table 12. S1000 block: measuring circuits and analog outputs

9.7.5 S1100 block: stabilization period nullification

Parameter	Meaning	Values	Explanations	
S1100	Stabilization time before nullification, group 0	0 .. 600 [0.0]	Time in seconds	
S1101	Stabilization time before nullification, group 1	0 .. 600 [0.0]	Time in seconds	
S1102	Stabilization time before nullification, group 2	0 .. 600 [0.0]	Time in seconds	

Table 13. S1100 block: stabilization periods nullification

9.7.6 S1200 block: flip-flops (flags)

Up to 10 flip-flops can be defined in block 1200. The initial state of the flip-flop can be queried by the FF function of the script interpreter. The flip-flops are set, if the set print has a value other than 0. The reinitialization is carried out according to the type of flip-flop respectively:

- Type 1: the rest output has a value <> 0.
- Type 2 and 3: after the defined preservation time has expired.

Types 2 and 3 differ in trigger behavior: Type 2 can be retriggered, i.e. the set term will be checked again in each cycle, and the preservation time will be restarted again, if necessary. Type 3 can not be triggered again, and it falls for one cycle after the preservation time has expired, before the set term is evaluated again.
The new output values of the flip-flop will be calculated with the sequence 0..9 in each cycle. A flip-flop definition, which queries the output of another flip-flop, reads the new value in the same cycle, if and only if the number of the queried flip-flop is smaller.

The following table shows only one flip-flop, the parameters of nine others follow with S1210, S1220 etc.

Parameter	Meaning	Values	Explanations	
S1200	Type of flag	0 .. 3 [0]	0: switched off 1: RS flip-flop 2: monostable, can be triggered again 3: monostable, can not be triggered again	
S1201	„Set“ term	String(63) [„“]	Term which sets the flag, if its value is <> 0. Applies for types 1-3.	
S1202	„Reset“ term	String(63) [„“]	Term which resets the flag, if its value is <> 0. Applies for type 1.	
S1203	Preservation time	0.02 .. 86400 [1.0]	Preservation time for the flags type 2 and 3 in seconds.	

Table 14. S1200 block: flip-flops (flags)

9.7.7 S1300 block: virtual outputs

Parameter	Meaning	Values	Explanations	
S1300	Term for output 0	String(63) [„“]	The term is evaluated in each cycle, if a connection exists.	
S1301	Term for output 1	String(63) [„“]	The term is evaluated in each cycle, if a connection exists.	
S1302	Term for output 2	String(63) [„“]	The term is evaluated in each cycle, if a connection exists.	
S1303	Term for output 3	String(63) [„“]	The term is evaluated in each cycle, if a connection exists.	
S1304	Term for output 4	String(63) [„“]	The term is evaluated in each cycle, if a connection exists.	
S1305	Term for output 5	String(63) [„“]	The term is evaluated in each cycle, if a connection exists.	
S1306	Term for output 6	String(63) [„“]	The term is evaluated in each cycle, if a connection exists.	
S1307	Term for output 7	String(63) [„“]	The term is evaluated in each cycle, if a connection exists.	
S1308	Term for output 8	String(63) [„“]	The term is evaluated in each cycle, if a connection exists.	
S1309	Term for output 9	String(63) [„“]	The term is evaluated in each cycle, if a connection exists.	
S1310	Term for output 10	String(63) [„“]	The term is evaluated in each cycle, if a connection exists.	
S1311	Term for output 11	String(63) [„“]	The term is evaluated in each cycle, if a connection exists.	
S1312	Term for output 12	String(63) [„“]	The term is evaluated in each cycle, if a connection exists.	
S1313	Term for output 13	String(63) [„“]	The term is evaluated in each cycle, if a connection exists.	
S1314	Term for output 14	String(63) [„“]	The term is evaluated in each cycle, if a connection exists.	
S1315	Term for output 15	String(63) [„“]	The term is evaluated in each cycle, if a connection exists.	
S1316	Term for output 16	String(63) [„“]	The term is evaluated in each cycle, if a connection exists.	
S1317	Term for output 17	String(63) [„“]	The term is evaluated in each cycle, if a connection exists.	
S1318	Term for output 18	String(63) [„“]	The term is evaluated in each cycle, if a connection exists.	
S1319	Term for output 19	String(63) [„“]	The term is evaluated in each cycle, if a connection exists.	

Table 15. S1300 block: virtual outputs

Further information

- Syntax of the control expressions see chapter 6.3

9.7.8 S1400 block: SPS control inputs

Parameter	Meaning	Values	Explanations	
S1400	Expression which determines the program for the measuring circuit 0 in the PLC mode.	String(63) [„“]	The expression will be evaluated after the start signal has been triggered by the PLC.	
S1401	Expression which determines the program for the measuring circuit 1 in the PLC mode.	String(63) [„“]	The expression will be evaluated after the start signal has been triggered by the PLC.	

S1402	Expression which determines the program for the measuring circuit 2 in the PLC mode.	String(63) [„“]	The expression will be evaluated after the start signal has been triggered by the PLC.	
S1403	Expression which determines the start signal for the PLC in the PLC mode.	String(63) [„“]	The expression will be evaluated in each cycle, if the PLC mode is active.	
S1404	Expression which determines the GO signal.	String(63) [„“]	The expression will be evaluated in each cycle, if the PLC mode is active.	
S1405	Expression which determines the ACK signal (reset of the NOK counter).	String(63) [„“]	The expression will be evaluated if a lockout exists due to too many errors.	
S1406	Expression which determines the ZERO signal.	String(63) [„“]	The expression will be evaluated after the start signal has been triggered by the PLC.	
S1407	Expression which determines the CALMIN signal.	String(63) [„“]	The expression will be evaluated after the start signal has been triggered by the PLC.	
S1408	Expression which determines the CALMAX signal.	String(63) [„“]	The expression will be evaluated after the start signal has been triggered by the PLC.	
S1409	Expression which determines the LDET signal (determination of the system leakage).	String(63) [„“]	The expression will be evaluated after the start signal has been triggered by the PLC.	
S1410	Expression which determines the VDET signal (determination of the test sample volume).	String(63) [„“]	The expression will be evaluated after the start signal has been triggered by the PLC.	
S1411	Expression for the extension signal #0 (specific to the product)	String(63) [„“]	The expression will be evaluated after the start signal has been triggered by the PLC.	
S1412	Expression for the extension signal #1 (specific to the product)	String(63) [„“]	The expression will be evaluated after the start signal has been triggered by the PLC.	
S1413	Expression for the extension signal #2 (specific to the product)	String(63) [„“]	The expression will be evaluated after the start signal has been triggered by the PLC.	

Table 16. S1400 block: control inputs

Further information

- Syntax of the control expressions see chapter 6.3

9.7.9 S1500 block: input/output allocations

Parameter	Meaning	Values	Explanations	
S1500	Number of the digital input for the STOP key	-1 0 .. 99 [1]	Readable only. Number of the digital input or –1 if none is defined.	
S1501	Number of the digital input for the TEST key	-1 0 .. 99 [-1]	Readable only. Number of the digital input or –1 if none is defined.	
S1502	Number of the digital input for the START key	-1 0 .. 99 [0]	Readable only. Number of the digital input or –1 if none is defined.	
S1503	Number of the digital input for the SAVE key	-1 0 .. 99 [-1]	Readable only. Number of the digital input or –1 if none is defined.	
S1504	Number of the digital input for the TEMP key	-1 0 .. 99 [-1]	Readable only. Number of the digital input or –1 if none is defined.	
S1505	Number of the digital input for the ZERO key	-1 0 .. 99 [3]	Readable only. Number of the digital input or –1 if none is defined.	
S1506	Number of the digital input for the EDIT key	-1 0 .. 99 [-1]	Readable only. Number of the digital input or –1 if none is defined.	
S1507	Number of the digital input for the PROG key	-1 0 .. 99 [-1]	Readable only. Number of the digital input or –1 if none is defined.	
S1508	Number of the digital input for the LEAK key	-1 0 .. 99 [-1]	Readable only. Number of the digital input or –1 if none is defined.	

Table 17. S1500 block: input/output allocations

9.7.10 S1600 block: impulse valves

Parameter	Meaning	Values	Explanations	
S1600	Number of the digital output for the opening of impulse valve 0.	-1 0 .. 99 [1]	Readable only. Number of the digital input or –1 if none is defined.	
S1601	Number of the digital output for the closing of impulse valve 0.	-1 0 .. 99 [-1]	Readable only. Number of the digital input or –1 if none is defined.	
S1602	Term which determines the status of impulse valve 0.	String(63) [„“]	The term is evaluated in each cycle and it determines the status of the valve.	
S1610	Number of the digital output for the opening of impulse valve 1.	-1 0 .. 99 [1]	Readable only. Number of the digital input or –1 if none is defined.	
S1611	Number of the digital output for the closing of impulse valve 1.	-1 0 .. 99 [-1]	Readable only. Number of the digital input or –1 if none is defined.	
S1612	Term which determines the status of impulse valve 1.	String(63) [„“]	The term is evaluated in each cycle and it determines the status of the valve.	
S1620	Number of the digital output for the opening of impulse valve 2.	-1 0 .. 99 [1]	Readable only. Number of the digital input or –1 if none is defined.	
S1621	Number of the digital output for the closing of impulse valve 2.	-1 0 .. 99 [-1]	Readable only. Number of the digital input or –1 if none is defined.	
S1622	Term, which determines the state of impulse valve 2.	String(63) [„“]	The term is evaluated in each cycle and it determines the status of the valve.	
S1630	Number of the digital output for the opening of impulse valve 3.	-1 0 .. 99 [1]	Readable only. Number of the digital input or –1 if none is defined.	
S1631	Number of the digital output for the closing of impulse valve 3.	-1 0 .. 99 [-1]	Readable only. Number of the digital input or –1 if none is defined.	
S1632	Term, which determines the state of impulse valve 3.	String(63) [„“]	The term is evaluated in each cycle and it determines the status of the valve.	
S1640	Number of the digital output for the opening of impulse valve 4.	-1 0 .. 99 [1]	Readable only. Number of the digital input or –1 if none is defined.	
S1641	Number of the digital output for the closing of impulse valve 4.	-1 0 .. 99 [-1]	Readable only. Number of the digital input or –1 if none is defined.	
S1642	Term, which determines the state of impulse valve 4.	String(63) [„“]	The term is evaluated in each cycle and it determines the status of the valve.	
S1650	Number of the digital output for the opening of impulse valve 5.	-1 0 .. 99 [1]	Readable only. Number of the digital input or –1 if none is defined.	
S1651	Number of the digital output for the closing of impulse valve 5.	-1 0 .. 99 [-1]	Readable only. Number of the digital input or –1 if none is defined.	
S1652	Term, which determines the state of impulse valve 5.	String(63) [„“]	The term is evaluated in each cycle and it determines the status of the valve.	
S1660	Number of the digital output for the opening of impulse valve 6.	-1 0 .. 99 [1]	Readable only. Number of the digital input or –1 if none is defined.	

S1661	Number of the digital output for the closing of impulse valve 6.	-1 0 .. 99 [-1]	Readable only. Number of the digital input or –1 if none is defined.	
S1662	Term, which determines the state of impulse valve 6.	String(63) [„“]	The term is evaluated in each cycle and it determines the status of the valve.	
S1670	Number of the digital output for the opening of impulse valve 7.	-1 0 .. 99 [1]	Readable only. Number of the digital input or –1 if none is defined.	
S1671	Number of the digital output for the closing of impulse valve 7.	-1 0 .. 99 [-1]	Readable only. Number of the digital input or –1 if none is defined.	
S1672	Term, which determines the state of impulse valve 7.	String(63) [„“]	The term is evaluated in each cycle and it determines the status of the valve.	
S1680	Number of the digital output for the opening of impulse valve 8.	-1 0 .. 99 [1]	Readable only. Number of the digital input or –1 if none is defined.	
S1681	Number of the digital output for the closing of impulse valve 8.	-1 0 .. 99 [-1]	Readable only. Number of the digital input or –1 if none is defined.	
S1682	Term, which determines the state of impulse valve 8.	String(63) [„“]	The term is evaluated in each cycle and it determines the status of the valve.	
S1690	Number of the digital output for the opening of impulse valve 9.	-1 0 .. 99 [1]	Readable only. Number of the digital input or –1 if none is defined.	
S1691	Number of the digital output for the closing of impulse valve 9.	-1 0 .. 99 [-1]	Readable only. Number of the digital input or –1 if none is defined.	
S1692	Term, which determines the state of impulse valve 9.	String(63) [„“]	The term is evaluated in each cycle and it determines the status of the valve.	

Table 18. S1600 block: impulse valves

Further information

- Syntax of the control expressions see chapter 6.3

9.7.11 S1800 block: digital outputs

Block S1800 allows to allocate expressions for up to 40 digital outputs, which determine the status of these outputs. The expressions are evaluated again in each cycle. The following definition of S1800 repeats up to 40 times (up to S1995) with an interval of 5.

Parameter	Meaning	Values	Explanations	
S1800	Number of the digital output, the state term of which is determined in S1801.	-1 0 .. 99 [1]	Readable only. Number of the digital input or –1 if none is defined.	
S1801	Expression which is evaluated for the determination of the status of the port defined in S1800.	String(63) [„“]	Readable only.	
S1805	Number of the digital output , the state term of which is determined in S1806.	-1 0 .. 99 [1]	Readable only. Number of the digital input or –1 if none is defined.	
S1806	Expression which is evaluated for the determination of the status of the port defined in S1805.	String(63) [„“]	Readable only.	
etc.	etc.	etc.	etc.	

Table 19. S1800 block: digital outputs

Further information

- Syntax of the control expressions see chapter 6.3

9.7.12 S2000/S3000 block: analog input channels

Parameter	Meaning	Values	Explanations	
S2n00	Type of sensor	-1 .. 4	-1: switched off 0: integrated analog input 1: serial sensor 2: R parameter 3: integrated frequency counter input 4: integrated incremental counter	
S2n01	Type of linearization Channel / sensor	-1 .. 1	-1: without linearization / polynomial 0: polynomial calculation 1: PT100/PT1000 linearization	
S2n05	Linearization SENSOR x Order	0 .. 9	Order of the polynomial	
S2n10	Linearization SENSOR x Coefficient order 0		Coefficient order 0 a0	
S2n11	Linearization SENSOR x Coefficient order 1		Coefficient order 1 a1	
S2n12	Linearization SENSOR x Coefficient order 2		Coefficient order 2 a2	
S2n13	Linearization SENSOR x Coefficient order 3		Coefficient order 3 a3	
S2n14	Linearization SENSOR x Coefficient order 4		Coefficient order 4 a4	
S2n15	Linearization SENSOR x Coefficient order 5		Coefficient order 5 a5	
S2n16	Linearization SENSOR x Coefficient order 6		Coefficient order 6 a6	
S2n17	Linearization SENSOR x Coefficient order 7		Coefficient order 7 a7	

S2n18	Linearization SENSOR x Coefficient order 8		Coefficient order 8 a8	
S2n19	Linearization SENSOR x Coefficient order 9		Coefficient order 9 a9	
S2n20	Linearization SENSOR x X factor		Scaling factor between sensor raw value and polynomial x value	
S2n21	Linearization SENSOR x Y factor		Scaling factor between polynomial y value and polynomial value in SI units	
S2n22	Serial number of the sensor	String(63)	Readable only	
S2n30	SENSOR x Offset value		Sensor offset in SI base unit (also applies for PT100)	*)
S2n31	SENSOR x Offset process	0 .. 1	0: Compensation before characteristic curve 1: Compensation after characteristic curve	*)
S2n32	Nullification	0 .. 3 [0]	0: no nullification 1: automatic nullification in groups on (command ZERO, nullification key or PLC). 2: manual nullification on (command IZERO or test menu). 3: automatic nullification in groups and manual nullification on.	
S2n33	Interval for automatic nullification	0..97200 [0.0]	0: no automatic nullification otherwise: interval in seconds	
S2n34	Arrangement for automatic nullification	0..2 [0]	Sensors in the same group are nullified together. The parameter indicates the allocation to one of three possible groups.	
S2n35	Display sensor error with 4 .. 20mA signal if I<3.5mA	0 .. 1	0: inactive 1: active	
S2n36	Treatment of exceedings of limit (limits in S2x03 & S2x04).	0 .. 4 [0]	0: inactive 1: active, check raw value and trigger sensor error if violated 2: limit raw value to limit value 3: active, check linearized value and trigger sensor error if violated 4: limit linearized value to limit value	
S2n37	minimum admissible raw value	[0.0]		
S2n38	maximum admissible sensor raw value	[2.0]		
S2n39	size of the ring buffer for attenuation	1 ... 5 [1]	Calculate average of n measuring values	

*) also applies for Pt100

Table 20. S2000/3000 block: analog input channels

9.7.12.1 Offset correction of the differential pressure sensors

Requirement:
The measuring system is equipped with valves which separate the differential pressure sensor from the primary element and which short-circuit its inputs.

Principle:
Both inputs of the differential pressure sensor are pneumatically shorted, the differential pressure measured after a stabilization time is used then as a zero point by the control software

The nullification is triggered by:

- Pressing the key „Zero“
- Sending the special command „ZERO“ by a serial interface (RS232)
- Automatically with defined intervals. The interval is determined for each analogs input by parameter S2x33, S2x33=0.0 disables automatic nullification. All inputs of a nullification group (S2x34) will be nullified together, as soon as the smallest interval within the group has expired. The parameters S110x determine the stabilization time for each group of inputs.

Characteristics of nullification:

- The nullification is only carried out with the mode of operation „measuring continuously“.
- With double section devices the nullification for the differential pressure sensors of both measuring circuits is carried out simultaneously.
- If the system is equipped with several differential pressure sensors for one measuring circuit (e.g. for automatic switching over of range), a nullification is only carried out for the sensor which is used in the program currently active.
- The manually triggered nullification is only triggered with PLC operation, if at the time of pressing the key „ZERO“ the system is in the state „POLL“ . The time interval induced nullification is carried out in the following state „POLL“ respectively.

9.7.13 Extended parameter set for integrated analog inputs

S2n50	Number of the integrated analogs input	0 .. 9	Has access to the input named AInn in the configuration (nn corresponds with the number of the analogs input).	
S2n51	Filter frequency	0 .. 1000 [0]	Filter frequency for the analogs input in Hz. If a value <> 0 is displayed here, the filter of the analogs card will be set to this value then.	

Table 21. Extended parameter set for integrated analog inputs

9.7.14 Extended parameter set for serial analogs inputs

S2n60	Preselection of sensor type, Channel determination to Ser2	0 .. 4	0: direct input, send without request, e.g. RPT. It may only occur once and not in connection with other types. (This parameter replaces the previous command -3 for sensor port.) 1: PDP, differential input 2: PDP, static input 3: DTM, absolute pressure 4: Meriam 1500	
S2n61	RS485 address	0 .. 99	RS485 address of the serial sensor	
S2n62	Read linearization data from sensor (only PDP)	0...1 [0]	0: inactive 1: active	

Table 22. Extended parameter set for serial analogs inputs

9.7.15 Extended parameters set for R parameter as inputs

S2n70	Number of the R parameter	0..2999	To generate the number of the R parameter, which is read, with the value for the input.	

Table 23. Extended parameters set for R parameter as inputs

9.7.16 Extended parameter set for integrated counter inputs

S2n80	Number of the integrated frequency input	0 .. 9	Has access to the input named FQnn in the configuration (nn corresponds with the number of the frequency input).	
S2n81	Prescaler value	1 .. 8	Exponent for the base 2 of the prescaler value (see documentation of the T500 and T510 cards). 1: Prescaler 2 2: Prescaler 4 3: Prescaler 8 4: Prescaler 16 5: Prescaler 32 6: Prescaler 64 7: Prescaler 128 8: Prescaler 256	

Table 24. Extended parameter set for integrated counter inputs

Note:
Since any changing of coefficients may result in loosing calibration, it is generally reserved to the manufacturer, that is the TetraTec Instruments GmbH.

Error handling:
If a serial sensor with direct input (i.e. a sensor sending without being requested) is at the same time available with other serial sensors (e.g. PDP) or several sensors with direct serial inputs the program will be stopped until the conflict (danger of bus collisions) is eliminated by changing the parameters. This error and communication errors occurring with the initialization of serial sensors are displayed with a ticker.

Serial sensors can be displayed and zeroed like physical inputs.

9.7.17 S4000-S7000 block: Linearization and type of primary elements

The data of the primary elements follow each other in an interval of 100.

Parameter	Meaning	Values	Explanations	
S4n00	Type of the primary element and type of evaluation	0 .. 1 20 .. 21 40 .. 43 45 .. 49 60 80 100 120 [0]	Type of the primary element and type of evaluation 0: standard LFE 1: uniflow LFE 20:critical nozzle according to PTB 21:critical nozzle according to CFO 40: orifice with drawing pressure by flange 41: orifice with drawing pressure from the corner 42: orifice with D-D/2 drawing of pressure 45: Venturi nozzle 46: Venturi tube, casted rawly 47: Venturi tube, finished 48: Venturi tube, welded 49: SAO nozzle 60: accutube 61: beta flow (Pdif) 62: beta flow (Polynomial above Reynolds number) 80: gas meter 100: direct mass flow input 120: leakage measuring (LMS)	
S4n01	Type of gas with calibration	0 .. 15 [1]	Type of gas with calibration 1: air 2: argon 3: carbon dioxide 4: carbon monoxide 5: helium 6: hydrogen 7: nitrogen 8: oxygen 9: methane 10: propane 11: n butane 12: natural gas H 13: natural gas L 14: laughing gas L 15: water vapour	
S4n02	Calibration pressure	0 .. 1000000 [101325]	Absolute pressure in Pascal	
S4n03	Calibration temperature	0 .. 1000 [294.26]	Temperature in Kelvin	
S4n04	Calibration humidity	0 .. 1 [0.0]	Humidity without dimension	
S4n05	Order polynomial	0 .. 9 [1]	Order of the polynomial	
S4n10	Coefficient order 0	[0.0]	Coefficient a0	
S4n11	Coefficient order 1	[1.0]	Coefficient a1	
S4n12	Coefficient order 2	[0.0]	Coefficient a2	
S4n13	Coefficient order 3	[0.0]	Coefficient a3	
S4n14	Coefficient order 4	[0.0]	Coefficient a4	
S4n15	Coefficient order 5	[0.0]	Coefficient a5	
S4n16	Coefficient order 6	[0.0]	Coefficient a6	
S4n17	Coefficient order 7	[0.0]	Coefficient a7	
S4n18	Coefficient order 8	[0.0]	Coefficient a8	
S4n19	Coefficient order 9	[0.0]	Coefficient a9	

S4n20	X factor	[0.01]	Scaling factor polynomial input value from SI units to polynomial units	
S4n21	Y factor	[60000]	Scaling factor polynomial output value (flow) from polynomial units to SI units	
S4n22	Serial number of the primary element	String(63) [„“]	Readable only.	

