FLOW GMBH
vision

Flow Meter | FC01-Ex-CA
USER HANDBOOK

M_FC01-Ex-CA_0621_e

Please follow these installation and adjustment instructions carefully.

Failure to comply with these instructions or misuse of this equipment will void your warranty coverage. The instructions cover software version Ex-CA-1.00000.

Equipment installation, connection and adjustment by qualified personnel only.

Failure to comply, or misuse of this equipment, could result in serious damage both to the equipment itself and to the installation. FlowVision is unable to accept responsibility for customer or third party liability, warranty claims or damage caused by incorrect installation or improper handling resulting from non-observance of these instructions.

Monitoring heads are not freely interchangeable with the FC01-Ex. The assembly of mating parts must be maintained.

Electronic control unit and monitoring head are always packed and dispatched in pairs.

Inhaltsverzeichnis

1 Description

The flow meter FC01-Ex is designed to provide stationary monitoring, detection and indication of flow in compressed air, gases and powders with evaluation of the measuring data of the calorimetric monitoring head CST-Ex-11AM1xxx with separate EC type test certificate.

In addition the FC01-Ex provides power to, and processes output signals from the intrinsically safe type CST-Ex monitoring head. Connections between the intrinsically safe area and the non-intrinsically safe area are via safety barriers. The FC01-Ex control unit must be installed outside the ex area.

2 Ex-atmosphere - Definitions and mounting instructions

2.1 Information on explosion protection

Safety barriers are installed between the Flow Meter FC01-Ex and the monitoring head CST-Ex. They are designed according to the directives of the European standards EN 60079-0:2012, EN 60079-11:2012 and EN 60079-15:2010 to type protection:

II 3 (1) G Ex nA [ia Ga] IIC T4 Gc
II (1) D [Ex ia Da] IIIC

They bear the EU-TYPE-EXAMINATION CERTIFICATE number PTB 01 ATEX 2053 X.

The monitoring head CST-Ex is an intrinsically safe equipment. It has been designed for use in potentially explosive atmospheres to directive 2014/34/EU and is meant for use in applications of the equipment group II, category 1 (gas zone 0 or dust zone 20).

It has been designed according to the European standards EN 60079-0:2012+A11:2013, EN 60079-11:2012, and EN 60079-26:2015 type of protection:

II 1/2 G Ex ia IIC T4 Ga/Gb
II 1 D Ex ia IIIC T100°C... T130°C Da

It bears the EU-TYPE-EXAMINATION CERTIFICATE number EPS 14 ATEX 1 682 X. (Available materials and design versions see chap. 2.3 and 3.1.1)

Special conditions:

1. Instructions of the user manual have to be observed, particularly with regard to reduced ambient temperatures.
2. Explosion protection depends in particular on the leak-tightness of the sensor tips. Therefore the monitoring head shall only be used in media, to which the material is suited with regard to corrosion resistance.
3. With Titanium sensors as wetted parts, a probable occurrence of impact or friction sparking has to be excluded by using suitable mounting methods.
4. Maximum surface temperatures (for dust) as a function of medium temperatures:

max. medium temperature [°C]	max. surface temperature [°C]
45	100
50	105
55	110
60	115
65	120
70	125
75	130

2.2 Classification Zones

Classification zones are described for areas where combustible gases, vapours or mist constitute an explosive hazard. When determining the explosion hazard, i.e. when categorising explosive areas, the European standard EN 13237, “Potentially explosive atmospheres - Terms and definitions for equipment and protective systems intended for use in potentially explosive