Table 25. S4000-S7000 block: linearization and type of primary elements

9.7.18 Extended parameter set for leakage measuring (LMS)

Parameter	Meaning	Values	Explanations	
S4n40	R parameter of pressure drop	0 .. 2999 [110]	Number of the R parameter containing the pressure drop for the leakage measuring.	
S4n41	Test sample volume	-1.0 .. 1.0 [10E-3]	Test sample volume in m^3	
S4n42	Reference leakage	-1.0 .. 1.0 [0.0]	Leakage of the reference leak in m3/s.	
S4n43	Inherent leakage	-1.0 .. 1.0 [0.0]	Inherent leakage of the system in Pa/s.	

Table 26. Extended parameter set for leakage measuring (LMS)

9.7.19 Extended parameter set for critical nozzles

Parameter	Meaning	Values	Explanations	
S4n50	Nozzle characteristic QVtr	0 .. 1 [0.001]	QVtr in m3/s	
S4n51	C* Correction factor for input pressure dependence	[0.0]	C* in 1/Pa	
S4n52	CFO calibration nozzle x Xt factor	[1.0] [°K -> °R]	Input scaling temperature correction	
S4n53	Lower limit input pressure	[0.0]	Pa	
S4n54	Upper limit input pressure	[900000.0]	Pa	

Table 27. Extended parameter set for critical nozzles

9.7.20 Extended parameter set for orifices

Parameter	Meaning	Values	Explanations	
S4n60	Internal tube diameter by operating conditions	[0.1]	Tube diameter in m (SI unit) on orifice input	
S4n61	Diameter of the throttle opening by operating conditions	[0.05]	in m (SI unit)	
S4n62	smallest Reynolds number with interpolation	[2000.0]	Minimum value without dimension of the Reynolds number	
S4n63	biggest Reynolds number with interpolation	[20000000]	Maximum value without dimension of the Reynolds number	

S4n64	Tolerance mass flow: Break-off conditions of the iteration	[0.001]	Break-off conditions of the iteration in kg/s (SI unit)	
S4n65	Calculation method flow coefficient	0 .. 2 [0]	0: Calculation according to DIN 1: Polynomial calculation with differential pressure 2: Polynomial calculation with Reynolds number	

Table 28. Extended parameter set for critical nozzles

9.7.21 Extended parameter set for gas meters

Parameter	Meaning	Values	Explanations	
S4n70	Input channel	0 .. 9 [0]	Channel CTn on counter card	
S4n71	Volume per pulse	[0.001]	in m3	
S4n72	Consider N pulses with continuous measuring	2 .. 250 [2]	Only with counter operation: wait for N start pulses	
S4n73	Timeout	1 .. 86400 [5.0]	The flow is set to 0 in continuous operation, if more time than set here lies between two pulses. With a measuring taking the mean the value set here will be used as a criteria of interruption for the initial pulse.	

Table 29. Extended parameter set for gas meters

9.7.22 Extended parameter set for accutubes

Parameter	Meaning	Values	Explanations	
S4n80	K: average KFlow	[0.6]		
S4n81	Tube diameter Di	[0.1]	in m	
S4n82	Determination temperature for the correction of the thermal expansion	[288.7] (519.67 °R)	in Kelvin	
S4n83	Thermal expansion coefficient of the tube material	[0.0]	in SI	
S4n84	Smallest Reynolds number with Fra interpolation	[2000]	Without dimension Minimum value of the Reynolds number	
S4n85	Highest Reynolds number with Fra interpolation	[20000000]	Without dimension Maximum value of the Reynolds number	
S4n86	Tolerance volume flow: Break-off conditions of the iteration	[0.001]	in m3/s (SI unit) Break-off conditions of the iteration	

Table 30. Extended parameter set for critical nozzles

9.7.23 Extended parameter set for betaflow

Parameter	Meaning	Values	Explanations	
S4n90	Neck diameter Di	[0.1]	in m	
S4n91	Iteration tolerance	[0.001]	in kg/s	
S4n92	Conversion factor for the display of the K factor	[775.428]	Factor, which is multiplied by the K factor based on SI units, before being made available in the R parameters.	

Table 31. Extended parameter set for betaflow

9.7.24 S8000 block: linearization outputs

Parameter	Meaning	Values	Explanations	
S8n00	Type of output	-1, 0	-1: switched off 0: integrated analog output	
S8n01	Type of linearization	-1 .. 0	-1: no linearization 0: polynomial calculation	
S8n05	Linearization output x order	0 .. 9	Order of the polynomial	
S8n10	Linearization output x coefficient order 0		Coefficient order 0 a0	
S8n11	Linearization output x coefficient order 1		Coefficient order 1 a1	
S8n12	Linearization output x coefficient order 2		Coefficient order 2 a2	
S8n13	Linearization output x coefficient order 3		Coefficient order 3 a3	
S8n14	Linearization output x coefficient order 4		Coefficient order 4 a4	
S8n15	Linearization output x coefficient order 5		Coefficient order 5 a5	
S8n16	Linearization output x coefficient order 6		Coefficient order 6 a6	
S8n17	Linearization output x coefficient order 7		Coefficient order 7 a7	
S8n18	Linearization output x coefficient order 8		Coefficient order 8 a8	
S8n19	Linearization output x coefficient order 9		Coefficient order 9 a9	
S8n20	Linearization output x X factor		Scaling factor between sensor raw value and polynomial x value	
S8n21	Linearization output x Y factor		Scaling factor between polynomial y value and polynomial value in SI units	
S8n22	Serial number of the output	String(63)	Readable only	

Table 32. S8000 block: linearization analog outputs

9.7.25 Extended parameter set for integrated analog outputs

Parameter	Meaning	Values	Explanations	
S8n50	Number of the analog port	0 .. 9	Port AOxx in the hardware configuration.	*)

Table 33. Extended parameter set for integrated analog outputs

9.7.26 S9000 block: special functions

Parameter	Meaning	Values	Explanations	
S9000	Measuring time for the system leak test	0.1 .. 259200 [1.0]	(in seconds)	
S9001	Stabilization time before system leak test	0 .. 300 [0.0]	(in seconds)	
S9002	Synchronize measuring.	0 .. 1 [0]	0: not active 1: active The measuring taking the mean is synchronized between the measuring circuits with several measuring circuits.	
	Influence of the synchronization switch S9002: Synchronization not active. Measuring or measuring time starts immediately for all primary elements. However, a gas meter counts from the next pulse at first, i.e., the real measuring time for the gas meter is shortened. Each primary element measures according to the set measuring time, the measuring is terminated completely, if all primary elements are ready. Synchronization active: If gas meters are in the system the measuring does not start prior to one of the gas meters has read the first pulse. The measuring time starts at first and it is used as timeout up to the first pulse. Then the measuring time is reset again and the measuring starts. The complete measuring is finished, if the measuring of all gas meters has been carried out. If measuring times of individual measuring circuits are shorter than this time, then the measuring in these measuring circuits will be already finished before.			
S9003	Reference pressure calculation	0 .. 1 [0]	0: not active 1: active	
S9100	Molar water portion Xv calculate for measuring system of humidity channel	-2 [-2] -1 0..449	-2: off -1: fixed value of S9101 Ry000...Ry449 R parameter humidity channel	
S9101	Fixed value Xv	0 .. 1 [0,01]	Fixed value of the molar water portion Xv	
S9103	Absolute pressure humidity measuring	0 .. 449	Ry000...Ry449 R parameter absolute pressure	
S9105	Temperature humidity measuring	0 .. 449	Ry000...Ry449 R parameter temperature	
S9110	System absolute pressure for measuring programs with relative pressure measuring	-2 [-2] -1 0 ... 19	-2: off -1: fixed value of S9111 0 to 19: sensor of block S20xx - S39xx	
S9111	System absolute pressure Fixed value	0...1.0E06 [1.0E05]	Fixed value in Pascal	

S9112	Display unit for the system absolute pressure Pbas	0...16 [0]	0: pascal [Pa] 1: hectopascal [hPa] 2: kilopascal [kPa] 3: millibar [mbar] 4: bar [bar] 5: at [at] 6: atmosphere [atm] 7: inch mercury at 0℃ [inHG] 8: inch WC at 4℃ [inWS] 9: pounds/in² [lbQI] 10: pounds/ft² [lbWF] 11: mm mercury at 0℃ [mmHG] 12: mm water at 4℃ [mmWS] 13: pounds/in2 [PSI] 14: torr [Torr] 15: mm water at 20℃ [mmWS] 16: inch water at 20℃ [inWS]	
S9113	Pbas decimal places	0 .. 5 [0]	Number of decimal places	
S9200	Correction calculation for volume and mass flow, with standardization to correction default values below	0 .. 4 [0]	0: off 1: speed of sound (T) 2: orifice (tightness) 3: orifice (density, dP) 4: viscosity	
S9201	Test pressure absolute Correction default value	0...1.0E06 [1.0E05]	Test pressure absolute fixed value in Pascal	
S9202	Measuring temperature Correction default value	233.15-333.15 [293.15]	Measuring temperature fixed value in Kelvin	
S9203	Measuring humidity Correction default value	0..1 [0.0]	Measuring humidity fixed value 0.. 0..1	
S9208	Relative pressure Correction default value	- 1.0 ..1.0*E06 [0.0]	Relative pressure fixed value in Pascal	

Table 34. S9000 block: special functions

9.7.27 S9300 block: protocol printout

Protocol printout functions are defined in block S9300. At the end of each mean taking measurement a string with results of the measurement can optionally be issued by one of the available interfaces or be saved in a file.

Parameter	Meaning	Values	Explanations	
S9300	Protocol function after test end	0 .. 8 [0]	0: inactive 1: output by link interface 2: output by terminal interface 3: output by RS485/1 4: output by RS485/2 5: output in file without flush 6: output in file with flush 7: output by network link (active) 8: output by network link (passive)	
	„Active network connection“ means, that the program provides a TCP connection to the remote station defined in S9306/S9307. If errors occur the running for a connection is repeated before each output of a protocol printout string. „Passive network connection“ means, that the program responds to external runnings for connection on the port defined in S9307. The host name in S9006 will be ignored at the same time.			
S9301	Format string #0 with placeholders	STRING(63) [„“]	See below.	
S9302	Format string #1 with placeholders	STRING(63) [„“]	See below.	

S9303	Format string #2 with placeholders	STRING(63) [„“]	See below.	
S9304	Format string #3 with placeholders	STRING(63) [„“]	See below.	
S9305	File name	STRING(63) [“”]	Name of the file which shall be typed into, if S9300 = 5 or 6.	
S9306	Host name	STRING(63) [“”]	Name or IP number of the remote station in the case of output by the network.	
S9307	Port number	1 .. 65535 [54493]	TCP port number in the case of output by the network.	
S9308	List of permitted remote stations	String(63) [„“]	These remote stations are permitted to establish a connection.	
S9309	List of unpermitted remote stations	String(63) [„“]	These remote stations are not permitted to provide a connection.	
S9310	Timeout	0.1 .. 90.0 [1.0]	Timeout for the providing of a connection.	
S9320	Term #0	STRING(63)	Term which is inserted for placeholders in S9301.	
S9321	Term #1	STRING(63)	Term which is inserted for placeholders in S9301.	
S9322	Term #2	STRING(63)	Term which is inserted for placeholders in S9301.	
S9323	Term #3	STRING(63)	Term which is inserted for placeholders in S9301.	
S9324	Term #4	STRING(63)	Term which is inserted for placeholders in S9301.	
S9325	Term #5	STRING(63)	Term which is inserted for placeholders in S9301.	
S9326	Term #6	STRING(63)	Term which is inserted for placeholders in S9301.	
S9327	Term #7	STRING(63)	Term which is inserted for placeholders in S9301.	
S9328	Term #8	STRING(63)	Term which is inserted for placeholders in S9301.	
S9329	Term #9	STRING(63)	Term which is inserted for placeholders in S9301.	

Table 35. S9300 block: protocol printout

Further information

- For restriction of access see chapter 5.2.5
- Syntax of format strings see chapter 6.2
- Syntax of the control expressions see chapter 6.3

9.7.28 S9500 block: definition of connection for virtual inputs and outputs

The system can provide the result of the terms defined in block S130X by a network connection. Virtual inputs are also provided by this network connection which can be queried in terms with the integrated function NI(). The following block specifies the connection parameters for the network connection

Parameter	Meaning	Values	Explanations	
S9500	TCP port	0 .. 65535	Number of the TCP port on which the controller waits for incoming connections. A value of 0 turns off the feature.	
S9501	List of permitted remote stations	String(63) [„“]	These remote stations are permitted to establish a connection.	
S9502	List of unpermitted remote stations	String(63) [„“]	These remote stations are not permitted to provide a connection.	
S9505	Timeout for virtual inputs	0 .. 86400	Value in seconds. If no input is received for a longer period of time than the one to be set the system will terminate the connection. A value of 0 turns off the timeout.	
S9506	Timeout for virtual outputs	0 .. 86400	Value in seconds. If no output value is provided for a longer period of time than the one to be set, because there are no changes, the sending will be forced. A value of 0 turns off the timeout.	
S9507	Format of the output	String(63) [„NO %Xh\r\n“]	A string, which indicates in what format the output data will be sent.	

Table 36. S9500 block: definition of connection for virtual outputs

Further information

- For restriction of access see chapter 5.2.5
- Description of the virtual inputs and outputs see chapter 5.4
- Syntax of format strings see chapter 6.2

9.8 P parameter: measuring program definitions

9.8.1 Px000 block: primary element, basic description

Parameter	**Meaning**	**Range of values**	**Explanations**	
Px000	Number primary element	-10 . -1 0 ... 39 40 ... 139 [0]	-10 . -1 nozzle combinations of Cxxxx 0 ... 39 flow element of S40xx-S70xx 40 ... 139 flow element of E00xx-E99xx	
Px001	Gas by primary element	-9 .. 0 1 .. 15 [1]	-9: gas mixture 9 (see M09xx) ... -1: gas mixture 1 (see M01xx) 0: gas mixture 0 (see M00xx) 1: air 2: argon 3: carbon dioxide 4: carbon monoxide 5: helium 6: hydrogen 7: nitrogen 8: oxygen 9: methane 10: propane 11: n butane 12: natural gas H 13: natural gas L 14: laughing gas 15: water vapour	
Px003	Tightness calculations	0 .. 2 [1]	0: ideal (ideal gas law) 1: real, virial coefficient calculation 2: real, BIPM recommendation (air only)	**)
Px004	Viscosity calculations	0 .. 1 [1]	0: ideal, Daubert & Danner 1: real, Kestin-Whitelaw (air only)	

*) optionally available, **) virial coefficient calculation for natural gas not supported

Table 37. Px000 block: primary element, basic description

9.8.2 Px010 block: primary measured variable

Parameter	**Meaning**	**Range of values**	**Explanations**	
Px010	Sensor / channel no. Primary measured variable	-1 0 ... 19 [0]	-1: fixed value of Px011 0 to 19: sensor of block S20xx - S39xx	
Px011	Fixed value	+/- 10000 [0]	Fixed value for sensor in SI units	
Px012	Display unit	0 .. 14 [1]	Display unit Depending on type of measured variable	
Px013	Display decimal places	0 .. 5 [2]	Display decimal places Number of decimal places	
Px014	Compensation of the primary measured variable by static pressure	+/- 100 [0]	Offset pressure correction in Pa/bar with regard of standard condition absolute pressure (S0101)	*)

*) Correction of the dependence of the differential pressure sensor of static pressure (measured by Pabs).

Table 38. Px010 block: primary measured variable, e.g. differential pressure

9.8.3 Px020 block: test pressure absolute (Pabs)

Parameter	**Meaning**	**Range of values**	**Explanations**	
Px020	Sensor / channel no. Test pressure absolute	-3, -2, -1 0 ... 19 [1]	-3: system absolute pressure -2: ignore input -1: fixed value of Px021 0 to 19: sensor of block S20xx - S39xx	
Px021	Fixed value	0...1.0*E06 [1.0E05]	Fixed value for sensor in SI units (Pascal)	
Px022	Display unit	0 .. 16 [1]	0: pascal [Pa] 1: hectopascal [hPa] 2: kilopascal [kPa] 3: millibar [mbar] 4: bar [bar] 5: at [at] 6: atmosphere [atm] 7: inch mercury at 0°C [inHG] 8: inch WC at 4°C [inWS] 9: pounds/in² [lbQI] 10: pounds/ft² [lbWF] 11: mm mercury at 0°C [mmHG] 12: mm water at 4°C [mmWS] 13: pounds/in2 [PSI] 14: torr [Torr] 15: mm water at 20°C [mmWS] 16: inch water at 20°C [inWS]	
Px023	Display decimal places	0 .. 5 [1]	Number of decimal places	
Px024	Correction	String(63) [„“]	Term, by which the test pressure can be corrected. It is possible to have access on the uncorrected test pressure included in the term by the variable THIS.	

Table 39. Px020 block: test pressure absolute

Example for Px024:
It is presumed that the test pressure is measured by a gauge pressure sensor, but for further calculations it will be needed as absolute pressure. Then the following settings will be required:
(exemplarily for program 0, space characters are to be disregarded)
S9110: Selection absolute pressure sensor (Pbas)
P0020: Selection gauge pressure sensor (Prel)

P0024="THIS + RPAR(0)"

Further information:
- For parameter S9110 see section 9.7.26
- For the allocation of the sensors see section 9.7.12
- For the function RPAR() see section 6.3.3
- For the available R parameters see section 9.10

9.8.4 Px030 block: measuring temperature (Tem)

Parameter	**Meaning**	**Range of values**	**Explanations**	
Px030	Sensor / channel no. Measuring temperature	-2 [2] -1 0 ... 19	-2: ignore input -1: fixed value of Px031 0 to 19: sensor of block S20xx - S39xx	
Fixed value of Px031	Fixed value	233.15-573.15 [293.15]	Fixed value for sensor in SI units (Kelvin)	
Px032	Display unit	0 .. 4 [1]	0: Kelvin [K] 1: Celsius 2: Fahrenheit 3: Rankine	
Px033	Display decimal places	0 .. 5 [1]	Number of decimal places	
Px034	Correction	String(63) [„“]	Term, by which the measuring temperature can be corrected. It is possible to have access on the uncorrected measuring temperature included in the term by the variable THIS.	

Table 40. Px030 block: measuring temperature

9.8.5 Px040 block: measuring humidity (Hum)

Parameter	**Meaning**	**Range of values**	**Explanations**	
Px040	Sensor / channel no. Measuring humidity	-3, -2, -1 0 ... 19 [3]	-3: calculate humidity of system Xv -2: ignore input -1: fixed value of Px041 0 to 19: sensor of block S20xx - S39xx	
Px041	Fixed value	0..1 [0.0]	Fixed value for sensor in SI (without dimension)	
Px042	Display unit	0 .. 1 [1]	0: 0..1 1: 0..100% r.F.	
Px043	Display decimal places	0 .. 5 [1]	Number of decimal places	
Px044	Correction	String(63) [„“]	Term, by which the measurement humidity can be corrected. It is possible to have access on the uncorrected measurement humidity included in the term by the variable THIS.	

Table 41. Px040 block: measuring humidity

9.8.6 Px050 block: reference pressure absolute (PabsB)

Parameter	**Meaning**	**Range of values**	**Explanations**	
Px050	Sensor / channel no. Reference pressure absolute	-2 -1 0 .. 19 [-2]	-2: ignore input -1: fixed value of Px051 0 to 19: sensor of block S20xx - S39xx	
Px051	Fixed value	0 .. 1.0E06 [1.0E05]	Fixed value for sensor in SI units (Pascal)	

Px052	Display unit	0...16 [1]	0: pascal [Pa] 1: hectopascal [hPa] 2: kilopascal [kPa] 3: millibar [mbar] 4: bar [bar] 5: at [at] 6: atmosphere [atm] 7: inch mercury at 0℃ [inHG] 8: inch WC at 4℃ [inWS] 9: pounds/in² [lbQI] 10: pounds/ft² [lbWF] 11: mm mercury at 0℃ [mmHG] 12: mm water at 4℃ [mmWS] 13: pounds/in2 [PSI] 14: torr [Torr] 15: mm water at 20℃ [mmWS] 16: inch water at 20℃ [inWS]	
Px053	Display decimal places	0 .. 5 [1]	Number of decimal places	
Px054	Correction	String(63) [„“]	Term, by which the reference pressure can be corrected. It is possible to have access on the uncorrected reference pressure included in the term by the variable THIS.	

Table 42. Px050 block: reference pressure absolute

Note
The display units and the decimal places correspond with the settings for the absolute test pressure (Px020). Compare also with parameter S9003.

9.8.7 Px060 block: reference temperature (TemB)

Parameter	Meaning	Range of values	Explanations	
Px060	Sensor / channel no. Reference temperature	-2 -1 0 .. 19 [-2]	-2: ignore input -1: fixed value of Px061 0 to 19: sensor of block S20xx - S39xx	
Px061	Fixed value	233.15 .. 333.15 [293.15]	Fixed value for sensor in SI units (Kelvin)	
Px062	Display unit	0 .. 4 [1]	0: Kelvin [K] 1: Celsius 2: Fahrenheit 3: Rankine	
Px063	Display decimal places	0 .. 5 [1]	Number of decimal places	
Px064	Correction	String(63) [„“]	Term, by which the reference temperature can be corrected. It is possible to have access on the uncorrected reference temperature included in the term by the variable THIS.	

Table 43. Px060 block: reference temperature

Note
The display units and the decimal places correspond with the settings for the measuring temperature (Px030). Compare also with parameter S9003.

9.8.8 Px070 block: reference humidity (HumB)

Parameter	Meaning	Range of values	Explanations	
Px070	Sensor / channel no. Reference humidity	-3, -2, -1 0 .. 19 [-2]	-3: calculate humidity of system Xv -2: ignore input -1: fixed value of Px071 0 to 19: sensor of block S20xx - S39xx	
Px071	Fixed value	0 .. 1 [0.0]	Fixed value for sensor in SI units (without dimension)	
Px072	Display unit	0 .. 1 [1]	0: 0..1 1: 0..100% r.F.	
Px073	Display decimal places	0 .. 5 [1]	Number of decimal places	
Px074	Correction	String(63) [„“]	Term, by which the reference humidity can be corrected. It is possible to have access on the uncorrected reference humidity included in the term by the variable THIS.	

Table 44. Px070 block: reference humidity

Note
The display units and the decimal places correspond with the settings for the measurement humidity (Px040). Compare also with parameter S9003.

9.8.9 Px075 block: auxiliary input 0 (Aux0)

Parameter	**Meaning**	**Range of values**	**Explanations**	
Px075	Sensor / channel no. Relative pressure	-2 [-2] -1 0 .. 19	-2: ignore input -1: fixed value of Px081 0 to 19: sensor of block S20xx - S39xx	*)
Px076	Fixed value	- 1.0.. 1.0E06	Fixed value for sensor in SI units	*)
Px077	Display unit	0 .. 16 [1]	0: pascal [Pa] 1: hectopascal [hPa] 2: kilopascal [kPa] 3: millibar [mbar] 4: bar [bar] 5: at [at] 6: atmosphere [atm] 7: inch mercury at 0℃ [inHG] 8: inch WC at 4℃ [inWS] 9: pounds/in² [lbQI] 10: pounds/ft² [lbWF] 11: mm mercury at 0℃ [mmHG] 12: mm water at 4℃ [mmWS] 13: pounds/in2 [PSI] 14: torr [Torr] 15: mm water at 20℃ [mmWS] 16: inch water at 20℃ [inWS]	*)
Px078	Display decimal places	0 .. 5 [1]	Number of decimal places	*)
Px079	Correction	String(63) [„“]	Term, by which the auxiliary input can be corrected. It is possible to have access on the uncorrected input value included in the term by the variable THIS.	

Table 45. Px075 block: auxiliary input 0 (Aux0)

9.8.10 Px080 block: auxiliary input 1 (Aux1)

Parameter	Meaning	Range of values	Explanations	
Px080	Sensor / channel no. Relative pressure	-2 [-2] -1 0 .. 19	-2: ignore input -1: fixed value of Px081 0 to 19: sensor of block S20xx - S39xx	*)
Px081	Fixed value	-1.0.. 1.0*E06	Fixed value for sensor in SI units	*)
Px082	Display unit	0 .. 16 [1]	0: pascal [Pa] 1: hectopascal [hPa] 2: kilopascal [kPa] 3: millibar [mbar] 4: bar [bar] 5: at [at] 6: atmosphere [atm] 7: inch mercury at 0℃ [inHG] 8: inch WC at 4℃ [inWS] 9: pounds/in² [lbQI] 10: pounds/ft² [lbWF] 11: mm mercury at 0℃ [mmHG] 12: mm water at 4℃ [mmWS] 13: pounds/in2 [PSI] 14: torr [Torr] 15: mm water at 20℃ [mmWS] 16: inch water at 20℃ [inWS]	*)
Px083	Display decimal places	0 .. 5 [1]	Number of decimal places	*)
Px084	Correction	String(63) [„“]	Term, by which the auxiliary input can be corrected. It is possible to have access on the uncorrected input value included in the term by the variable THIS.	

Table 46. Px080 block: auxiliary input 1 (Aux1)

9.8.11 Px085 block: auxiliary input 2 (Aux2)

Parameter	Meaning	Range of values	Explanations	
Px085	Sensor / channel no. Relative pressure 3	-2 [-2] -1 0 .. 19	-2: ignore input -1: fixed value of Px086 0 to 19: sensor of block S20xx - S39xx	*)
Px086	Fixed value t	-1.0.. 1.0*E06	Fixed value for sensor in SI units	*)
Px087	Display unit	0 .. 16 [1]	0: pascal [Pa] 1: hectopascal [hPa] 2: kilopascal [kPa] 3: millibar [mbar] 4: bar [bar] 5: at [at] 6: atmosphere [atm] 7: inch mercury at 0℃ [inHG] 8: inch WC at 4℃ [inWS] 9: pounds/in² [lbQI] 10: pounds/ft² [lbWF] 11: mm mercury at 0℃ [mmHG] 12: mm water at 4℃ [mmWS] 13: pounds/in2 [PSI] 14: torr [Torr] 15: mm water at 20℃ [mmWS] 16: inch water at 20℃ [inWS]	*)
Px088	Display decimal places	0 .. 5 [1]	Number of decimal places	*)
Px089	Correction	String(63) [„“]	Term, by which the auxiliary input can be corrected. It is possible to have access on the uncorrected input value included in the term by the variable THIS.	

Table 47. Px085 block: auxiliary input 2 (Aux2)

9.8.12 Px090 block: auxiliary input 3 (Aux3)

Parameter	Meaning	Range of values	Explanations	
Px090	Sensor / channel no. Relative pressure	-2 [-2] -1 0 .. 19	-2: ignore input -1: fixed value of Px091 0 to 19: sensor of block S20xx - S39xx	*)
Px091	Fixed value	-1.0.. 1.0*E06	Fixed value for sensor in SI units	*)
Px092	Display unit	0 .. 16 [1]	0: pascal [Pa] 1: hectopascal [hPa] 2: kilopascal [kPa] 3: millibar [mbar] 4: bar [bar] 5: at [at] 6: atmosphere [atm] 7: inch mercury at 0℃ [inHG] 8: inch WC at 4℃ [inWS] 9: pounds/in² [lbQI] 10: pounds/ft² [lbWF] 11: mm mercury at 0℃ [mmHG] 12: mm water at 4℃ [mmWS] 13: pounds/in2 [PSI] 14: torr [Torr] 15: mm water at 20℃ [mmWS] 16: inch water at 20℃ [inWS]	*)
Px093	Display decimal places	0 .. 5 [1]	Number of decimal places	*)
Px094	Correction	String(63) [„“]	Term, by which the auxiliary input can be corrected. It is possible to have access on the uncorrected input value included in the term by the variable THIS.	

Table 48. Px090 block: auxiliary input 3 (Aux3)

9.8.13 Px095 block: auxiliary input 4 (Aux4)

Parameter	Meaning	Range of values	Explanations	
Px095	Sensor / channel no. Relative pressure 4	-2 [-2] -1 0 .. 19	-2: ignore input -1: fixed value of Px096 0 to 19: sensor of block S20xx - S39xx	*)
Px096	Fixed value	-1.0.. 1.0*E06	Fixed value for sensor in SI units	*)
Px097	Display unit	0 .. 16 [1]	0: pascal [Pa] 1: hectopascal [hPa] 2: kilopascal [kPa] 3: millibar [mbar] 4: bar [bar] 5: at [at] 6: atmosphere [atm] 7: inch mercury at 0℃ [inHG] 8: inch WC at 4℃ [inWS] 9: pounds/in² [lbQI] 10: pounds/ft² [lbWF] 11: mm mercury at 0℃ [mmHG] 12: mm water at 4℃ [mmWS] 13: pounds/in2 [PSI] 14: torr [Torr] 15: mm water at 20℃ [mmWS] 16: inch water at 20℃ [inWS]	*)
Px098	Display decimal places	0 .. 5 [1]	Number of decimal places	*)
Px099	Correction	String(63) [„“]	Term, by which the auxiliary input can be corrected. It is possible to have access on the uncorrected input value included in the term by the variable THIS.	

Table 49. Px095 block: auxiliary input 4 (Aux4)

9.8.14 Px100 block: volume flows/ frequencies

Parameter	Meaning	Range of values	Explanations	
Px101	Measuring volume flow, Display unit	0 .. 14 [4]	0: m3/sec [m3/s] 1: m3/min [m3/m] 2: m3/hour [m3/h] 3: liters/sec [L/s] 4: liters/min [L/m] 5: liters/hour [L/h] 6: cm3/sec [cm3s] 7: cm3/min [cm3m] 8: cm3/hour [cm3h] 9: ft3/sec [CFPS] 10: ft3/min [CFDM] 11: ft3/hour [ACFH] 12: inch3/sec [CIPS] 13: inch3/min [CIPM] 14: inch3/h [CIPH]	
Px102	Measuring volume flow Display decimal places	0 .. 5 [2]	Number of decimal places	

Px103	Measuring volume complete, Display unit	0 .. 4 [1]	0: m3 [m3] 1: liter [Lit.] 2: cm3 [cm3] 3: ft3 [CF] 4: inch3 [CI]	
Px104	Measuring volume complete Display decimal places	0 .. 5 [1]	Number of decimal places	
Px105	Standard volume flow, Display unit	0 .. 14 [4]	0 - 14 as Px101 9 - 14: [SCFS] etc.	
Px106	Standard volume flow Display decimal places	0 .. 5 [2]	Number of decimal places	
Px107	Standard volume complete, Display unit	0 .. 4 [1]	as Px103	
Px108	Standard volume complete Display decimal places	0 .. 5 [1]	Number of decimal places	
Px109	Reference volume flow, Display unit	0 .. 14 [4]	0 - 14 as Px101	
Px110	Reference volume flow Display decimal places	0 .. 5 [2]	Number of decimal places	
Px111	Reference volume complete Display unit	0 .. 4 [1]	0 - 4 as Px103	
Px112	Reference volume complete Display decimal places	0 .. 5 [1]	Number of decimal places	
Px115	Frequency, unit	0 .. 4 [0]	0: Hz 1: kHz 2: MHz 3: 1/min 4: 1/h	
Px116	Frequency Display decimal places	0 .. 5 [1]	Number of decimal places	

Table 50. Px100 block: volume flows/frequencies

9.8.15 Px120 block: mass flow

Parameter	Meaning	Range of values	Explanations	
Px121	Mass flow, display unit	0 .. 10 [4]	0: kg/sec [kg/s] 1: kg/min [kg/m] 2: kg/hour [kg/h] 3: g/sec [g/s] 4: g/min [g/m] 5: g/hour [g/h] 6: lb/sec [LBPS] 7: lb/min [LBPM] 8: lb/hour [LBPH]	
Px122	Mass flow, display decimal places	0 .. 5 [1]	Number of decimal places	

Px123	Mass complete, display unit	0 .. 2 [1]	0: kg [kg] 1: g [g] 2: lb [lb] 3: t [t]	
Px124	Mass complete, display decimal places	0 .. 5 [1]	Number of decimal places	

Table 51. Px120 block: mass flow

9.8.16 Px130 block: heating capacity

Parameter	Meaning	Range of values	Explanations	
Px131	Heating capacity, unit	0 .. 6 [0]	0: Watt [W] 1: kW [kW] 2: MW [MW] 3: cal/sec [c/s] 4: kcal/hour [kc/h] 5: BTU/min [btum] 6: BTU/hour [btuh]	
Px132	Heating capacity, display decimal places	0 .. 5 [1]	Number of decimal places	
Px133	Heat flow volume	0 .. 7 [0]	0: Joule [J] 1: Ws [Ws] 2: Wh [Wh] 3: kWh [kWh] 4: MWh [MWh] 5: cal [c] 6: kcal [kcal] 7: btu [btu]	
Px134	Heat flow volume, Display decimal places	0 .. 5 [1]	Number of decimal places	

Table 52. Px130 block: heating capacity

9.8.17 Px140 block: density

Parameter	Meaning	Range of values	Explanations	
Px141	Density, display unit	0 .. 3 [0]	0: Kg/m3 [kgm3] 1: g/m3 [g/m3] 2: lb/cubic foot [lbcf] 3: lb/cubic inch [lbph]	
Px142	Density, display decimal places	0 .. 5 [3]	Number of decimal places	

Table 53. Px140 block: density

Note: The configuration selected by Px141 and Px142 is valid for all types of density able to be displayed: measuring density, standard density, reference density and calibration density

9.8.18 Px160 block: viscosity

Parameter	**Meaning**	**Range of values**	**Explanations**	
Px161	Viscosity, display unit	0 .. 1 [1]	0: pascalsec. [Pa*s] 1: micropoises [uPoi] 2: centipoises [cPoi] 3: lb/(inch*sec) [lbis]	
Px162	Viscosity, display decimal places	0 .. 5 [2]	Number of decimal places	

Table 54. Px160 block: viscosity

Note
The configuration selected by Px161 and Px162 is valid for all types of viscosity able to be displayed: measuring viscosity, standard viscosity, reference viscosity and calibration viscosity.

9.8.19 Px180 block: speed

Parameter	**Meaning**	**Range of values**	**Explanations**	
Px181	Speed, display unit	0 .. 4 [0]	0: meter per second 1: kilometer per hour 2: feet per second 3: knots 4: miles per hour	
Px182	Speed, display decimal places	0 .. 5 [2]	Number of decimal places	

Table 55. Px180 block: speed

Note
The configuration selected by Px181 and Px182 is valid for all speeds able to be displayed.

9.8.20 Px190 block: pressure drop

Parameter	**Meaning**	**Range of values**	**Explanations**	
Px191	Pressure drop, display unit	0 .. 11 [0]	0: pascal/sec. 1: pascal/Min. 2: pascal/h 3: millibar/sec 4: millibar/min 5: millibar/hour 6: bar/sec 7: bar/min 8: bar/hour 9: pounds / (inch2*sec) 10: pounds / (inch2*min) 11: pounds / (inch2*hour)	
Px192	Pressure drop, display decimal places	0 .. 5 [0]	Number of decimal places	

Px193	Pressure drop Pdif, Display unit	0 .. 11 [0]	0: pascal/sec. 1: pascal/min. 2: pascal/h 3: millibar/sec 4: millibar/min 5: millibar/hour 6: bar/sec 7: bar/min 8: bar/hour 9: pounds / (inch2*sec) 10: pounds / (inch2*min) 11: Pounds / (inch2*hour)	
Px194	Pressure drop Pdif, display decimal places	0 .. 5 [0]	Number of decimal places	

Table 56. Px190 block: pressure drop

Note
The configuration selected by Px191 and Px192 is valid for all pressure drops able to be displayed, with the exception of pressure drop Pdif.

9.8.21 Px300 block: ratio formation

Parameter	Meaning	Range of values	Explanations	
Px300	Type of calculation	0 .. 4 [0]	0: switched off 1: ratio - Px301 / Px302 2: product – Px301 * px302 3: sum – Px301 + Px302 4: difference – Px301 – Px302 The intended operation will be carried out with the absolute numerical values of the R parameters indicated below. The result is available in the R parameter Ry050. The denominator of the division must not be 0.	
Px301	Number of the R parameter for the ratio formation	0 .. 2999 [30]	Number of the first R parameter for one of the operations indicated above.	
Px302	Number of the R parameter for the ratio formation	0 .. 2999 [30]	Number of the second R parameter for one of the operations indicated above.	
Px303	Magnitude of the result of the ratio formation	0 .. 21 [10]	0: pressure 1: volume flow 2: mass flow 3: density 4: viscosity 5: temperature 6: change of pressure per time 7: time 8: volume 9: mass 10: without unit 11: voltage 12: current 13: electric resistance 14: length 15: speed 16: acceleration 17: unused 18: power 19: energy, work 20: power, heating capacity 21: frequency	
Px304	Unit of the result of the ratio formation	0 .. 16 [0]	The meaning is different, according to the magnitude in Px303. The value 0 always corresponds with the SI unit of the respective magnitude.	
Px305	Result, display decimal places	0 .. 5 [2]	Number of decimal places.	

Table 57. Px300 block: ratio formation

9.8.22 <u>Px310 block: functions</u>

Parameter	**Meaning**	**Range of values**	**Explanations**	
Px310	Type of function	0 .. 1 [0]	0: switched off 1: straight line of regression	
Px311	Minimum time	0.02 .. 3600.0 [5.0]	Shortest time providing valid values.	
Px312	Maximum time	0.02 .. 3600.0 [10.0]	Maximum time for which the function is used for.	
Px313	Input value of the function	0 .. 2999 [1]	Number of the R parameter building the X value of the function.	
Px320	Magnitude of the first function result	0 .. 21 [10]	0: pressure 1: volume flow 2: mass flow 3: density 4: viscosity 5: temperature 6: change of pressure per time 7: time 8: volume 9: mass 10: without unit 11: voltage 12: current 13: electric resistance 14: length 15: speed 16: acceleration 17: unused 18: power 19: energy, work 20: power, heating capacity 21: frequency	
Px321	Unit of the first function result	0 .. 16 [0]	The meaning is different, depending on magnitude. The value 0 always corresponds with the SI unit of the respective magnitude.	
Px322	Number of decimal places for the first function result	0 .. 5 [2]		

Px325	Magnitude of the second function result	0 .. 21 [10]	0: pressure 1: volume flow 2: mass flow 3: density 4: viscosity 5: temperature 6: change of pressure per time 7: time 8: volume 9: mass 10: without unit 11: voltage 12: current 13: electric resistance 14: length 15: speed 16: acceleration 17: unused 18: power 19: energy, work 20: power, heating capacity 21: frequency	
Px326	Unit of the second function result	0 .. 16 [0]	The meaning is different, depending on magnitude. The value 0 always corresponds with the SI unit of the respective magnitude.	
Px327	Number of decimal places for the second function result	0 .. 5 [2]		
Px330	Magnitude of the third function result	0 .. 21 [10]	0: pressure 1: volume flow 2: mass flow 3: density 4: viscosity 5: temperature 6: change of pressure per time 7: time 8: volume 9: mass 10: without unit 11: voltage 12: current 13: electric resistance 14: length 15: speed 16: acceleration 17: unused 18: power 19: energy, work 20: power, heating capacity 21: frequency	

Px331	Unit of the third function result	0 .. 16 [0]	The meaning is different, depending on magnitude. The value 0 always corresponds with the SI unit of the respective magnitude.	
Px332	Number of decimal places for the third function result	0 .. 5 [2]		

Table 58. Px310 block: functions

The results of the function will be written in the R parameters R110, R111 and R112

9.8.23 Px350 block: calculated R parameters

The values in block Px350 are used to allocate calculated values depending on the program to the R parameters. These values can be used, e.g., with the ratio formation to show the deviation of a measurement value and a fixed value, to issue fixed values to analog outputs, or to carry out conversions to other units.

Parameter	Meaning	Range of values	Explanations	
Px350	Calculated R parameter #0	String(63) [„“]	Will be written to Ry100.	
Px351	Magnitude for calculated R parameter #0	0 .. 21 [10]	0: pressure 1: volume flow 2: mass flow 3: density 4: viscosity 5: temperature 6: change of pressure per time 7: time 8: volume 9: mass 10: without unit 11: voltage 12: current 13: electric resistance 14: length 15: speed 16: acceleration 17: unused 18: power 19: energy, work 20: power, heating capacity 21: frequency	
Px352	Unit for calculated R parameter #0	0 .. 16 [0]	The meaning is different, depending on magnitude. The value 0 always corresponds with the SI unit of the respective magnitude.	
Px353	Number of decimal places for calculated R parameter #0	0 .. 5 [2]		
Px360	Calculated R parameter #1	String(63) [„“]	Is written according to Ry101.	

Px361	Magnitude for calculated R parameter #1	0 .. 21 [10]	0: pressure 1: volume flow 2: mass flow 3: density 4: viscosity 5: temperature 6: change of pressure per time 7: time 8: volume 9: mass 10: without unit 11: voltage 12: current 13: electric resistance 14: length 15: speed 16: acceleration 17: unused 18: power 19: energy, work 20: power, heating capacity 21: frequency	
Px362	Unit for calculated R parameter #1	0 .. 16 [0]	The meaning is different, depending on magnitude. The value 0 always corresponds with the SI unit of the respective magnitude.	
Px363	Number of decimal places for calculated R parameter #1	0 .. 5 [2]		

Table 59. Px350 block: calculated R parameters

Further information

- Syntax of the control expressions see chapter 6.3.

9.8.24 Px400 and Px450 blocks: control

Two controllers are available for each program. For this purpose always one parameter block is available with Px400, and a second one with Px450. In the cycle the first controller (with Px400) and then the second one (with Px450) is calculated at first. This sequence has to be considered in the case of cascading the controllers. In this case the first controller should be used as an outside controller and the second one as an inside controller.

Both integrated PID controllers can be configured as controllers for all magnitudes measured or calculated by the LaminarMaster (e.g., pressures or volume flows).
The scaling and definition of the analog output for the issue of the control variable is done in the block Px900 (analog outputs).

Each controller can be configured as a P, PI or PIDT1 controller. The control variable, i.e. the controller output, is linked with an analog output (see Px900 block). An arbitrary measured variable or operand can be defined as a control variable from the Ry000 block.
The following table indicates parameters for the configuration of the controller. The determination of the controller parameters (Px402-Px405) can be done, for example, according to the setting regulations of *Ziegler - Nichols* (see below).

For this purpose the controller will be defined as a mere P controller at first (TI = 0, TD = 0) [see also table adjustment parameter control]. Then the loop gain KR is set to a value which results in a stable cycle of the actual value, i.e., the controlled variable. This value for KR is indicated as Kkrit. The cycle duration of the cycle (Tkrit.) should be measured by recorder or oscilloscope.

Using the values for Kkrit. and Tkrit. the controller parameters can be defined then according to the following table.
These values must be entered then as values for the parameters Px403 - Px405.

Adjustment rules for PID controllers according to Ziegler, Nichols:

Controller	KR	TI	TD
P	**0,5 * Kkrit**		
PI	**0,45 * Kkrit**	**0,85 * Tkrit**	
PID	**0,6 * Kkrit**	**0,5 * Tkrit**	**0,12 * Tkrit**

Parameter	Meaning	Range of values	Explanations	
Px400 (Px450 ff.)	Control mode	0 .. 2	0: control off 1: manual control 2: automatic control	
Px401	Hotedit on/off	0 .. 1	0: changing of the controller parameters in the controller menu only with manual operation. 1: changing of the controller parameters in the controller menu even with running controller.	
Px402	Control time constant (T1)	0,02 .. 10 [0,02]	Delay time for the D portion in seconds. For discretizational reasons T1 must be as long as the cycle time at least. In this case the controller is all but an ideal PID controller.	
Px403	Control differential portion (TD)		D portion of the controller in seconds. If TD=0, then no D proportion, i.e. Px402 without effect (PI controller)	

Px404	Control integral portion (TI)		I portion of the controller in seconds. If TI =0 (corresponds to ∞ !), the no I portion and no D portion, i.e. Px402 and Px403 without effect (P controller)	
Px405	Loop gain (KR)		P portion of the controller, without dimension, as floating point figure	
Px406	Restriction of control variable lower limit		floating point figure without dimension.	
Px407	Restriction of control variable upper limit		floating point figure without dimension.	
Px411	Controlled variable, actual value	y000-y999	Allocation to R parameter	
Px412	Characteristics with actual value errors	0 .. 1 [0]	0: display of the corresponding error message 1: error message "noCalc" is eliminated and the value determined in Px413 is used as actual value. Other errors are treated unchanged. E.g. for gas meters, which require a minimum number of counts for their evaluation.	
Px413	Default actual value		See explanation for Px412=1	
Px416	Reset behaviour	0 .. 1	0: Last output value 1: Use fixed value of Px417	
Px417	Output value after reset	.. 1.0 [0.0]	If Px416 = 1, then this output value is used after reset.	
Px418	Control variable scaling setpoint control, Minimum value 0% Addition to controller output		(in SI unit of the actual value) Add no setpoint portion to control variable up to this value (only if Px420=1)	
Px419	Control variable: Scaling setpoint guide, maximum value 100% addition to controller output		(in SI unit of the actual value) Add 100% setpoint portion to control variable starting from this value (only if Px420=1)	
Px420	Setpoint addition on/off	0 .. 1	0: off 1: on. The setpoint addition causes the pilot control of the control variable in dependence of the setpoint, and it reduces settling times.	
Px421	Setpoint / channel no.	-1 0 .. 2999	-1: setpoint fixed value of Px422 0 to 2999: number of a R parameter	
Px422	Setpoint controller Fixed value default	0 ..	Setpoint fixed value of the controller in SI units of the actual value, see Px411 or the corresponding R parameter.	
Px423	Setpoint ramp		Speed of increase absolute in SI units of the control variable per second	
Px424	Setpoint ramp, initial value		in SI units of the control variable	
Px425	Setpoint guide ramp	-1 .. 0 .. 1	-1: use, starting value according to Px424 0: not used 1: use, start value = current value	
Px430	Linearization of the output	0 .. 2 [0]	0: Linearization off 1: Rotary slave servo valve 3/4: KV = 0.428 2: Rotary slave servo valve 3/6: KV = 0.672	
Px435	Interference of the output signal with a jitter configured in Px436 and Px437.	0 .. 1	0: inactive 1: active	

Px436	Maximum setpoint/actual value difference for jitter.	0..1E30	The jitter signal is only active, if the reference/actual difference is less than the value set here.	
Px437	Jitter amplitude.	0..1E30	The output signal is increased or decreased in each cycle by the half of the amplitude set here.	
Px441	Control variable, display unit	0 .. 1	0: absolute (0,0...1,0) 1: percent (0 - 100,0%)	
Px442	Control variable, decimal places	0 .. 5	Number of decimal places	

Table 60. Px400 block: control

9.8.25 Px500 block: limit values

Parameter	Meaning	Range of values	Explanations	
Px500	Type of rating	0 .. 2	0: switched off (always good). 1: evaluate after termination of test. 2: evaluate continuously.	
Px501	Magnitude to be controlled	0 .. 2999	Number of the R parameter to be evaluated.	
Px502	Lower limit	-1E38 .. 1E38	Lower limit value in SI units	
Px503	Upper limit	-1E38 .. 1E38	Upper limit value in SI units	
Px504	Override for good rating	String(63)	The term indicated here will be evaluated before each rating. If the result is <> 0, then the result of the individual rating is always „good“. If no term exists, or it is 0, then a normal rating will be carried out.	
Px510	Type of rating	0 .. 2	0: switched off (always good). 1: evaluate after termination of test. 2: evaluate continuously.	
Px511	Magnitude to be controlled	0 .. 2999	Number of the R parameter to be evaluated.	
Px512	Lower limit	-1E38 .. 1E38	Lower limit value in SI units	
Px513	Upper limit	-1E38 .. 1E38	Upper limit value in SI units	
Px514	Override for good rating	String(63)	See Px504.	
Px520	Type of rating	0 .. 2	0: switched off (always good). 1: evaluate after termination of test. 2: evaluate continuously.	
Px521	Magnitude to be controlled	0 .. 2999	Number of the R parameter to be evaluated.	
Px522	Lower limit	-1E38 .. 1E38	Lower limit value in SI units	
Px523	Upper limit	-1E38 .. 1E38	Upper limit value in SI units	
Px524	Override for good rating	String(63)	See Px504.	
Px530	Type of rating	0 .. 2	0: switched off (always good). 1: evaluate after termination of test. 2: evaluate continuously.	
Px531	Magnitude to be controlled	0 .. 2999	Number of the R parameter to be evaluated.	
Px532	Lower limit	-1E38 .. 1E38	Lower limit value in SI units	
Px533	Upper limit	-1E38 .. 1E38	Upper limit value in SI units	
Px534	Override for good rating	String(63)	See Px504.	

Table 61. Px500 block: limit values

9.8.26 Px550 block: automatic program toggle

For the automatic program toggle two R parameters per program can be evaluated, according to the settings in S1030 (S1031, S1032). Block Px550 will be repeated with Px560 again.

Parameter	Meaning	Range of values	Explanations	
Px550	R parameter to be evaluated	0 .. 2999	Number of the R parameter, which shall initialize a program toggle in the case of a limit being exceeded.	
Px551	Lower limit value for program toggle	[0]	A falling below of this value results in a toggle of the program according to Px553.	
Px552	Upper limit value for program toggle	[1E+08]	An exceeding of this value results in a toggle of the program according to Px554.	
Px553	New program if the limit value falls below in Px551.	0 .. 9	If the limit value falls below in Px551, there is a toggle to this program, provided that it is in the valid range of the corresponding measuring circuit (S101k, S102k).	
Px554	New program if the limit value is exceeded in Px552.	0 .. 9	If the limit value is exceeded in Px552, there is a toggle to this program, provided that it is in the valid range of the corresponding measuring circuit (S101k, S102k).	

Table 62. Px550 block: automatic program toggle

9.8.27 Px700 block: process times

Parameter	Meaning	Range of values	Explanations	
Px701	Measuring time	0.1 .. 86400.0	(in seconds)	
Px702	Measuring time, unit	0..2 [0]	0: seconds 1: minutes 2: hours 3: days	
Px703	Measuring time, decimal places	0 .. 5 [1]	Number of decimal places	
Px705	Number of measuring pulses of the gas meter by pulse count method	2 .. 100000	Measuring time is terminated after pulse number has expired (target time measurement).	*)
Px710	Prefill time	0.0 .. 86400.0	in seconds	**)
Px711	Fill time	0.0 .. 86400.0	in seconds	**)
Px712	Stabilization period in the SPS mode	0.0 .. 86400.0	in seconds	**)
Px713	Ventilation time	0.0 .. 86400.0	in seconds	**)
Px714	Time for display of the measurement results	0.0 .. 86400.0	In seconds	**)

*) with gas meter as primary element
**) only in SPS mode

Table 63. Px700 block: process times

Notes:
Normally only the following values are reasonable for Px714:

0: no waiting time for the result display, behaviour as in the standard version, „GO" signal without effect.

Very high value: the result display is always terminated by the „GO" signal.

For double section devices the process times of both devices can be asynchronous. However, for the setting of the (common) test end the process times of the longest operating section are valid! Comparison: S9002 " Synchronize measurement "

The phases „fill" and „display result" can be terminated prematurely by the signal „GO" before the corresponding waiting time expires. This may be sensefull, for example, if during the phase „Fill" manual settings shall be made, if the phase „Fill" shall be terminated by an event, which is evaluated by the superior control, or if the measuring result shall be evaluated manually (particularly in the case of operation with several cycles, see below). The signal „GO" is implemented by the term defined in S1404.

9.8.28 Px800 block: display parameters depending on the program

In addition to the display of particular predefined data there are two possibilities to display the value of R parameters (see also chapter 9.2.3):

- Display of a directly allocated parameter
- Display of the R parameter, which is saved in an allocated P parameter

Here the focus lies on the P parameters, in which those R parameters are saved, in which values shall be displayed This direct allocation has the advantage that different magnitudes can be displayed specific to the program.

Parameter	**Meaning**	**Range of values**		
Px800	Display parameter #0	y000 - y999		
Px801	Display parameter #1	y000 - y999		
Px802	Display parameter #2	y000 - y999		
Px803	Display parameter #3	y000 - y999		
Px804	Display parameter #4	y000 - y999		
Px805	Display parameter #5	y000 - y999		
Px806	Display parameter #6	y000 - y999		
Px807	Display parameter #7	y000 - y999		
Px808	Display parameter #8	y000 - y999		
Px809	Display parameter #9	y000 - y999		
Px810	Display parameter #10	y000 - y999		
Px811	Display parameter #11	y000 - y999		
Px812	Display parameter #12	y000 - y999		
Px813	Display parameter #13	y000 - y999		
Px814	Display parameter #14	y000 - y999		
Px815	Display parameter #15	y000 - y999		
Px816	Display parameter #16	y000 - y999		
Px817	Display parameter #17	y000 - y999		
Px818	Display parameter #18	y000 - y999		
Px819	Display parameter #19	y000 - y999		

Table 64. Px800 block: display parameters depending on the program

9.8.29 Px900 block: analog outputs

The magnitudes to be displayed, the display units and the image of the displayed value to the analog output are selected in this menu. 10 parameter blocks exist per program on Px900, Px910, Px920, etc.

Parameter	**Meaning**	**Range of values**	**Explanations**	
Px900	Number of the analog output	-1 0 .. 9	-1: switched off 0 .. 9: use output definition of S8n00.	
Px901	Analog output z Allocation R parameter	y000 -y999	Allocation to the R parameter	
Px902	Analog output z Output signal 0.0	0 .. 1.0 E06 [0.0]	With this value (in SI unit) of the R parameter 0% is displayed.	
Px903	Analog output z Output signal 1.0	0 .. 1.0 E06 [1.0]	With this value (in SI unit) of the R parameter 100% is displayed.	
Px904	Behaviour with faulty R parameter	0 .. 1 [0]	0: no output (old value is continuously displayed) 1: scale and display value of Pz9x5.	
Px905	Display value with faulty R parameter	0 .. 1.0 E06 [0.0]	If the R parameter to be displayed is faulty (not calculated), and Px9z4 = 1, then this value will instead be scaled and displayed.	

Table 65. Px900 block: analog outputs

Important note
The difference of the parameters Px902 and Px903 must not be zero!

9.9 U parameter: sub programs

The program determines the used P parameter set. It is possible to select parts of this parameter set independent of the program by using sub programs. The parts of the P parameter set switchable by sub programs are indicated as parameter segments. For each parameter segment a set of configuration parameters exists (U parameter set), in which the behaviour of the appropriate sub program is determined (see Table 66).

All sub programs are coupled with the program in the basic configuration. This corresponds with the state before the introduction of the sub programs. Alternatively a sub program can be determined by an expression, or – similar to the program – it can be switched over automatically.

The switch over of parameter segments makes possible, for example, the switch over of a sensor in the case of a measuring range switch over without the need of switching over the complete program. Thus more programs are available for different evaluations, automated measuring cycles or other tasks.

If a sub program shall not be connected with the program, there are two different possibilities to define the switch over behaviour:

- The switch over is carried out independently of the state of a control expression.
- The switch over is carried out automatically, if a R parameter exceeds an upper limit or falls below a lower limit. In this case the R parameter to be monitored, the limit values and the appropriate switch over targets are defined in the F parameters. See also section 9.4.

Switch over actions must not occur any time. E.g., it is possible to define that a certain waiting time has to be respected between two switch over actions, or that switch over actions are eliminated in certain states, as e.g., during a measuring taking the mean.

Note:
The waiting time is also valid if the sub program is coupled firmly with the program. If, for example, a waiting time of 2 seconds has been determined for a sub program, the sub program will be switched over possibly only after 2 seconds have passed after the program has changed!

For each parameter segment there is an own U parameter set. The individual U parameter sets follow with a distance of 20. Though the thousands digit indicates the measuring circuit.

U parameter sets existing at the moment:

Number of the U parameter set	**Start U parameter**	**Parameter Segment**	**Explanation**
10	Uy200	Px000, Px003, Px004	Primary element, see section 9.8.1
11	Uy220	Px001	Type of gas, see section 9.8.1
12	Uy240	Px010-Px014	Primary measured variable, see section 9.8.2
13	Uy260	Px020-Px024	Absolute pressure, see section 9.8.3
14	Uy280	Px030-Px034	Measuring temperature, see section 9.8.4
15	Uy300	Px040-Px044	Measuring humidity, see section 9.8.5
16	Uy320	Px050-Px055	Reference pressure absolute, see section 9.8.6
17	Uy340	Px060-Px064	Reference temperature, see section 9.8.7
18	Uy360	Px070-Px074	Reference density, see section 9.8.8
19	Uy380	Px075-Px079	Auxiliary input 0, see section 9.8.9
20	Uy400	Px080-Px084	Auxiliary input 1, see section 9.8.10
21	Uy420	Px085-Px089	Auxiliary input 2, see section 9.8.11
22	Uy440	Px090-Px094	Auxiliary input 3, see section 9.8.12
23	Uy460	Px095-Px099	Auxiliary input 4, see section 9.8.13

Table 66. U parameter sets. y = measuring circuit

In the following the U parameter set starting at U0200 is shown as an example. The other U parameter sets have an identical structure:

Parameter	Meaning	Values	Explanations	
U0200	Coupling	0...2 [0]	0: Coupling with the program. 1: Determination by the expression in U0203. 2: Automatic switch over with vectors in U0210-U0219.	
U0201	Initial sub program	0...9 [0]	Initial value for the sub program.	
U0202	Waiting time	0...3600 [0]	Waiting time between switch over actions. After a switch over of the sub program other switch over actions are eliminated for the time set here in seconds.	
U0203	Allow switch over?	String(63) [„“]	If U0200 has the value 1 or 2, then the expression in U0203 determines, whether a switch over is permitted or not. If the expression is empty or invalid, then a switch over is always permitted.	
U0204	Expression for sub program	String(63) [„“]	If U0200 has the value 1, then the sub program is determined by the expression specified here.	
U0210	Switch over vector	0...49 [0]	Refers to a F parameter set. If U0200 has the value 2 and the current sub program is 0, then this switch over vector is used to determine a new sub program, if necessary.	
U0211	Switch over vector	0...49 [0]	F parameter set, if sub program = 1.	
U0212	Switch over vector	0...49 [0]	F parameter set, if sub program = 2.	
U0213	Switch over vector	0...49 [0]	F parameter set, if sub program = 3.	
U0214	Switch over vector	0...49 [0]	F parameter set, if sub program = 4.	
U0215	Switch over vector	0...49 [0]	F parameter set, if sub program = 5.	
U0216	Switch over vector	0...49 [0]	F parameter set, if sub program = 6.	
U0217	Switch over vector	0...49 [0]	F parameter set, if sub program = 7	
U0218	Switch over vector	0...49 [0]	F parameter set, if sub program = 8	
U0219	Switch over vector	0...49 [0]	F parameter set, if sub program = 9	

Table 67. U0000 block: Structure of an U parameter set

9.10 Ryxxx block: readparameter, measurement results

Parameter	Meaning/physical value	Display Name	Amendment
Ry000	System absolute pressure	Pbas	
Ry001	Differential pressure	Pdif	
Ry002	Test pressure absolute	Pabs	
Ry003	Measuring temperature	Temp	
Ry004	Measuring humidity	Hum	
Ry010	Reference pressure absolute	RPab	
Ry011	Reference temperature	RTem	
Ry012	Reference humidity	RHum	
Ry015	Auxiliary input 0	Aux0	
Ry016	Auxiliary input 1	Aux1	
Ry017	Auxiliary input 2	Aux2	
Ry018	Auxiliary input 3	Aux3	
Ry019	Auxiliary input 4	Aux4	
Ry020	Direct mass flow input	Qmd	
Ry030	Measuring volume flow	QVac	
Ry031	Standard volume flow	QVno	
Ry032	Reference volume flow	RQVa	
Ry033	Heating capacity	CPwr	
Ry034	Heat flow volume	HQty	
Ry035	Mass flow	QMas	
Ry036	Reynolds number flow element	Re_d	
Ry037	Reynolds number tube	Re_D	
Ry038	Speed flow element	v_d	
Ry039	Speed tube	v_D	
Ry040	K factor betaflow	K	
Ry041	Pressure drop LMS	dpdt	
Ry050	Ratio or total value	Rate	
Ry051	Correction measuring volume flow	CQVa	
Ry052	Correction standard volume flow	CQVn	
Ry053	Correction reference volume flow	CQVr	
Ry054	Correction mass flow	CQMa	
Ry091	Measuring density	ADen	
Ry092	Standard density	NDen	
Ry093	Reference density	RDen	
Ry096	Measuring viscosity	AVis	
Ry097	Calibration viscosity	NVis	
Ry098	Reference viscosity	RVis	
Ry099	Molar water portion Xv	Xv	
Ry100	Calculated R parameter of Px350		
Ry101	Calculated R parameter of Px360		
Ry110	Function result 0	FuncRes0	
Ry111	Function result 1	FuncRes1	
Ry112	Function result 2	FuncRes2	
Ry150	Control 1, set value	Set1	
Ry151	Control 1, actual value	Act1	

Ry152	Control 1, output control variable	Cor1	
Ry160	Control 2, set value	Set2	
Ry161	Control 2, actual value	Act2	
Ry162	Control 2, output control variable	Cor2	
Ry170	Evaluated value of Px501		
Ry171	Lower limit value of Px502	LLim	
Ry172	Upper limit value of Px503	ULim	
Ry173	Evaluated value of Px511		
Ry174	Lower limit value of Px512	LLim	
Ry175	Upper limit value of Px513	ULim	
Ry176	Evaluated value of Px521		
Ry177	Lower limit value of Px522	LLim	
Ry178	Upper limit value of Px523	ULim	
Ry179	Evaluated value of Px531		
Ry180	Lower limit value of Px532	LLim	
Ry181	Upper limit value of Px533	ULim	
Ry190	Number of pulses during measurement (gas meter)	Pulse	
Ry195	Balance time, fill	Fill	
Ry196	Balance time, stabilize	Calm	
Ry197	Balance time, stabilize	Zero	
Ry198	Balance time, ventilate	Vent	
Ry199	Time, measurement	Time	Meas
Ry200	Average system absolute pressure	Pbas	Avrg
Ry201	Average differential pressure	Pdif	Avrg
Ry202	Average test pressure absolute	Pabs	Avrg
Ry203	Average measuring temperature	Temp	Avrg
Ry204	Average measuring humidity	Hum	Avrg
Ry210	Average reference pressure absolute	RPab	Avrg
Ry211	Average reference temperature	RTem	Avrg
Ry212	Average reference humidity	Rhum	Avrg
Ry215	Average auxiliary input 0	Aux0	Avrg
Ry216	Average auxiliary input 1	Aux1	Avrg
Ry217	Average auxiliary input 2	Aux2	Avrg
Ry218	Average auxiliary input 3	Aux3	Avrg
Ry219	Average auxiliary input 4	Aux4	Avrg
Ry220	Average direct mass flow	Qmd	Avrg
Ry230	Average measuring volume flow	QVac	Avrg
Ry231	Average standard volume flow	QVno	Avrg
Ry232	Average reference volume flow	QVre	Avrg
Ry233	Average heating capacity	CPwr	Avrg
Ry234	Average heat flow volume	HQty	Avrg
Ry235	Average mass flow	QMas	Avrg
Ry236	Average Reynolds number flow element	Ref	Avrg
Ry237	Average Reynolds number tube	Ret	Avrg
Ry238	Average speed flow element	Vf	Avrg
Ry239	Average speed tube	Vt	Avrg
Ry240	Average K factor	K	Avrg
Ry241	Average pressure drop LMS	dpdt	Avrg
Ry250	Average ratio or total value	Rate	Avrg
Ry251	Average correction measuring volume flow	CQva	Avrg
Ry252	Average correction standard volume flow	CQvn	Avrg
Ry253	Average correction reference volume flow	CQvr	Avrg

Ry254	Average correction mass flow	CQMa	Avrg
Ry291	Average measuring density	ADen	Avrg
Ry292	Average standard density	NDen	Avrg
Ry293	Average reference density	RDen	Avrg
Ry296	Average measuring viscosity	AVis	Avrg
Ry297	Average calibration viscosity	NVis	Avrg
Ry298	Average reference viscosity	RVis	Avrg
Ry299	Average molar water portion Xv	Xv	Avrg
Ry300	Sum system absolute pressure	Pbas	Sum
Ry301	Sum differential pressure	Pdif	Sum
Ry302	Sum test pressure absolute	Pabs	Sum
Ry303	Sum measuring temperature	Temp	Sum
Ry304	Sum measuring humidity	Hum	Sum
Ry310	Sum reference pressure absolute	RPab	Sum
Ry311	Sum reference temperature	RTem	Sum
Ry312	Sum reference humidity	Rhum	Sum
Ry315	Sum auxiliary input 0	Aux0	Sum
Ry316	Sum auxiliary input 1	Aux1	Sum
Ry317	Sum auxiliary input 2	Aux2	Sum
Ry318	Sum auxiliary input 3	Aux3	Sum
Ry319	Sum auxiliary input 4	Aux4	Sum
Ry320	Sum direct mass flow	Qmd	Sum
Ry330	Sum measuring volume flow	QVac	Sum
Ry331	Sum standard volume flow	QVno	Sum
Ry332	Sum reference volume flow	QVre	Sum
Ry333	Sum heating capacity	CPwr	Sum
Ry334	Sum heat flow volume	HQty	Sum
Ry335	Sum mass flow	QMas	Sum
Ry336	Sum Reynolds number flow element	Ref	Sum
Ry337	Sum Reynolds number tube	Ret	Sum
Ry338	Sum speed flow element	Vf	Sum
Ry339	Sum speed tube	Vt	Sum
Ry340	Sum K factor	K	Sum
Ry341	Sum pressure drop LMS	dpdt	Sum
Ry350	Sum ratio or total value	Rate	Sum
Ry351	Sum correction measuring volume flow	CQva	Sum
Ry352	Sum correction standard volume flow	CQvn	Sum
Ry353	Sum correction reference volume flow	CQvr	Sum
Ry354	Sum correction mass flow	CQMa	Sum
Ry391	Sum measuring density	ADen	Sum
Ry392	Sum standard density	NDen	Sum
Ry393	Sum reference density	RDen	Sum
Ry396	Sum measuring viscosity	AVis	Sum
Ry397	Sum calibration viscosity	NVis	Sum
Ry398	Sum reference viscosity	RVis	Sum
Ry399	Sum molar water portion Xv	Xv	Sum

Ry400	Minimum system absolute pressure	Pbas	Min
Ry401	Minimum differential pressure	Pdif	Min
Ry402	Minimum test pressure absolute	Pabs	Min
Ry403	Minimum measuring temperature	Temp	Min
Ry404	Minimum measuring humidity	Hum	Min
Ry410	Minimum reference pressure absolute	RPab	Min
Ry411	Minimum reference temperature	RTem	Min
Ry412	Minimum reference humidity	Rhum	Min
Ry415	Minimum auxiliary input 0	Aux0	Min
Ry416	Minimum auxiliary input 1	Aux1	Min
Ry417	Minimum auxiliary input 2	Aux2	Min
Ry418	Minimum auxiliary input 3	Aux3	Min
Ry419	Minimum auxiliary input 4	Aux4	Min
Ry420	Minimum direct mass flow	Qmd	Min
Ry430	Minimum measuring volume flow	QVac	Min
Ry431	Minimum standard volume flow	QVno	Min
Ry432	Minimum reference volume flow	QVre	Min
Ry433	Minimum heating capacity	CPwr	Min
Ry434	Minimum heat flow volume	HQty	Min
Ry435	Minimum mass flow	QMas	Min
Ry436	Minimum Reynolds number flow element	Ref	Min
Ry437	Minimum Reynolds number tube	Ret	Min
Ry438	Minimum speed flow element	Vf	Min
Ry439	Minimum speed tube	Vt	Min
Ry440	Minimum K factor	K	Min
Ry441	Minimum pressure drop LMS	dpdt	Min
Ry450	Minimum ratio or total value	Rate	Min
Ry451	Minimum correction measuring volume flow	CQva	Min
Ry452	Minimum correction standard volume flow	CQvn	Min
Ry453	Minimum correction reference volume flow	CQvr	Min
Ry454	Minimum correction mass flow	CQMa	Min
Ry491	Minimum measuring density	ADen	Min
Ry492	Minimum standard density	NDen	Min
Ry493	Minimum reference density	RDen	Min
Ry496	Minimum measuring viscosity	AVis	Min
Ry497	Minimum calibration viscosity	NVis	Min
Ry498	Minimum reference viscosity	RVis	Min
Ry499	Minimum molar water portion Xv	Xv	Min
Ry500	Maximum system absolute pressure	Pbas	Max
Ry501	Maximum differential pressure	Pdif	Max
Ry502	Maximum test pressure absolute	Pabs	Max
Ry503	Maximum measuring temperature	Temp	Max
Ry504	Maximum measuring humidity	Hum	Max
Ry510	Maximum reference pressure absolute	RPab	Max
Ry511	Maximum reference temperature	RTem	Max
Ry512	Maximum reference humidity	Rhum	Max

Ry515	Maximum auxiliary input 0	Aux0	Max
Ry516	Maximum auxiliary input 1	Aux1	Max
Ry517	Maximum auxiliary input 2	Aux2	Max
Ry518	Maximum auxiliary input 3	Aux3	Max
Ry519	Maximum auxiliary input 4	Aux4	Max
Ry520	Maximum direct mass flow	Qmd	Max
Ry530	Maximum measuring volume flow	QVac	Max
Ry531	Maximum standard volume flow	QVno	Max
Ry532	Maximum reference volume flow	QVre	Max
Ry533	Maximum heating capacity	CPwr	Max
Ry534	Maximum heat flow volume	HQty	Max
Ry535	Maximum mass flow	QMas	Max
Ry536	Maximum Reynolds number flow element	Ref	Max
Ry537	Maximum Reynolds number tube	Ret	Max
Ry538	Maximum speed flow element	Vf	Max
Ry539	Maximum speed tube	Vt	Max
Ry540	Maximum K factor	K	Max
Ry541	Maximum pressure drop LMS	dpdt	Max
Ry550	Maximum ratio or total value	Rate	Max
Ry551	Maximum correction measuring volume flow	CQva	Max
Ry552	Maximum correction standard volume flow	CQvn	Max
Ry553	Maximum correction reference volume flow	CQvr	Max
Ry554	Maximum correction mass flow	CQMa	Max
Ry591	Maximum measuring density	ADen	Max
Ry592	Maximum standard density	NDen	Max
Ry593	Maximum reference density	RDen	Max
Ry596	Maximum measuring viscosity	AVis	Max
Ry597	Maximum calibration viscosity	NVis	Max
Ry598	Maximum reference viscosity	RVis	Max
Ry599	Maximum molar water portion Xv	Xv	Max
Ry600	Standard deviation system absolute pressure	Pbas	Dev
Ry601	Standard deviation differential pressure	Pdif	Dev
Ry602	Standard deviation test pressure absolute	Pabs	Dev
Ry603	Standard deviation measuring temperature	Temp	Dev
Ry604	Standard deviation measuring humidity	Hum	Dev
Ry610	Standard deviation reference pressure absolute	RPab	Dev
Ry611	Standard deviation reference temperature	RTem	Dev
Ry612	Standard deviation reference humidity	Rhum	Dev
Ry615	Standard deviation auxiliary input 0	Aux0	Dev
Ry616	Standard deviation auxiliary input 1	Aux1	Dev
Ry617	Standard deviation auxiliary input 2	Aux2	Dev
Ry618	Standard deviation auxiliary input 3	Aux3	Dev
Ry619	Standard deviation auxiliary input 4	Aux4	Dev
Ry620	Standard deviation direct mass flow	Qmd	Dev
Ry630	Standard deviation measuring volume flow	QVac	Dev
Ry631	Standard deviation standard volume flow	QVno	Dev
Ry632	Standard deviation reference volume flow	QVre	Dev
Ry633	Standard deviation heating capacity	CPwr	Dev
Ry634	Standard deviation heat flow volume	HQty	Dev

Ry635	Standard deviation mass flow	QMas	Dev
Ry636	Standard deviation Reynolds number flow element	Ref	Dev
Ry637	Standard deviation Reynolds number tube	Ret	Dev
Ry638	Standard deviation speed flow element	Vf	Dev
Ry639	Standard deviation speed tube	Vt	Dev
Ry640	Standard deviation K factor	K	Dev
Ry641	Standard deviation pressure drop LMS	dpdt	Dev
Ry650	Standard deviation ratio or total value	Rate	Dev
Ry651	Standard deviation correction measuring volume flow	CQva	Dev
Ry652	Standard deviation correction standard volume flow	CQvn	Dev
Ry653	Standard deviation correction reference volume flow	CQvr	Dev
Ry654	Standard deviation correction mass flow	CQMa	Dev
Ry691	Standard deviation measuring density	ADen	Dev
Ry692	Standard deviation standard density	NDen	Dev
Ry693	Standard deviation reference density	RDen	Dev
Ry696	Standard deviation measuring viscosity	AVis	Dev
Ry697	Standard deviation calibration viscosity	NVis	Dev
Ry698	Standard deviation reference viscosity	RVis	Dev
Ry699	Standard deviation molar water portion Xv	Xv	Dev
Ry700	Modification system absolute pressure	Pbas	ddt
Ry701	Modification differential pressure	Pdif	ddt
Ry702	Modification test pressure absolute	Pabs	ddt
Ry703	Modification measuring temperature	Temp	ddt
Ry704	Modification measuring humidity	Hum	ddt
Ry710	Modification reference pressure absolute	RPab	ddt
Ry711	Modification reference temperature	RTem	ddt
Ry712	Modification reference humidity	Rhum	ddt
Ry715	Modification auxiliary input 0	Aux0	ddt
Ry716	Modification auxiliary input 1	Aux1	ddt
Ry717	Modification auxiliary input 2	Aux2	ddt
Ry718	Modification auxiliary input 3	Aux3	ddt
Ry719	Modification auxiliary input 4	Aux4	ddt
Ry720	Change direct mass flow	Qmd	ddt
Ry730	Modification measuring volume flow	QVac	ddt
Ry731	Modification standard volume flow	QVno	ddt
Ry732	Modification reference volume flow	QVre	ddt
Ry733	Modification heating capacity	CPwr	ddt
Ry734	Modification heat flow volume	HQty	ddt
Ry735	Modification mass flow	QMas	ddt
Ry736	Modification Reynolds number flow element	Ref	ddt
Ry737	Modification Reynolds number tube	Ret	ddt
Ry738	Modification speed flow element	Vf	ddt
Ry739	Modification speed tube	Vt	ddt
Ry740	Modification K factor	K	ddt
Ry741	Modification pressure drop LMS	dpdt	ddt
Ry750	Modification ratio or total value	Rate	ddt
Ry751	Modification correction measuring volume flow	CQva	ddt
Ry752	Modification correction standard volume flow	CQvn	ddt
Ry753	Modification correction reference volume flow	CQvr	ddt
Ry754	Modification correction mass flow	CQMa	ddt

Ry791	Modification measuring density	ADen	ddt
Ry792	Modification standard density	NDen	ddt
Ry793	Modification reference density	RDen	ddt
Ry796	Modification measuring viscosity	AVis	ddt
Ry797	Modification calibration viscosity	NVis	ddt
Ry798	Modification reference viscosity	RVis	ddt
Ry799	Modification molar water portion Xv	Xv	ddt
Ry800	Raw input value channel 0	IN00	Raw
Ry801	Raw input value channel 1	IN01	Raw
Ry802	Raw input value channel 2	IN02	Raw
Ry803	Raw input value channel 3	IN03	Raw
Ry804	Raw input value channel 4	IN04	Raw
Ry805	Raw input value channel 5	IN05	Raw
Ry806	Raw input value channel 6	IN06	Raw
Ry807	Raw input value channel 7	IN07	Raw
Ry808	Raw input value channel 8	IN08	Raw
Ry809	Raw input value channel 9	IN09	Raw
Ry810	Raw input value channel 10	IN10	Raw
Ry811	Raw input value channel 11	IN11	Raw
Ry812	Raw input value channel 12	IN12	Raw
Ry813	Raw input value channel 13	IN13	Raw
Ry814	Raw input value channel 14	IN14	Raw
Ry815	Raw input value channel 15	IN15	Raw
Ry816	Raw input value channel 16	IN16	Raw
Ry817	Raw input value channel 17	IN17	Raw
Ry818	Raw input value channel 18	IN18	Raw
Ry819	Raw input value channel 19	IN19	Raw
Ry820	Linearized input value channel 0	IN00	Lin
Ry821	Linearized input value channel 1	IN01	Lin
Ry822	Linearized input value channel 2	IN02	Lin
Ry823	Linearized input value channel 3	IN03	Lin
Ry824	Linearized input value channel 4	IN04	Lin
Ry825	Linearized input value channel 5	IN05	Lin
Ry826	Linearized input value channel 6	IN06	Lin
Ry827	Linearized input value channel 7	IN07	Lin
Ry828	Linearized input value channel 8	IN08	Lin
Ry829	Linearized input value channel 9	IN09	Lin
Ry830	Linearized input value channel 10	IN10	Lin
Ry831	Linearized input value channel 11	IN11	Lin
Ry832	Linearized input value channel 12	IN12	Lin
Ry833	Linearized input value channel 13	IN13	Lin
Ry834	Linearized input value channel 14	IN14	Lin
Ry835	Linearized input value channel 15	IN15	Lin
Ry836	Linearized input value channel 16	IN16	Lin
Ry837	Linearized input value channel 17	IN17	Lin
Ry838	Linearized input value channel 18	IN18	Lin
Ry839	Linearized input value channel 19	IN19	Lin
Ry840	Raw output value channel 0	Out0	Raw
Ry841	Raw output value channel 1	Out1	Raw
Ry842	Raw output value channel 2	Out2	Raw
Ry843	Raw output value channel 3	Out3	Raw
Ry844	Raw output value channel 4	Out4	Raw
Ry845	Raw output value channel 5	Out5	Raw
Ry846	Raw output value channel 6	Out6	Raw

Ry847	Raw output value channel 7	Out7	Raw
Ry848	Raw output value channel 8	Out8	Raw
Ry849	Raw output value channel 9	Out9	Raw
Ry860	Linearized output value channel 0	Out0	Lin
Ry861	Linearized output value channel 1	Out1	Lin
Ry862	Linearized output value channel 2	Out2	Lin
Ry863	Linearized output value channel 3	Out3	Lin
Ry864	Linearized output value channel 4	Out4	Lin
Ry865	Linearized output value channel 5	Out5	Lin
Ry866	Linearized output value channel 6	Out6	Lin
Ry867	Linearized output value channel 7	Out7	Lin
Ry868	Linearized output value channel 8	Out8	Lin
Ry869	Linearized output value channel 9	Out9	Lin
Ry901	Differential pressure, uncorrected	Pdif	Orig
Ry902	Test pressure absolute, uncorrected	Pabs	Orig
Ry903	Measuring temperature, uncorrected	Temp	Orig
Ry904	Measuring humidity, uncorrected	Hum	Orig
Ry910	Reference pressure absolute, uncorrected	RPab	Orig
Ry911	Reference temperature, uncorrected	RTem	Orig
Ry912	Reference humidity, uncorrected	RHum	Orig
Ry915	Auxiliary input 0, uncorrected	Aux0	Orig
Ry916	Auxiliary input 1, uncorrected	Aux1	Orig
Ry917	Auxiliary input 2, uncorrected	Aux2	Orig
Ry918	Auxiliary input 3, uncorrected	Aux3	Orig
Ry919	Auxiliary input 4, uncorrected	Aux4	Orig
Ry920	Direct mass flow input, uncorrected	Qmd	Orig

*) if available. y: Measuring circuit index runs from 0 to 2 (single to triple section device)
Ry000 block: read parameter

10 Basic Units – Conversion (X and Y Factors)

SI factor	X or Y factor: 1/SI factor	A = a0	Unit	Display Abbreviation
Pressure /			**Differential pressure** **Absolute pressure** **Reference abs. pressure** **Relative pressure**	**Pdif** **Pabs** **RPab** **Prel**
1,00000E-00	1,00000E-00	0,000	Pascal	Pa
1,00000E+02	1,00000E-02	0,000	Hectopascal	hPa
1,00000E+03	1,00000E-03	0,000	Kilopascal	kPa
1,00000E+02	1,00000E-02	0,000	Millibar	mbar
1,00000E+05	1,00000E-05	0,000	Bar	bar
9,80670E+04	1,01971E-05	0,000	techn. atmosphere	at
1,01325E+05	9,86923E-06	0,000	phys. atmosphere	atm
3,38639E+03	2,95300E-04	0,000	inch mercury @0℃	inHG
2,49089E+02	4,01463E-03	0,000	inch Ws @4℃	inWC
6,89476E+03	1,45038E-04	0,000	Pounds/in2	lbi2
4,78802E+01	2,08855E-02	0,000	Pounds/ft2	lbf2
1,33322E+02	7,50062E-03	0,000	mm mercury @0℃	mmHG
9,80670E-00	1,01971E-01	0,000	mm water @4℃	mmWC
6,89476E+03	1,45038E-04	0,000	Pounds /in²	psi
1,33322E+02	7,50062E-03	0,000	Torr	Torr
9,79000E-00	1,02145E-01	0,000	mm water @20° C	mmWC
2,48648E+02	4,02175E-03	0,000	inch Ws @20℃	inWC
Density:			**Current density** **Standard density** **Reference density**	**ADen NDen** **RDen**
1,00000E-00	1,00000E-00	0,000	Kg/cubic meter	kgm3
1,00000E-03	1,00000E+03	0,000	g/cubic meter	g/m3
1,60185E+01	6,24278E-02	0,000	lb/cubic foot	lbcf
2,76799E+04	3,61273E-05	0,000	lb/cubic inch	lbci
Mass flow:			**Mass flow**	**Qmas**
1,00000E-00	1,00000E-00	0,000	kg/sec	kg/s
1,66667E-02	6,00000E+01	0,000	kg/min	kg/m
2,77778E-04	3,60000E+03	0,000	kg/hour	kg/h
1,00000E-03	1,00000E+03	0,000	g/sec	g/s
1,66667E-05	6,00000E+04	0,000	g/min	g/m
2,77778E-07	3,60000E+06	0,000	g/hour	g/h
4,53590E-01	2,20463E-00	0,000	lb/sec	PPS
7,55980E-03	1,32279E+02	0,000	lb/min	PPM
1,25000E-04	8,00000E+03	0,000	lb/hour	PPH
Mass			**Total mass**	**Mass**
1,00000E-00	1,00000E-00	0,000	Kg	kg
1,00000E-03	1,00000E+03	0,000	G	g
4,53590E-01	2,20463E-00	0,000	Lb	lb
1,00000E+03	1,00000E-03	0,000	T	t

Volume flow:			**Current volume flow** **Volume flow** **Standard volume flow** **Reference volume flow**	**QVac** **QVno** **QVre**
1,00000E-00	1,00000E-00	0,000	m³/sec	m3/s
1,66667E-02	6,00000E+01	0,000	m³/min	m3/m
2,77778E-04	3,60000E+03	0,000	m³/hour	m3/h
1,00000E-03	1,00000E+03	0,000	Liter/sec	L/s
1,66667E-05	6,00000E+04	0,000	Liter/min	L/m
2,77778E-07	3,60000E+06	0,000	Liter/hour	L/h
1,00000E-06	1,00000E+06	0,000	cm³/sec	cm3s
1,66667E-08	6,00000E+07	0,000	cm³/min	cm3m
2,77778E-10	3,60000E+09	0,000	cm³/hour	cm3h
2,83170E-02	3,53145E+01	0,000	ft³/sec	CFS
4,71950E-04	2,11887E+03	0,000	ft³/min	CFM
7,86580E-06	1,27133E+05	0,000	ft³/hour	CFH
1,63870E-05	6,10240E+04	0,000	inch³/sec	CIS
2,73120E-07	3,66139E+06	0,000	inch³/min	CIM
4,55190E-09	2,19688E+08	0,000	inch³/h	CIH
Volume:			**Current total volume** **Standard total volume** **Reference total volume**	**Avol** **Nvol** **Rvol**
1,00000E-00	1,00000E-00	0,000	m³	m3
1,00000E-03	1,00000E+03	0,000	Liter	Lit.
1,00000E-06	1,00000E+06	0,000	cm³	cm3
2,83170E-02	3,53145E+01	0,000	ft³	CF
1,63870E-05	6,10240E+04	0,000	inch³	CI
Humidity:			**Humidity** **Reference humidity**	**Hum RHum**
1,00000E-00	1,00000E-00	0,000	Relative humidity	-
1,00000E-02	1,00000E+02	0,000	Relative humidity [%]	%rH
Temperature:			**Temperature** **Reference temperature**	**Temp RTem**
1,00000E-00	1,00000E-00	0,000	Kelvin	"K
1,00000E-00	1,00000E-00	273,150	Celsius	"C
5,55556E-01	1,80000E-00	255,372	Fahrenheit	"F
5,55556E-01	1,80000E-00	0,000	Rankine	"R
Viscosity:			**Current viscosity** **Calibration viscosity** **Reference viscosity**	**AVis** **CVis** **RVis**
1,00000E-00	1,00000E-00	0,000	Pascal sec.	Pa*s
1,00000E-07	1,00000E+07	0,000	Micropoises	uPoi
1,00000E-03	1,00000E+03	0,000	Centipoises	cPoi
1,78583E+01	5,59965E-02	0,000	lbm / (in * s)	lbis
Pressure change per time:			**Pressure change per time:**	**dpdt**
1,00000E-00	1,00000E-00	0,000	Pascal/sec.	Pa/s
1,66667E-02	6,00000E+01	0,000	Pascal/Min.	Pa/m
2,77778E-04	3,60000E+03	0,000	Pascal/h	Pa/h
1,00000E+02	1,00000E-02	0,000	Millibar/sec	mb/s
1,66667E-00	6,00000E-01	0,000	Millibar/min	mb/m

2,77778E-02	3,60000E+01	0,000	Millibar/hour	mb/h
1,00000E+05	1,00000E-05	0,000	Bar/sec	b/s
1,66667E+03	6,00000E-04	0,000	Bar/min	b/m
2,77778E+01	3,60000E-02	0,000	Bar/hour	b/h
6,89476E+03	1,45038E-04	0,000	Pounds /in²/sec	PSIs
1,14913E+02	8,70227E-03	0,000	Pounds /in²/min	PSIm
1,91521E-00	5,22136E-01	0,000	Pounds /in²/hour	PSIh
Time:			**Time:**	**TMea**
1,00000E-00	1,00000E-00	0,000	Second (s)	sec.
6,00000E+01	1,66667E-02	0,000	Minute (min)	min.
3,60000E+03	2,77778E-04	0,000	Hour (h)	hour
8,64000E+04	1,15741E-05	0,000	Day	day
Without dimension:			**Number of measured data**	**Nval**
1,00000E-00	1,00000E-00	0,000	Without dimension -	-
1,00000E-02	1,00000E+02	0,000	Percent %	%
1,00000E+03	1,00000E-03	0,000	Kilo	E+03
1,00000E+06	1,00000E-06	0,000	Mega	E+06
1,00000E-03	1,00000E+03	0,000	Milli	E-03
1,00000E-06	1,00000E+06	0,000	Micro	E-06
Frequency:			**Frequency:**	**f**
1,00000E-00	1,00000E-00	0,000	Hertz	Hz
1,00000E+03	1,00000E-03	0,000	KiloHertz	kHz
1,00000E+06	1,00000E-06	0,000	Megahertz	MHz
1,66667E-02	6,00000E+01	0,000	1/Minute	1/m
2,77778E-04	3,60000E+03	0,000	1/Hour	1/h
Section / Length:			**Measurement period:**	**D / d / S / s**
1,00000E-00	1,00000E-00	0,000	Meter (m)	m
1,00000E+02	1,00000E-02	0,000	Centimeter (cm)	cm
1,00000E+03	1,00000E-03	0,000	Millimeter (mm)	mm
1,00000E+03	1,00000E-03	0,000	Kilometer (m)	km
3,048006E-01	3,2808334E-00	0,000	Foot (ft)	feet
2,540005E-02	3,39370E+01	0,000	Inch / inch (in)	inch
9,144018E-01	1,0936111E-00	0,000	Yard (yd)	yard
1,609344E+03	6,213711E-04	0,000	Mile (mil)	mile
Speed:			**Speed:**	**v**
1,00000E-00	1,00000E-00	0,000	Meter/second (m/s)	m/s
6,00000E+01	1,66667E-02	0,000	Meter/minute (m/min)	m/mi
3,60000E+03	2,77778E-04	0,000	Kilometer/hour (km/h)	km/h
1,00000E+03	1,00000E-03	0,000	Kilometer/second (m/s)	km/s
2,540005E-02	3,39370E+01	0,000	Inch/second (in/s)	in
3,048006E-01	3,2808334E-00	0,000	Foot/second (ft/second)	ft/s
9,144018E-01	1,0936111E-00	0,000	Yard/second (yd/s)	yd/s
1,609344E+03	6,213711E-04	0,000	Mile/second (mil/s)	mils
2,68244E+01	3,72823E-2	0,000	Mile/minute (mil/min)	milm
4,47040E-00	2,23694E-00	0,000	Mile/hour (mil/h)	milh
5.14444E-01	1,94384E-00	0,000	Knot	knot
Acceleration:			**Acceleration:**	**a**
1,00000E-00	1,00000E-00	0,00	Meter/second^2 (m/s^2)	m/s2
3,048006E-01	3,2808334E-00	0,00	Foot/second^2 (ft/s^2)	fts2

Force:			**Force:**	**F**
1,00000E-00	1,00000E-00	0,00	Newton	N
1,00000E-05	1,00000E+05	0,00	Dyne	dyne
1,00000E+03	1,00000E-03	0,00	KiloNewton	kN
4,44822E-00	2,24809E-01	0,00	pound force	lbf
1,38255E-01	7,23301E+00	0,00	poundel	pdl
Energy			**Energy**	**W**
1,00000E-00	1,00000E-00	0,00	Joule	J
1,00000E-00	1,00000E-00	0,00	Watt second	Ws
3,60000E+03	2,77778E-04	0,00	Watt hour	Wh
3,60000E+06	2,77778E-07	0,00	KiloWatt hour	kWh
3,60000E+09	2,77778E-10	0,00	MegaWatt hour	MWh
4,1868 E+00	2,38846E-01	0,00	Calorie	cal
4.1868 E+03	2,38849E-04	0,00	Kilo calorie	kcal
1,05506E+03	9,47813E-04	0,00	British Thermal Unit	btu
Power:			**Power:**	**P**
1,00000E-00	1,00000E-00	0,000	Watt	W
1,00000E+03	1,00000E-03	0,000	KiloWatt	kW
1,00000E+06	1,00000E-06	0,000	MegaWatt	MW
4,1868 E+00	2,38846E-01	0,000	Calorie/second	c/s
1,163 E+00	8,59845E-01	0,000	Kilocalorie / hour	kc/h
1,75843E+01	5,68688E-02	0,000	BTU/minute	btum
2,93072E-01	3,41213E+00	0,000	BTU/hour	btuh
Voltage:			**Voltage:**	**U**
1,00000E-00	1,00000E-00	0,000	Volt	V
1,00000E-03	1,00000E+03	0,000	MilliVolt	mV
1,00000E-06	1,00000E+06	0,000	MicroVolt	uV
Current:			**Current:**	**I**
1,00000E-00	1,00000E-00	0,000	Ampere	A
1,00000E-03	1,00000E+03	0,000	Milliampere	mA
1,00000E-06	1,00000E+06	0,000	Microampere	uA
Resistance:			**Resistance:**	**R**
1,00000E-00	1,00000E-00	0,000	Ohm	Ohm
1,00000E-03	1,00000E+03	0,000	MilliOhm	mOhm
1,00000E+03	1,00000E-03	0,000	KiloOhm	kOhm
1,00000E+06	1,00000E-06	0,000	MegaOhm	MOhm

Table 68. Basic units – conversion (X and Y factors)

11 Indications to the Methods of Calculation

11.1 Ideal gas law

The decisive tests for the description of the thermodynamic behavior of gases were already carried out in the 19th century by the French and English physicists Gay-Lussac, Boyle and Mariotte. They defined the ideal gas law:

$$\frac{p_1 \cdot V_1}{T_1} = \frac{p_2 \cdot V_2}{T_2} \qquad \text{or} \qquad \frac{p \cdot V}{T} = const.$$

The product of pressure and volume divided by the absolute temperature is consistent with a defined amount (mass m) of a gas.
The equation of state is precisely valid only for ideal gases, for real gases with good approximation, but not for vapors. The equation of state includes three special cases:

Overview:	**Special cases of the equation of state**		
Indication:	Isobar change of state	Isochore change of state	Isotherm change of state
Condition:	P=const.	V=const.	T=const.
Formula:	$\frac{V_1}{V_2} = \frac{T_1}{T_2}$	$\frac{p_1}{p_2} = \frac{T_1}{T_2}$	$\frac{p_1}{p_2} = \frac{V_2}{V_1}$
Law of:	Gay-Lussac	Gay-Lussac	Boyle-Mariotte

In pV/t = constant the numerical value of the constant quotient depends on the mass of the enclosed gas. If the equation refers to more than 1 kg of mass, a division by the mass m has to be made, resulting in:

$$\frac{p \cdot V}{m \cdot T} = const. = R_i$$

There Ri is the special gas constant depending on the kind of gas. If the special gas constant is multiplied by the molar mass M, the universal gas constant R = 8,314 J/kmol K is received. With the

definition for the density

$$\rho = \frac{m}{V}$$

the following correlation can be derived for density:

$$\rho = \frac{p}{R_i \cdot T}$$

The density of an ideal gas at a known special gas constant Ri can be determined by the measured variables (absolute) pressure and temperature from this equation.

11.2 Correlation between the flow measured variables

Gases are compressible media and gas flow is thus depending on density. With the help of the continuity equation (law of the conservation of mass) the following correlation can be indicated for the flow of a gas:

$$\dot{m} = QM_{as} = \rho \cdot QV = \rho_{ac} \cdot QV_{ac} = \rho_{no} \cdot QV_{no} = \rho_{re} \cdot QV_{re}$$

This correlation makes clear that the different volume flows can be converted into each other with the density ratio any time. In the following chapter the different volume flows computed by the LMF are briefly explained.

Among other things, the LMF makes available the following flow measured variables:

- Current volume flow (QVac)
- Mass flow (QMas)
- Standard volume flow (QVno)
- Reference volume flow (QVre)

Current volume flow (QVac)
The current volume flow (QVac) is determined on the input of the volume flow measuring instrument (e.g., LFE). It is the primary magnitude of the LMF. The current volume flow results from the pressure drop of the LFE (differential pressure) in connection with the calibration data of the LFE (see calibration protocol, if necessary). With Laminar-Flow elements the basic principle for that is the law of Hagen - Poiseuille of the pressure drop in straight pipes which are laminar flowed. The current volume flow is corrected by the ratio of calibration viscosity to current viscosity. The calibration conditions are the conditions which existed with the calibration of the LFE and they have to be taken from the calibration data sheets of the LFE.
The current volume flow is to be understood as „surface“ x „flow speed“ = „volume per time „. SI unit: m^3 / sec

Mass flow (QMas)
For the calculation of the mass flow the current volume flow is multiplied by the current density (with current temperature, current absolute pressure and current humidity. SI unit: kg / sec

Standard volume flow (QVno)
The standard volume flow is a volume flow relating to the standard density.
The standard volume flow is calculated by dividing the mass flow by the agreed standard density (e.g., with 1013 mbar, 20 °C and 0% of humidity). Since the standard conditions are determined, the conversion to mass flow always remains in a constant ratio! SI unit: m^3 / sec

Reference volume flow (QVre)
The reference volume flow is a computed current volume flow for another density and another place than the input of the flow measuring instrument. As a reference a place is selected, to which the current volume flow shall be converted (e.g., test sample input). For the calculation of the reference volume flow the currently measured reference density is computed (with current reference temperature, current reference pressure and current reference humidity). The measured mass flow (see above) is divided by this reference density and thus proves the reference volume flow. SI unit: m^3 / sec

11.3 Adjustable kinds of gas

Settings Px001, gas by primary element: operational kind of gas

Air under atmospheric conditions is often the standard calibration media of primary elements for cost reasons. By use of the real density calculation for air in a range of 5..35°C, 800..1200 hPa absolute pressure and 0..95% of relative humidity, announced by a BIPM recommendation, the highest calculation accuracies are achieved.
With precision applications the kind of gas should possibly correspond with the operational kind of gas when being calibrated.
If another kind of gas is applied, it must be made sure that the Reynolds number of the flow to be measured is similar to the Reynolds number of the calibration. Then with LFE there is the option to operate with another operational kind of gas as well.

As a default the following kinds of gas are deposited in the LMF:

1 - air
2 - argon
3 - carbon dioxide
4 - carbon monoxide
5 - helium
6 - hydrogen
7 - nitrogen
8 - oxygen
9 - methane
10 - propane
11 - n butane
12 - natural gas H
13 - natural gas L
14 - laughing gas
15 – water vapour

For other gases please ask the TetraTec Instruments GmbH

11.4 Density calculation

Density is determined by the measured variables for temperature, absolute pressure and, if necessary, humidity. The following correlation can be used as a fist formula for error estimation:

1 °temperature error, corresponds to
3 mbar pressure error, corresponds to
45% humidity error, corresponds to
approx. 0.3% of error with density calculation!

From this correlation the weighting of the sensors can be recognized, i.e., disregarding the humidity measurement causes the most minor error in the density calculation, for example.
With the LMF the density can be computed according to different models. These models are adjusted in parameter Px003. In the following the different arithmetic models are explained.

Ideal: [0] (Px003=0)

With the setting ideal no real gas corrections will be carried out. The calculation runs purely according to the ideal gas law without consideration of the current humidity.

Real: [1] (Px003=1)

With the setting Real [1] real gas corrections are carried out for high pressures. The calculation runs taking into account the Real gas behavior. By means of real gas factors and their development according to virial coefficients the pressure behavior of real gases is described. This arithmetic model applies to all (dry) gases and should be always used with pressures >4 bar even with air.

Real: [2] (Px003=2)

With the setting Real [2] real gas corrections are carried out taking into account humidity. The calculation is made according to BIPM and PTB recommendations. This arithmetic model only applies to air ≤ 4 bar taking into account humidity and it is the default setting for air.

11.5 Viscosity calculation

The viscosity is determined from the measured variables for temperature and, if necessary, humidity. The following correlation can be used as a fist formula for error estimation:

1 °temperature error, corresponds to
45% humidity error, corresponds to
approx. 0.2% error with the viscosity calculation!

The viscosity is absolutely independent of pressure up to approx. 7 bar. With the LMF the viscosity can be computed according to different models. These models are adjusted in parameter Px004. In the following the different arithmetic models are explained.

Ideal:

With the setting ideal a universal temperature correction of the viscosity of pure gases is carried out. Thus, only the behaviour of dry air is considered. The calculation with all kinds of gas runs according to the recommendations of Daubert & Danner. It applies for a wide range of temperature.

Real:

With the setting real the exact viscosity correction is carried out, in addition, by taking into account humidity, this is the default setting for air. The calculation proceeds according to the law of Kestin-Whitelaw and it applies only for air.

Another arithmetic model for viscosity is planned for future times. This model should then, in addition, absolutely correct the pressure dependence of the viscosity with pressures ≥ 7 bar.

11.6 Measuring sensors and reference sensors

The program parameter blocks Px010 to Px095 or the system parameter block S91xx define the function of the sensors which are used on the measuring problem. With the help of these set parameters it is possible to determine which functions of the sensors should be used for the determination of the flow measurement values and measuring conditions. The sensors can be divided in the following groups:

1. Measuring sensor for differential pressure or direct mass flow input (Px010 / 15)
   These sensors deliver the measuring signal which indicates the flow as immediately as possible. It maps "the physics" of the selected primary element on an electronically measurable size.
2. Measuring sensors for the determination of density and viscosity (Px020 / 30/40)
   The measuring sensors record static pressure, temperature and relative humidity on the input of the primary element (measuring conditions for the flow). These sensors offer the possibility to determine the current density and viscosity on the input of the primary element.
3. Reference sensors for the determination of tightness and viscosity (Px050 / 60/70)
   The reference sensors record static pressure, temperature and relative humidity at an arbitrary place of the flow system. As a rule this will be the input of the test sample to be calibrated. The conversion of the flow rates to the test sample input conditions is possible then with known reference tightness and viscosity.
4. Auxiliary inputs (e.g., for relative pressure sensors) (Px075 to Px099)
   The auxiliary inputs (Aux0 to Aux 4)) can be freely defined, e.g., for additional relative sensors or differential pressure sensors.
5. System pressure (S9110)
   The system pressure makes available a central absolute pressure to the measuring system. The measured relative pressures can be converted to absolute pressures then using this system pressure.
6. Molar water portion Xv
   The central calculation of the molar water content Xv allows the conversion of the relative humidity at any place of the flow system, provided that the values of pressure, temperature and humidity are known there. To calculate the molar water content Xv a sensor is defined for the relative humidity and the suitable sensors for pressure, temperature and humidity with the parameters S91xx.

The following descriptions give an overview of the different settings for the sensors which can be connected to the LMF (independent of the primary element) for the determination of density and viscosity. In particular the focus lies on a possible sensor linkage, if necessary.

11.6.1 Measuring sensors

11.6.1.1 Pabs

Absolute pressure of the gas in the inlet section of the primary element (LFE, gas meter or nozzle).

Measuring alternatively by:

Constant	Input of the absolute pressure as a constant value in Pascal in program parameter Px021, if Px020 is set to -1.
Sensor	Measuring of the absolute pressure on the input side of the primary element by an absolute pressure sensor (Px020 is the measuring channel)
Arithmetic value	Measuring pressure + system pressure For this purpose the system absolute pressure must be measured as ambient pressure (S9110 = sensor/ channel of the absolute pressure sensor) and the test pressure (Px020) must be measured as relative pressure. The linkage „ test pressure + system pressure " is switched on (see Px024) for the calculation.

TIP
By using the following test set-up it is possible to protect the absolute pressure sensor of a LFE measuring section from capacity overload. For this purpose the absolute pressure must be measured on the outlet side of the LFE as system pressure (S9110 = sensor/channel of the pressure sensor). The differential pressure of the LFE is now declared as the test pressure for „Pabs". The absolute pressure on the inlet side is computed with the linkage „ test pressure + system pressure " (see Px024) as a sum of the absolute pressure and differential pressure of the output of the LFE.

11.6.1.2 Temp

Temperature of the gas in the inlet section of the primary element (LFE, gas meter or nozzle).

Measuring alternatively by:

Constant	Input of the temperature as a constant in Kelvin in program parameter Px031, if Px030 is set on -1
Sensor	Measurement of the temperature in the gas flow by temperature sensor (Px030 is the measuring channel)

11.6.1.3 Hum

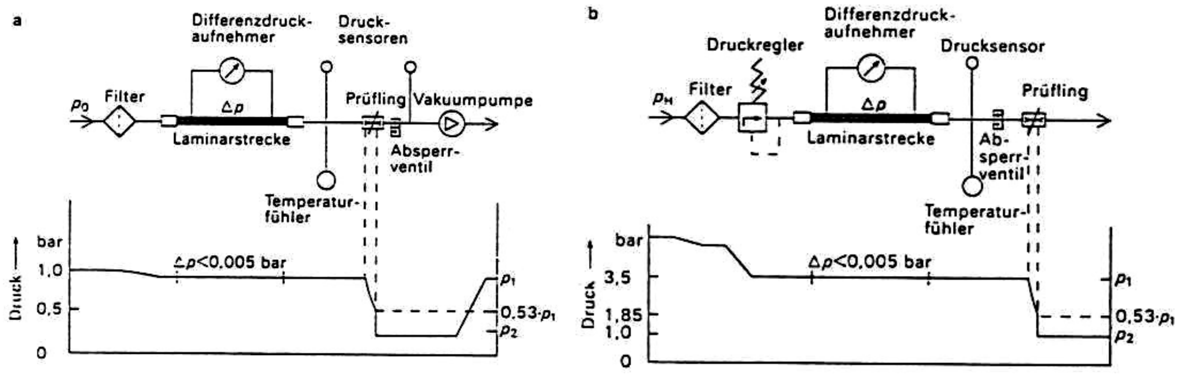
Relative humidity of the gas in the inlet section of the primary element (LFE, gas meter or nozzle).

Measuring alternatively by:

Constant	Input of the relative humidity as a constant in program parameter Px041, if Px040 is set on -1
Sensor	Measurement of the relative humidity in the gas flow by humidity sensor (Px040 is the measuring channel)
Arithmetic value	Calculation of the relative humidity from the molar water content Xv. Defined inS91xx, s. o.

11.6.2 Reference sensors

According to test section design and test sample differences arising from the system may appear between the current test sample conditions and the measuring conditions in the primary element. For compensation (conversion) of these differences reference sensors can be used.



Pressure drop along the measuring section

a) vacuum
b) pressure

When applying the continuity law (conservation of mass) of the thermodynamics it is possible to convert the measuring conditions (on the input of the primary element) to the test sample conditions (reference sensors RPab, RTem, RHum) by using density.

11.6.2.1 RPab

Absolute pressure of the gas in the inlet section of the primary element (LFE, gas meter or nozzle).

Measuring alternatively by:

Constant	Input of the absolute pressure as a constant in Pascal in program parameter Px051, if Px050 is set on -1.
Sensor	Measurement of the reference pressure with a pressure sensor (Px050 is the measuring channel)
Arithmetic value(1)	Measuring pressure + system pressure For this purpose the system pressure must be defined as ambient pressure (S9110 = sensor/channel of the pressure sensor) and the reference pressure (test pressure Px050) must be measured as relative pressure. For calculation the linkage „ test pressure + system pressure “ is switched on (Px054 = 1).
Arithmetic value(2)	Measuring pressure + system pressure – differential pressure For this purpose the system pressure is defined as absolute pressure on the primary element input (S9110 = sensor/channel of the pressure sensor) and the reference pressure (test pressure Px050) is measured as relative pressure. To compute the ambient pressure (on the output of the primary element), the differential pressure of the primary element must be subtracted from the system pressure. The linkage „ test pressure + system pressure - differential pressure “ will be switched on (Px054 = 2) for the calculation.

11.6.2.2 Rtem

Temperature of the gas by reference measuring tools or normal measuring tools.

Measuring alternatively by:

Constant	Input of the temperature as a constant in Kelvin in program parameter Px061 if Px060 is set to -1
Sensor	Measurement of the temperature in the gas flow by a (second) temperature sensor (Px060 is the measuring channel)

TIP
Measuring of the reference temperature by the measuring temperature sensor (Px030) assuming that no significant temperature changes will appear. Px060 is set to the same measuring channel as the measuring temperature sensor (Px030) for this purpose.

11.6.2.3 Rhum

Temperature of the gas by reference measuring tools or normal measuring tools.

Measuring alternatively by:

Constant	Input of the relative humidity as a constant in program parameter Px071, if Px070 is set on -1
Sensor	Measurement of the relative humidity in the gas flow by a (second) humidity sensor (Px070 is the measuring channel)
Arithmetic value	Calculation of the relative humidity from the molar water content Xv. Defined in S91xx, see above

TIP
Measuring of the reference humidity by a humidity sensor (Px030) assuming that no significant humidity changes will appear. Px070 is set to the same measuring channel as the measuring humidity sensor (Px030) for this purpose.

The mounting of the LMF with additional hardware is necessary for the measuring with reference sensors.

11.6.3 Auxiliary

The auxiliary inputs can be used, e. g., for the supervision of a pressure at any place or in particular with the application of the correction calculation (see below) for the determination of the differential pressure of the test sample. The auxiliary inputs may be configured in the same way as the reference pressure.

11.7 Correction calculations

The measurement of test sample characteristic curves with regard to pressure and flow requires correction calculations with demands of high accuracy. Possibly flows will be changed by the physical behavior of the test sample (e. g. , thermal expansion) and of the test media (temperature and pressure dependence of viscosity and density). Depending on what " physics" applies for the type of a test sample, these changes may show different dependences. Depending on what "physics" applies for the type of a test sample, these changes may show different dependencies.

Another application of correction calculations is the long time stability of measurement values. If the "physics" of a test sample is known, it is possible to compensate the influence of atmospheric variations on the set behavior of the test sample in such a way that the measurement value of the flow shows a considerably lower dispersion for weeks and months - a fact which is very important in quality management.

11.7.1 Correction calculations of the LMF (S9200)

Correction calculations are applied with the series connection of final control elements (test samples) and volume flow/mass flow measuring devices, i.e. of the LMF.
The LMF supports different correction calculation methods. These differ by their theoretical approach to take into consideration the adjustment characteristic and the flow-determining physical effects of certain final control elements.
The following correction calculation methods are supported by the LMF:

a) Speed of sound correction (S9200=1)
If nozzles are operated with an overcritical pressure ratio (empirical formula: inlet pressure = double output pressure), the current speed of sound is adjusted in the narrowest cross section of the nozzle, from which follows that the current volume flow only depends on the speed of sound in a super critically operated nozzle. With the speed of sound correction the temperature dependence of the speed of sound is standardized on a correction temperature (S9202). This prevents variations of the volume flow due to changes of the current speed of sound.
Correction factor for the current volume flow:

$$f_{korr.} = \sqrt{\frac{T_0}{T_{akt.}}}$$

b) Density correction with orifice with Δp = constant (S9200=2)
If nozzles are operated below the critical pressure ratio, they will behave like orifices. If nozzles are operated below the critical pressure ratio, they will behave like orifices for the current volume flow: $\dot{V} = c \cdot \sqrt{\frac{\Delta p}{\rho_{akt.}}}$
This correlation is a simplification, which can be differentiated by the Bernoulli equation. The dependence of the current volume flow from the present differential pressure and the current density can be recognized with this correlation. A lower density causes a higher flow speed at identical differential pressure, i.e. the propelling force for the volume flow. A bigger current volume flow (= surface x speed) results from it. To compensate this change of the volume flow, the volume flow is standardized to a correction density with correction values for temperature (S9202), air pressure (S9201) and humidity (S9203) with the application of the density correction. Correction factor for the current volume flow:

$$f_{korr.} = \sqrt{\frac{\rho_{akt.}}{\rho_0}}$$

c) Density correction with orifice with variable differential pressure (S9200=3)
The density correction at variable differential pressure follows the same approach as the density correction with Δp = constant. Nevertheless, in addition, the changing differential pressure is standardized to a correction differential pressure (S9208). The correction factor for the current volume flow is: $f_{korr.} = \sqrt{\frac{\rho_{akt.} \cdot \Delta p_0}{\rho_0 \cdot \Delta p_{akt.}}}$

d) Viscosity correction for laminar test leaks with Δp = constant (S9200=4)
Thin tubes (capillaries) create a pressure drop proportional to the flow when passed through by air or gases. The flow of this tube can be described according to the law of Hagen- Poiseuille in dependence of the differential pressure and the current viscosity as follows:

$$\dot{V} = c \cdot \frac{\Delta p}{\eta}$$

e) The viscosity primarily depends on temperature, what is the reason for standardizing them to the correction temperature (S9202). The correction factor for the current volume flow is:

$$f_{korr.} = \frac{\eta_{akt.}}{\eta_{0.}}$$

11.7.2 Example: corrected mass flow

In the following the approach for the correction of physical effects shall be explained on the example of corrected ("standardized") mass flow of air in theory and practically (setting of the suitable parameters). This process, e.g., with the characteristic curve measurement is applied by the control butterfly valves with which the mass flow should be shown as a function of the flap position with constant differential pressure about the flap. The measurement of the mass flow is carried out on this occasion with the help of the LMF using a LFE as primary element.

On basis of the current mass flow the corrected mass flow $\dot{M}_{korr.}$ shall be calculated with the help of a correction calculation.
The intention of this correction is the calculation of a mass flow which is regardless of the current ambient conditions, i.e., of the current density.
At first a density at correction conditions = ρ_o is defined for that purpose. The correction conditions are agreed values of temperature (S9202), air pressure (S9201) and humidity (S9203).
The mass flow is corrected to these conditions.

<u>Mass flow for a final control element with orifice characteristics (e.g., control butterfly valve):</u>

The volume flow for an orifice can be described with the following correlation: $\dot{V} = c \cdot \sqrt{\frac{\Delta p}{\rho_{akt.}}}$
where the constant c is the orifice factor which among other things contains the orifice geometry or the like. With the assumption Δp = const. and after having multiplied by $\rho_{akt.}$ the result for the current mass flow is:

$$\dot{M} = c_2 \cdot \sqrt{\rho_{akt.}}$$

From the dependence of the mass flow of the current density it can be explained, why an identical test sample provides different characteristic curves on different days according to weather, i.e. to current density.

The mass flow for a final control element with orifice characteristics on correction conditions, i.e. with the correction density ρ_o is defined as: $\dot{M}_0 = c_2 \cdot \sqrt{\rho_0}$. The target is to receive a constant measured variable for the mass flow. For this purpose the corrected mass flow (Ry199)
$\dot{M}_{korr.} = \dot{M}_0 = \dot{M} \cdot f_{korr.}$ is defined. Insertion and resolution according to $f_{korr.}$ offers for the correction factor: $f_{korr.} = \frac{c_2 \cdot \sqrt{\rho_0}}{c_2 \cdot \sqrt{\rho_{akt.}}} = \sqrt{\frac{\rho_0}{\rho_{akt.}}}$

This is the correction function for the standardized mass flow which is applied on selection of the correction method „ orifice (density) “, i.e., 9200=2 and selection correction volume flow „ CQMa as a mass flow “.

11.7.3 Calibration of the LMF by using calibration leaks

A widespread method of checking the calibration of a volume flow measuring instrument is the comparison with an overcritical nozzle. The overcritical nozzle sets a current volume flow which is largely independent of density. To compare two volume flow measuring devices with each other, the comparison of the mass flows is usually used. The following scheme should give an overview of the arithmetic steps which are necessary to compare a calibrated nozzle to the measurement values of the LMF:

$$\dot{V}_{Düse\ ,akt\ .}$$

12 Linearization of Sensors and Primary Elements

The linearization of the sensors increases the measuring accuracy. Even the exchange of a linearized sensor is possible with minimum deviations of the complete system. Only the linearization data of the sensor must also be exchanged then.

The linearization of a primary element has to be distinguished from that. Here the topic is the calculation of a flow rate. In the first attempt it could be calculated from the linearized sensor data and the indications for the configuration of the primary element according to the valid theory respectively. Nevertheless, there are light deviations in reality. They are measured during calibration and corrected by means of the linearization polynomial.

12.1 Linearization of the analogous value sensors with analogous or serial output

Up to 20 linearization data sets for analogous or serial sensors can be defined. At the same time, the number of sensors with analogous output signal is limited by number and type of the analogous input cards (maximum 10 with 5 Typ100 cards). The LMF is typically equipped and configured according to the application. The LMF offers three different linearization options:

0. Polynomial linearization
1. PT100 / PT1000 linearization
2. No linearization (linear according to the raw values of the sensors)

The correlation between sensor signal (raw value, x) and physical value (measurement value, y) is measured within the scope of the calibration. Any calibration supporting point delivers a value pair (xi, yi). The values xi and yi lie in the intervals X and Y. Now a distinction has to be made between scaling and linearization.
At first the scaling has to be determined, since it influences the coefficients of the linearization polynomial. With the help of the scaling factors Fx and Fy the values xi and yi can be mapped, e.g., in the numerically advantageous interval [0...1]. Or you are able to convert the values of the units used with the measurement in divergent units, e.g., SI units. For the special case that the scaling factor has the value 1.0 the linearization polynomial maps the raw values immediately on the (corrected) measurement value.
The linearization is the attempt to map the (scaled) raw values of the sensor on the physical value which the master sensor has measured during calibration with an error as small as possible. For this purpose the polynomial having the smallest deviations compared with the calibration supporting points (method of the smallest error squares) is determined by means of established numerical processes.

Example of a linearization:

Sensor signal (mA / V)	⇨	X factor =1.0 (S2x20)	⇨	Linearization polynomial (S2x10 to 19)	⇨	Y factor =1/SI factor (S2x21)	⇨	Sensor value in SI units
x_s		Fx		y = p(x)		Fy		Ya

The linearization polynomial p (x) of the sensor signal is calculated by the following equation:

$$y = a_0 + a_1 x + ... + a_8 x^8 + a_9 x^9$$

The scaling factors and the linearization polynomial are used in such a way that each sensor value x_s is at first multiplied by the X factor Fx, then the function value of the linearization polynomial p (x) is calculated at this point and this function value is still converted by division of Fy in SI units.

Note
Regardless of the unit used with the calibration or the desired output the conversion to SI units is obligatory, since the LMF internally operates exclusively in SI units (exception: mA instead of A). A suitable selection of Fy must be observed. The unit for the output is defined at another place and it can be selected arbitrarily.

The final calculation is then:

$$y_a = \frac{a_0 + a_1 x + ... + a_8 x^8 + a_9 x^9}{Fy}$$

A list of the suitable factors is included in chapter.

Example of a sensor linearization

There is the correction polynomial of a pressure sensor to be connected which supplies a signal of 0-10 V and which is calibrated on 0 - 20 mbar (according to the pressure value) lying in front of you. The value read in by the sensor, e.g., 0-10Vn serves as input quantity for the correction calculation. Since for this example this already corresponds with the required polynomial input quantity, the X factor has to be selected with 1.0. As a polynomial output size 0 - 20mbar is received. For the processing of the sensor the measurement value is required in SI units, i.e., in Pascal. The Y factor, by which the polynomial value is divided, is used for conversion. The Y factor is 1.0E-02 in this example, because 1 mbar = 100 Pa or 1 Pa = 1.0E-02 mbar.

12.2 Linearization of primary elements

The LMF can manage up to 140 different linearization data sets for primary elements. It supports the following primary element types (see definition parameter S4x00, chapter):

- LFE according to Hagen-Poiseuille or Universal-Flow
- Critical nozzles according to PTB or CFO
- Orifices with different pressure-extracting assemblies
- Pitot tubes / Accutubes according to manufacturer's regulation
- Different types of Venturi nozzles and Venturi tubes
- SAO nozzles
- Accutubes
- Beta-Flows (Pdiff or polynomial about Reynolds number)
- Gas meters
- Mass flow meters (direct input)

The theory of these primary elements is partially so complicated that their complete description would go beyond the scope of this reference manual. This is why the characteristics of these primary elements will only be treated briefly.

12.2.1 LFE according to Hagen-Poiseuille

Linearization increases the measuring accuracy. The LMF is typically equipped and configured according to the application. A change, e. g. , of the LFE data is only required with change, fouling or cleaning of a LFE. The principal approach corresponds with that being described in chapter 12.1. The input quantity of the LFE linearization according to Hagen-Poiseuille is, for example, the originating differential pressure. The calculation of the LMF calculates the differential pressure in Pascal. The output quantity is the current volume flow. The calculation of the LMF calculates the differential pressure in Pascal. If another polynomial input scaling is required, it will be correspondingly converted with the help of the X factor = 1/SI factor (table see chapter). The volume flow in the polynomial output scaling must scaled back again tot the SI unit with the Y factor.

SI unit [Pa] Pdif	⇨	X factor =1/SI factor (S5x20)	⇨	Polynomial linearization In: Pdif out: Qvac (S5x10 bis 19)	⇨	Y factor =1/SI factor (S5x21)	⇨	SI unit (m^3/s) Qvac

Example

There is the correction polynomial of a used LFE with the input quantity in
0 - 8 inches water column (inWC) for the differential pressure and the output size
0 - 150 ccm/min (according to the flow) lying in front of you.

The internal calculation calculates the measured differential pressure with the SI unit Pa. With the help of the X factor the pressure in Pa will be scaled on the necessary polynomial input quantity. In this example the X factor is (S5x020 =) 4,01463E-03.
As a polynomial output size 0 - 150 cfm/min is received (cubic feet per minute). For the subsequent treatment the result is required in SI units, i.e., in m3 / sec. The Y factor serves for conversion. In this example the Y factor is (S5x021 =) 2,11887E+03 for the conversion from cfm/min to m3/sec.

12.2.2 <u>LFE according to Universal Flow</u>

If laminar flow elements are used with higher pressures, the atmospheric calibration according to Hagen-Poiseuille fails, since, e. g. , density, viscosity and pressure are no independent variables. With these applications the Universal Flow calibration is used. This is a process in which the calibration supporting points are converted to independent variables at first.

12.2.3 <u>Overcritical nozzles according to DIN EN ISO 9300</u>

Overcritical nozzles supply a current volume flow which is widely independent of input pressure and output pressure. But it is necessary there that the overcritical nozzles are operated with a pressure ratio pe/pa ≥ 2. Basic principle for this effect is that with a over critically operated nozzle the flow reaches speed of sound in the smallest cross section. The speed of sound depends (indirectly) on temperature. To compensate the temperature dependence with the evaluation of the overcritical nozzle, a temperature measurement is necessary in addition to pressure measurement therefore.

12.2.4 <u>Gas meter</u>

When calibrating data for gas meters irregularities of the gas meter are compensated with the help of the linearization polynomial. These irregularities are based, e.g., on leakage, friction, resonances and machining tolerances.

12.2.5 <u>Orifices, Venturi tubes, Pitot tubes / Accutubes...</u>

With these so-called "square root devices" a pressure drop arises, which is proportionally to the square of the volume flow or, in other words, the volume flow is proportional to the square root of the measured pressure drop:

$$\dot{V} \sim \sqrt{\Delta p}$$

„Square root devices“, as a rule, can only be used in the measuring range 1:6, since the differential pressure must be measured otherwise with a too high (any more payable) accuracy.
Another important size in the operation of these primary elements is the Reynolds number. The Reynolds number characterizes the flow and it is taken into consideration with the calculation of the volume flow.

13 Allocation of the Sensors and Primary elements

The allocation of the sensors and the primary elements to the measuring sections and programs shall be explained with an example.

Example
A double section measuring instrument is equipped with 7 sensors and 2 LFE.

Sensor 0:	Differential pressure (active pressure), section 0; Parameter set: S2000 - S2031 for linearization
Sensor 1:	Absolute pressure, section 0; Parameter set: S2100 - S2131 for linearization
Sensor 2:	Gas temperature, section 0; Parameter set: S2200 - S2231 for linearization
Sensor 3:	Humidity, section 0; Parameter set: S2300 - S3231 for linearization
Sensor 4:	Differential pressure (active pressure), section 1; Parameter set: S2400 - S2431 for linearization
Sensor 5:	Absolute pressure, section 1; Parameter set: S2500 - S2531 for linearization
Sensor 6:	Gas temperature, section 1; Parameter set: S2600 - S2631 for linearization
LFE 0:	LFE, section 0; Parameter set: S4000 – S4022 for linearization
LFE 1:	LFE, section 1; Parameter set: S4100 – S4122 for linearization

At first a program is allocated to the measuring circuits (section 0 or section 1):

S1000 = 0
S1001 = 4

Section 0 is evaluated therefore with measuring program 0, section 1 is evaluated with measuring program 4.

Each measuring program now needs the different input quantities for the flow calculation.

Program 0:

P0000 = 0; in program 0 the primary element defined in parameter set P4000 to P4022 is evaluated
P0010 = 0; in program 0 sensor 0 is used for the differential pressure measurement
P0020 = 1; in program 0 sensor 1 is used for the absolute pressure measurement
P0030 = 2; in program 0 sensor 2 is used for temperature measurement
P0040 = 3; in program 0 sensor 3 is used for humidity measurement
P0050 =-1; in program 0 the fixed value of P0051 is used for the absolute reference pressure
P0060 =-1; in program 0 the fixed value of P0061 is used for the reference temperature
P0070 =-1; in program 0 the fixed value of P0071 is used for the reference humidity

Program 4:

P4000 = 1; in program 4 the primary element defined in parameter set P4100 to P4122 is evaluated
P4010 = 4; in program 4 sensor 4 is used for the differential pressure measurement
P4020 = 5; in program 4 sensor 5 is used for the absolute pressure measurement
P4030 = 6; in program 4 sensor 6 is used for temperature measurement
P4040 =-1; in program 4 the fixed value of P4041 is used for humidity
P4050 =-1; in program 4 the fixed value of P4051 is used for the absolute reference pressure
P4060 =-1; in program 4 the fixed value of P4061 is used for the reference temperature
P4070 =-1; in program 4 the fixed value of P4071 is used for reference humidity

Thus the basic configuration is specified for each of both measuring programs and the desired sensors are taken into consideration for the measurement.
Now the fine tuning in the next steps remains:
Units, comma place, measured variables etc. must be configured for the display.

14 Measuring and Correction Processes

A widespread measuring method for the measurement of gap geometries, annular gap geometries, nozzle geometries, opening geometries and orifice geometries is the flow of air and the measurement of the volume flow or mass flow. It is assumed that the test sample behaves like a more or less critically flowed nozzle. There three measurement setups must be distinguished.

Method 1:

The test sample is charged with compressed air (mostly approx. 2. 5 bar of overpressure). The outflowing air is measured behind the test sample with the LFE. The volume flow by the test sample depends on the following quantities:

* Absolute pressure before the test sample (roughly proportional).
* Temperature of the test air (proportional to the square root of the absolute temperature).
* Absolute pressure on the outlet side (atmospheric pressure), the dependence is proportional roughly vice versa.

To compensate the variations of the atmospheric pressure, the volume flow on the outlet side of the test sample must be converted to standard conditions therefore, i.e. the standard volume flow must be evaluated.

In addition, with highly fluctuating inlet pressure the absolute pressure before the test sample must be measured as an inlet pressure correction. The temperature of the test air may also deviate from the air flowing through the LFE. Therefore, the test air temperature can be measured with an additional temperature sensor.

The LFE will be possibly contaminated with this arrangement by dust, splinters, abrasion and oil of the test sample. The installation of a filter is highly recommended.

Method 2:

The test sample is charged with compressed air (mostly approx. 2.5 bar of overpressure for compliance with the critical pressure ratio). The volume before the test sample is measured by means of LFE. For evaluation the volume flow must be consulted.
The volume flow before the test sample is depending on the following quantities:

* Temperature of the test air (proportional to the square root of the absolute temperature).

* It is little depending on the absolute pressure of the test air (an ideal critically flowed nozzle would set the volume flow independent of the inlet pressure) and very little depending on the outlet pressure.

The LFE can be operated with this method by guaranteed dry, dust-free and oil-free air.

Method 3:

The test sample is connected to a vacuum pump. The volume flow before the test sample (air intake from the atmosphere) is measured by LFE. With this measuring method the volume flow is also valued.
The volume flow before the test sample is depending on the following quantities:

- Temperature of the test air (proportional to the square root of the absolute temperature)

- It is little depending on the absolute pressure of the test air, which is the atmospheric air pressure with this arrangement. A supercritically flowed nozzle would set the volume flow almost independently of the inlet pressure. It is very little depending on the suction pressure of the vacuum pump, provided that the critical pressure ratio is kept.

Even here the LFE cannot be contaminated by the test samples. However, the atmospheric air should be filtered.

A correction of the temperature dependence of the flow by the test sample has to be carried out as with measuring method 2.

Particularly the subcontractors to the automotive industry check and calibrate many final control elements which are for setting a certain air mass flow (no-load operation actuator, E-gas flaps, venting valves). Therefore, mass flow values are often prescribed in test specifications.

However, for testing geometry, outlet characteristics, etc. in manufacturing the mass flow is not a suitable size for evaluation, but - depending on the measurement setup - only volume flow or standard volume flow are so. The evaluation of the mass flow would introduce the same undesirable dependencies of the measurement value of test air and ambient conditions to method 2 and 3 as method 1!

The TetraTec Instruments GmbH recommends method 3 for the measurement of new products, the test specifications of which are still not determined, since this method includes the simplest and safest test section design and shows the quickest response time (= shortest stabilization time of the flow conditions) and the slightest fouling problems.

15 Uncertainty of Measurement Budget

15.1 Basic considerations Qv , Qm , ρ(p , T, xv)

The determination of the current volume flow Q_v in the test sample is done generally by the measurement of the current volume flow on the normal comparative value (master) and conversion to the conditions on the test sample by the density ratio (density **ρ**).

$$Q_{v,\text{Prüfling}} = Q_{v,Master} \cdot \frac{\rho_{Master}}{\rho_{\text{Prüfling}}}$$

The measured variable mass flow (Q_m) is calculated as the product of current volume flow and density and it is identical on each point of the measuring system

$$Q_{m,\text{Prüfling}} = Q_{m,Master} = Q_{v,Master} \cdot \rho_{Master}$$

The effect of the error propagation by the relative uncertainty of measurement of the individually measured variables is determined according to ISO / TR 5168 by standard deviation.

$$u_{ges,std} = \sqrt{\sum_i u_i^2}$$

The extended uncertainty of measurement u_{ges}, which results from the relative standard uncertainty of measurement $u_{ges,std}$ by multiplication with the extension factor k = 2 corresponds to the interval in which the measurement value lies with a probability of 95%. The smallest extended uncertainty of measurement of the comparative measurement to be indicated is identical with this extended standard uncertainty of measurement. With the standard uncertainty of measurement of a test sample an additional value has to be taken in consideration which describes the dispersions of the test sample, or of the calibration results.

Crucial for the uncertainty of measurement of the comparative measurement is at first the uncertainty with the determination of the current volume flow on the normal comparative value. The uncertainty with the determination of the density ratio between normal comparative value and test sample is added (for the measured variable current volume flow), or with the determination of the density on the normal comparative value (for the measured variable mass flow) from the measured variables relative air humidity as well as absolute pressure and temperature on the normal comparative value or test sample.

15.2 Percentage of uncertainty of measurement caused by leakage in the test section design

In the run-up phase of each comparative measurement it has to be made sure by a tightness test (pressure drop test) that the maximum error caused by leakage in the test section design remains below an agreed value.
If the volume of the test section design is V, the test pressure with leak testing is p and the smallest flow to be calibrated is $Q_{\min}$, the maximum allowed pressure drop in the test section design for an uncertainty u_L is

$$\frac{dp}{dt} \leq u_L \cdot Q_{\min} \cdot \frac{p}{V}$$

15.3 Uncertainties of measurement on comparative measurements with Laminar Flow Elements:

The extended standard uncertainty of measurement of the normal comparative value is determined by the calibration in a measuring chain which can be referred to the Physikalisch-Technische Bundesanstalt (Federal Institute for Physics and Engineering). The calculation of the current volume flow in the test sample with comparative measurement against Laminar Flow elements is done according to the following measuring chain (Law of Hagen-Poiseuille and Law of Conservation of Mass / Continuity Equation):

$$Q_{vol,\text{Prüfling}} = Q_{cal,LFE}(dp) \cdot \frac{\eta_{cal}}{\eta_{aktuell}} \cdot \frac{\rho_{LFE}}{\rho_{\text{Prüfling}}}$$

The uncertainty of measurement with the comparative measurement against Laminar Flow elements consists of the following factors:

- uncertainty of measurement u_{Kal} uKal of the normal comparative value during its calibration, typically
  $u_{Kal} = 0{,}325\% v.M.$ (Half of the extended uncertainty of measurement of typically 0.65%)
- uncertainty of measurement u_{dp} for the measurement of the differential pressure in the LFE
  For the measurement of the differential pressure in the LFE the identical differential pressure sensor is used with the factory calibration as well as with external comparative measurement, so that its absolute accuracy is not necessarily decisive, but only the ability of reproduction of the measurement values. In addition, the uncertainty by thermal and long-term drift of the sensor has to be taken into consideration. Typical values in the margin 2 - 25 hPa:
  relative uncertainty of measurement $u_{dp} = 0{,}15\% v.M.$
  thermal uncertainty: $u_L = 0{,}02\% v.M./°C$
  zero point drift of the sensor: $u_N = 0{,}05\% v.E.$

- uncertainty of measurement uη for the viscosity ratio by the conversion of calibration conditions to current conditions with the comparative measurement, typically
  $u_\eta = 0{,}056\%$
- uncertainty of measurement uρ for the density ratio. The accuracies of the absolute pressure measurement and temperature measurement, as well as humidity by the conversion of conditions on the normal comparative value to conditions in the test sample, typically
  $u_\rho = 0{,}14\%$ for mass flow
  $u_\rho = 0{,}12\%$ for volume flow
- uncertainty of measurement u_{LFE} for the comparative measurement with Laminar Flow Elements. This percentage of insecurity included the standard deviation of the calibration points with regard to the polynomial linearization, as well as an evaluation of the short-temporal and long-temporal drift behavior between the comparative measurements. The value is settled at first and is customized in the long term on the basis of historical data.
  $u_{LFE} = 0{,}15\%$

For the extended total uncertainty of measurement therefore applies:

$$u_{ges} = 2 \cdot \sqrt{u_{Kal}^2 + u_{dp}^2 + u_\eta^2 + u_\rho^2 + u_L^2 + u_{LFE}^2} + 2 \cdot u_N$$

This is for the example of the volume flow:

$$u_{ges} = 2 \cdot \sqrt{0{,}325^2 + 0{,}15^2 + 0{,}056^2 + 0{,}12^2 + 0{,}02^2 + 0{,}15^2} + 2 \cdot 0{,}05\% v.E.$$
$$= 0{,}82\% v.M. + 0{,}1\% v.E.$$

and for the mass flow in the worst case (for humid air):

$$u_{ges} = 2 \cdot \sqrt{0{,}325^2 + 0{,}15^2 + 0{,}056^2 + 0{,}14^2 + 0{,}02^2 + 0{,}15^2} + 2 \cdot 0{,}05\% v.E.$$
$$= 0{,}84\% v.M. + 0{,}1\% v.E.$$

15.4 Uncertainties of measurement with comparative measurements with orifices:

The extended standard uncertainty of measurement of the normal comparative value is determined by the calibration in a measuring chain which can be referred to the Physikalisch-Technische Bundesanstalt (Federal Institute for Physics and Engineering). The calculation of the current volume flow on the test sample with comparative measurement against orifices is done according to the following measuring chain (Law of Bernoulli Law and Law of Conservation of Mass / Continuity Equation):

$$Q_{vol,uut} = \sqrt{dp \cdot \rho_{uut}} \cdot \frac{C_{cal}(\mathrm{Re})}{\rho_{uut}}$$

The uncertainty of measurement with comparative measurements against orifices is thus made of the following factors:

- uncertainty of measurement u_{Kal} of the normal comparative value with its calibration, typically $u_{Kal} = 0{,}325\% v.M.$ (Half of the extended uncertainty of measurement of typically 0.65%)
- uncertainty of measurement u_{dp} for the measurement of the differential pressure on orifices
  For the measurement of the differential pressure on orifices the identical differential pressure sensor is used with the factory calibration as well as with external comparative measurement, so that its absolute accuracy is not necessarily decisive, but only the ability of reproduction of the measurement values. In addition, the uncertainty by thermal and long-term drift of the sensor has to be taken into consideration. Typical values in the margin 2 - 25 hPa:
  relative uncertainty of measurement $u_{dp} = 0{,}15\% v.M.$
  thermal uncertainty: $u_L = 0{,}02\% v.M./°C$
  zero point drift of the sensor: $u_N = 0{,}05\% v.E.$
- uncertainty of measurement u_η for the influence of the Reynolds number with the determination of the flow coefficient $C_{cal}(\mathrm{Re})$, typically:
  $u_{\mathrm{Re}} = 0{,}06\%$
- uncertainty of measurement u_ρ for the density ratio. The accuracies of the absolute pressure measurement and temperature measurement, as well as humidity by the conversion of conditions on the normal comparative value to conditions in the test sample, typically
  $u_\rho = 0{,}14\%$ for mass flow and volume flow
- uncertainty of measurement u_{OR} for the comparative measurement with orifices. This portion of insecurity includes the standard deviation of the calibration points with regard to the polynomial linearization, as well as an evaluation of the short-temporal and long-temporal drift behavior between the comparative measurements. The value is settled at first and is customized in the long term on the basis of historical data.
  $u_{OR} = 0{,}15\%$

For the <u>extended total uncertainty of measurement</u> therefore applies:

$$u_{ges} = 2 \cdot \sqrt{u_{Kal}^2 + 0{,}5 \cdot u_{dp}^2 + u_{\mathrm{Re}}^2 + 0{,}5 \cdot u_\rho^2 + u_L^2 + u_{OR}^2} + 2 \cdot u_N$$

The example of the mass flow and volume flow results in:

$$u_{ges} = 2 \cdot \sqrt{0{,}325^2 + 0{,}5 \cdot 0{,}15^2 + 0{,}06^2 + 0{,}5 \cdot 0{,}14^2 + 0{,}02^2 + 0{,}15^2} + 2 \cdot 0{,}05\% v.E.$$
$$= 0{,}76\% v.M. + 0{,}1\% v.E.$$

15.5 Uncertainties of measurement with comparative measurements with critical nozzles:

The extended standard uncertainty of measurement of the normal comparative value is determined by the calibration in a measuring chain which can be referred to the Physikalisch-Technische Bundesanstalt (Federal Institute for Physics and Engineering). The calculation of the current volume flow in the test sample with comparative measurement against critical nozzles (CFO) is done according to the following measuring chain (Law of Sound of Speed and Law of Conservation of Mass / Continuity Equation):

$$Q_{vol,\Pr üfling} = Q_{vol,CFO} \cdot \frac{\rho_{CFO}}{\rho_{\Pr üfling}} = F(c(T)) \cdot \frac{\rho_{CFO}}{\rho_{\Pr üfling}}$$

The uncertainty of measurement with the comparative measurement against critical nozzles (CFO) consists of the following factors:

- uncertainty of measurement $u_{Kál}$ of the normal comparative value during its calibration, typically $u_{Kal} = 0{,}325\% v.M.$ (Half of the extended uncertainty of measurement of typically 0.65%)
- uncertainty of measurement uc for the dependency on sound of speed by temperature, typically $u_c = 0{,}06\%$
- uncertainty of measurement uρ for the density ratio. The accuracies of the absolute pressure measurement and temperature measurement, as well as humidity by the conversion of conditions on the normal comparative value to conditions in the test sample, typically
  $u_\rho = 0{,}14\%$ for mass flow
  $u_\rho = 0{,}12\%$ for volume flow
- uncertainty of measurement u_{CFO} for the comparative measurement with critical nozzles (CFO). This percentage of uncertainty includes the standard deviation of the calibration points with regard to the polynomial linearization, as well as an evaluation of the short-temporal and long-temporal drift behavior between the comparative measurements. The value is settled at first and is customized in the long term on the basis of historical data.
  $u_{CFO} = 0{,}15\%$

For the extended total uncertainty of measurement therefore applies:

$$u_{ges} = 2 \cdot \sqrt{u_{Kal}^2 + u_c^2 + u_\rho^2 + u_{CFO}^2}$$

This is for the example of the volume flow:

$$u_{ges} = 2 \cdot \sqrt{0{,}325^2 + 0{,}06^2 + 0{,}12^2 + 0{,}15^2} = 0{,}77\% v.M.$$

and for the mass flow in the worst case (for humid air):

$$u_{ges} = 2 \cdot \sqrt{0{,}325^2 + 0{,}06^2 + 0{,}14^2 + 0{,}15^2} = 0{,}78\% v.M.$$

16 PLC Interface

The PLC interface is used for remote-controlled operation of automatic testing schedules. Besides, it is unimportant for the LMF whether it communicates with a classical programmable logic controller (PLC), a PC, or with a manual remote control.

This chapter informs about:
- PLC modes of operation (paragraph 16.1)
- Overview of test steps and functions (paragraph 16.2)
- Detailed information for the particular test steps (paragraph 16.3)
- Overview and explanation of the signals used for control (paragraph 16.4)
- Configuration of the interface (allocation of the signals, paragraph 16.5)
- Schematic signal functions (paragraph 16.6)

16.1 PLC modes of operation

The automatic PLC operation is a special mode of operation. In addition to automatic cycle a step operation is also possible. The mode of operation is determined by the values of the parameters S0001 (step operation) and S0010 (PLC operation):

S0001	S0010	Meaning/Use
0	0	standard mode of operation of the LMF without PLC, e.g., for calibration of the sensors
0	15	automatic PLC mode
1	0	standard mode of operation with the step operation, only for debugging
1	15	manual PLC mode, step operation

16.2 Overview of test steps and functions

The test schedules are divided in single test steps which are partly an automatic or dependent sequence of parameter settings, events or signals. For example, it is possible to check a test sample for several times without adaptation and renewed deadaptation to take into consideration the inlet behavior of the test sample. Or to submit the test sample successively to different tests, where another test program is selected for each test automatically. In addition it is possible to monitor how many NOK parts follow each other and to evaluate, if necessary, a disabling signal, e.g., to stop production. These options are set with the following parameters:

S0011	number of flows with one test sample
S0012	program step (if S0011> 1), allows successively different tests with a test sample
S0013	counter NOK; triggers lockout, if n successive parts are NOK.

Standard testing schedule

If each test sample is checked only once and no lockout becomes active, the cycle is typically as follows:
- wait for PLC start
- select program
- pre-fill
- fill
- calm
- measure (with continuous monitoring of the testing pressure)
- evaluate result
- indicate result on display
- ventilation
- display result digitally
- wait for removal PLC start

Several test flows with a test sample
Optionally several test flows can be carried out with a test sample (without deadaptation, without interruption of the available control, if necessary), where the following cycle is kept (intermediate steps for the result processing are not listed):

- select program
- pre-fill
- fill
- calm
- measuring
- distinction of cases
  - the cycle just carried out was not the last cycle: back to „pre-fill“, next cycle.
  - the cycle just carried out was the last cycle: go on with „ventilation“.
- ventilation

The number of cycles is determined in parameter S0011.

Automatic program step with several test cycles
Only possibly with one-way section systems.
If by means of S0011> 1 several test cycles are initialized, there is the possibility to increase the program number with each cycle by 1:

- first cycle: start routine, as specified with the PLC start.
- second cycle: start routine + 1
- etc.

The program step is limited by the parameters S1010 (the lowest valid program number measuring circuit 0) and S1020 (the highest valid program number measuring circuit 0). The program step is activated by S0012=1.

16.3 Detailed information for the particular test steps

16.3.1 Wait for PLC start

If the device is ready to start, the indication „Poll“ appears below on the right side the display. Then the signal „Ready“ is set.
If the NOK counter is set, and too many test samples have been recognized as bad before, (parameter S0013 default), the message „Lock“ will appear instead of that. This results in a lockout which must be acknowledged explicitly. In automatic operation this is done by the receipt of „Acknowledge“, in manual operation by pressing the STOP key. Only after removal of the lockout the signal „Ready“ will be set.

The PLC cycle is started by:

- PLC start signal with automatic operation
- START button with PLC step operation

If there are still result signals of a preceding test, they will be reset immediately after the new test has begun. A minimum delay has to be calculated.

The PLC cycle is now carried out according to the times specified in the parameter set with automatic operation. With the double section device the steps are changed asynchronously and each section can pass the test steps with autonomous times. Only at the end of the testing schedule is a waiting period as long as the longer running section has finished the test. Only then the signal „End“ is displayed.

With step operation there is a pause in each test section, until the next step is requested by pressing the start button.

Note
The signal „PLC start“ must be present during the whole testing schedule up to the end of the test. An untimely reset will be interpreted as a stop signal. In the manual PLC step operation it is not necessary to press the start button.

16.3.2 Program selection

Automatic operation:
With automatic PLC operation the program is read according to the selected bit-encoded program inputs 0 to 3. A signal must be set! If all inputs are deactivated, this will be interpreted as a non-readiness, error: „No program defined“.

Digital signal on program inputs 0-3:	Program allocation LMF	First program with double section	Second program with double section
0 0 0 0	Invalid	Invalid	Invalid
1 0 0 0	0	0	1
0 1 0 0	1	Invalid	Invalid
1 1 0 0	2	2	3
0 0 1 0	3	Invalid	Invalid
1 0 1 0	4	4	5
0 1 1 0	5	Invalid	Invalid
1 1 1 0	6	6	7
0 0 0 1	7	Invalid	Invalid
1 0 0 1	8	8	9
0 1 0 1	9	Invalid	Invalid
1 1 0 1 ... 1 1 1 1	Invalid	Invalid	Invalid

Table 69. Digital program input

With valid program selection the selected program is displayed in the lower line of the display. A waiting period is not necessary for this step and, hence, it cannot be initialized.

With invalid program selection an error message appears in the display. The schematic signal function in this case is explained in paragraph 16.6.2.1.
A „lock“ is not triggered by this error. The readiness is established immediately after the stop signal again.

Program selection with step operation
With manual operation the program selection is done from the list of parameters (S1000 and, in addition, with double section from version S1001).

16.3.3 Pre-fill

During the fill the signal "Fill" is set. The pressure is adjusted.
The selected program is displayed on the left side below, the indication „Pfil“.

The duration of the phase „pre-fill“ is determined by parameter Px710. The phase „fill“ can be quit just as the phase „display result“ by the signal „Go“ prematurely before the respective waiting period. This may make sense, e.g., if the phase "Fill" shall be quit by an event which is evaluated by the superior control.
If the waiting period is set to 0 or has already run off, the signal „Go“ has no effect.

16.3.4 Fill

During the fill the signal "Fill" is set. The pressure is adjusted.
The selected program is displayed on the left side below, the indication "Fill" on the right side.

The duration of the phase "Fill" is determined by parameter Px711. The phase „fill“ can be quit just as the phase „display result“ by the signal „Go“ prematurely before the respective waiting period. This may make sense, e.g., if the phase "Fill" shall be quit by an event which is evaluated by the superior control.
If the waiting period is set to 0 or has already run off, the signal „Go“ has no effect.

At the end of the phase „Fill“ the signal „Fill“ will be reset.

16.3.5 Calm

Display as above, only with the indication „Calm“ on the right side below.
Signal „Calm“ set.

The duration of the phase „Calm“ is determined by parameter Px712.

At the end of the phase „Calm“ the signal „Calm“ will be reset.

16.3.6 Measuring

Signal „Measure“ set.
The measured variable which is relevant for the evaluation of the test sample, as well as the testing pressure and the measuring time are usually displayed.
The testing pressure is continuously monitored. If the testing pressure lies beyond the value range, which is determined by the parameters Px512 and Px5213, the measurement is cancelled. Even if a sensor error appears, the measurement is cancelled.

If the measurement is cancelled on a measuring circuit by a device with double section, the measurement is even continued on the other, provided that this measurement is perfect.

16.3.7 Evaluate result

The signal „Measuring“ still remains set.

If the testing pressure has not been reached, the pressure achieved after the stabilization period is usually displayed.
If the measurement fails due to a sensor error, the message „Error“ is correspondingly displayed, and on the right of it the identification of the sensor, which triggered the error is displayed.
If the measurement can be carried out correctly, the evaluation is carried out due to the window defined by parameters Px502 and Px503:

Possibilities
- flow rate within window: OK
- flow rate below window: Low
- flow rate above window: High

The result is indicated from this test step up to the next testing schedule start on the display. It differs in the single section version to the double section version. It is possible to change between the different displays by pressing any of the function keys.

16.3.8 Display results

The measurement results are summarized in different display figures. Outgoing from the configured standard display they can be toggled with the function keys F1 and F3. The designations correspond with the entries in the Read parameter block Ryxxx. The result displays differ according to configuration and equipment of the system and they are not listed here explicitly.

The duration of the result display is determined by the parameter Px714. The phase „Display results“ can be quit by a signal „GO“ just as the phase „Fill“ prematurely before the respective waiting period. This may make sense, e.g., if the measurement result shall be evaluated manually (particularly during operation with several flows).
If the waiting period is set to 0 or has already run off, the signal „Go“ has no effect.

At the end of the result display the signal „Measuring” will be reset.

16.3.9 Ventilation

The signal „Ventilate“ is set. On the display the identification „Vent“ appears (with free lower display). There is a pressure equalization.

The duration of the phase „Ventilate“ is defined by parameter Px713.

At the end of the phase „Ventilate“ the signal „Ventilate“ will be reset.

16.3.10 Display result digitally

For signaling please see paragraph 16.6.

For all evaluations NOK the „NOK counter“ is increased. With each test evaluated „OK“ the counter will be reset again. If a lot of NOK tests follow immediately one after the other so that the NOK counter reaches the value deposited in S0013, the signal „Lockout“ will be set, which must be acknowledged explicitly with the signal „Acknowledge“.
If S0013 = is 0, the NOK counter is deactivated.
The double section device has two independent counters, but only one limit (S0013).

At the end of the testing schedule the signal „End“ will be set, no matter whether it is quit regularly or it has been cancelled.

16.3.11 Wait for PLC stop

There is a pause in this state as long as a stop signal (removal of the signal „PLC start“ with automatic operation or pressing the STOP key with manual operation) will be received. For further signaling please see paragraph 16.6.

16.4 Overview of the signals

A detailed allocation of the signals to the pins or ports of the PLC interface is included in chapter 16.5.

16.4.1 Control inputs

Signals which the PLC sets for the realization of the testing schedule:

Prog. Bit 0	Selects the program number according to the entries in Table 69.
Prog. Bit 1	
Prog. Bit 2	
Prog. Bit 3	
PLC start	starts the testing schedule. If the signal is left out, this will be interpreted as a stop signal (except in the manual step operation).
GO	The phases „Fill“ and “Display result” can be quit by the signal „Go“ prematurely before the respective waiting period. See also the comments for the process times 9.8.27.
Acknowledgement	For the continuation after the occurrence of states which must be acknowledged see also next paragraph.

16.4.2 Control outputs

Signals which the LMF sets to display states to be acknowledged.

Lockout	If S0013 is set to a value different to zero, the number of consecutive NOK events will be monitored, and there is an own NOK counter for each measuring circuit. If one of the NOK counters reaches the value defined in S0013, the LMF sets the signal to lockout. The LMF sets a signal „Ready“ only again if the signal „Lockout“ has been acknowledged by the signal „Acknowledgement“.

16.4.3 Status outputs

Signals which the LMF sets to inform the PLC about the momentary state of the testing schedule (in which phase the test is):

Ready	Signals that the LMF waits for the signal PLC start
Fill	Signals the phase in which the test conditions are produced.
Calm	Signals the phase in which the test conditions stabilize.
Measuring	Signals the phase in which the real measurement takes place.
Ventilation	Signals the phase in which a pressure equalization is produced with the environment.
End	Signals the end of the testing schedule.

16.4.4 Result outputs

Signals which the LMF sets to inform the PLC about the result of the last test carried out.

OK	The test has been quit free of errors and the measurement value lies in the specified value range.
NOK	The measurement value lies beyond the specified valuation, or no valid measurement value could be measured, e.g., with too low test pressure or with program termination.
NOKL	The measurement value lies below the specified valuation.
POK	The required test pressure was kept during the measurement.
no malfunction	The test was quit trouble-free (without consideration of the monitoring of proof pressure)

16.5 Standard configuration of the PLC digital interface

If a divergent configuration is specified, this is documented in the „Getting Started Guide and System Configuration“ of the device.

Hardware interface or virtual PLC interface
According to the equipment of the device either a digital hardware interface or a virtual interface via TCP/IP (Ethernet) is used for the communication with the PLC. The pins or ports of these interfaces are indicated as follows:

DI	Digital In	Indication of an input of the digital interface
DO	Digital Out	Indication of an output of the digital interface
NI	Network In	Port of the virtual interface used as an input.
NO	Network Out	Port of the virtual interface used as an output.

Note
If you use a hardware interface with external supply of the optoelectronic couplers for reasons of the galvanic separation, specific pins must be supplied with 24 V for this purpose. Thus follow the circuit diagram!

Inputs

DI	NI	Function	Note	Plug	Pin	Indication
			Supply	X50	10	24V
DI08	0		Reserve	X50	9	0
DI09	1		Reserve	X50	8	1
DI10	2		Reserve	X50	7	2
DI11	3		Reserve	X50	6	3
DI12	4		Reserve	X50	5	4
DI13	5	Go		X50	4	5
DI14	6	PLC start		X50	3	6
DI15	7	Acknowledge-ment		X50	2	7
			Supply	X50	1	0V

			Supply	X52	10	24V
DI16	8		Reserve	X52	9	0
DI17	9	Prog. Bit 0		X52	8	1
DI18	10	Prog. Bit 1		X52	7	2
DI19	11	Prog. Bit 2		X52	6	3
DI20	12	Prog. Bit 3		X52	5	4
DI21	13		Reserve	X52	4	5
DI22	14		Reserve	X52	3	6
DI23	15		Reserve	X52	2	7
			Supply	X52	1	0V

Outputs

DO	NO	Function	Note	Plug	Pin	Indication
			Supply	X51	10	24V
DO08	0	Measuring		X51	9	0
DO09	1	NOKL		X51	8	1
DO10	2	Ventilation		X51	7	2
DO11	3	Fill		X51	6	3
DO12	4	Calm		X51	5	4
DO13	5		Reserve	X51	4	5
DO14	6	Ready		X51	3	6
DO15	7	OK		X51	2	7
			Supply	X51	1	0V

			Supply	X53	10	24V
DO16	10	NOK		X53	9	0
DO17	11	No malfunction		X53	8	1
DO18	12	Lockout		X53	7	2
DO19	13	End		X53	6	3
DO20	14	POK		X53	5	4
DO21	15		Reserve	X53	4	5
DO22	16		Reserve	X53	3	6
DO23	17		Reserve	X53	2	7
			Supply	X53	1	0V

16.6 Schematic signal functions

16.6.1 Regular testing schedule

16.6.1.1 Procedure

PLC	**LMF**
	• The LMF sets the signal „Ready“ Result outputs of the previous test are still set (except on the first test after turning on)
• The PLC sets the signals for program selection	
• The PLC sets the signal PLC start	• The result signals of the previous test are reset (Reset) • The signal „Ready“ is reset (Reset) The testing schedule begins. The LMF sets the signals according to the current test step: • Fill • Calm • Measuring • Ventilation Test finished: • The LMF sets the result signals • The LMF sets the signal „End“
	The LMF waits for the reset of the signal PLC start by the PLC
• The PLC resets the signal PLC start	
	• The LMF resets the signal „End“ • The LMF sets the signal „Ready“ • Result signals are not reset

16.6.1.2 Result signals

After a regular testing schedule without malfunction the following result signals are set

Signal	**Note**
No malfunction	Is always set.
POK (Test pressure OK)	Is always set.
OK	Is set if the measured variable to be valued lies within the window which is specified by the parameters Px502 and Px503.
NOK	Is set if the measured variable to be valued lies beyond the window which is specified by the parameters Px502 and Px503. If S0013 is set, the lock counter is additionally incremented.
NOKL	Is set (in addition to signal NOK) if the measured variable to be valued lies below the lower limit specified by parameter Px502

16.6.2 Testing schedules with malfunction

16.6.2.1 Testing schedule without correctly set program inputs

The testing schedule is cancelled under the following circumstances immediately after having set the signal PLC start:

- None of the signals Prog Bit 0 to Prog Bit 3 is set

- or-

- The signals Prog bit 0 to Prog bit 3 encode a program which is not permissible (Example: all 4 signals are set, this corresponds to the selection of program 14, nevertheless, the highest possible program number is 9)

Reaction of the LMF:

PLC	**LMF**
	• The signal NOK is set • The signal no malfunction is not set • The signal „End“ is set
	The LMF waits for the reset of the signal PLC start by the PLC
• The PLC resets the signal PLC start	
	• The signal „End“ is reset • The signal „Ready“ is set • The signal NOK remains set

16.6.2.2 Termination of test by the PLC

The PLC can quit prematurely the test any time by resetting the signal PLC start

Then the LMF changes immediately to the phase Ventilate.
After the phase Ventilate has finished the following signals are displayed:

PLC	**LMF**
	• The signal NOK is set • The signal no malfunction is not set • The signal „End“ is temporarily set (for an internal cycle) • Then the signal „Ready“ is immediately set

A termination of test during the phase Ventilate by reset of the signal PLC start remains without effect, the further cycle and the output of the test results do not differ from a regular test, the only difference: the signal End is set only for an internal cycle, then the signal Ready will be set.

16.6.2.3 Termination of test by faulty test pressure

If the test pressure lies beyond the limits specified by the parameters Px512 and Px513, the test is cancelled. The test pressure is tested during the complete phase Measuring (and only then). After termination of the test the following signals are displayed:

PLC	LMF
	• The signal NOK is set • The signal no malfunction is set • The signal POK (test pressure OK) is not set • The Signal „End“ is set
	The LMF waits for the reset of the signal PLC start by the PLC
• The PLC resets the signal PLC start	
	• The signal „End“ is reset • The signal „Ready“ is set The result signals (NOK, POK and no malfunction) remain unchanged.

16.6.2.4 Testing schedule with sensor error

If a sensor error appears during the testing schedule (possibly by cable break, defective sensor, defective contact or similar), the test is still carried out regularly. If the sensor error appears (temporarily or permanently) during the phase Measuring, the following result signals are set:

PLC	LMF
	• The signal NOK is set • The signal no malfunction is not set • The signal POK (test pressure OK) is set (except the sensor error is related to the test pressure sensor) • The Signal „End“ is set
	The LMF waits for the reset of the signal PLC start by the PLC
• The PLC resets the signal PLC start	
	• The signal „End“ is reset • The signal „Ready“ is set The result signals (NOK, POK and no malfunction) remain unchanged.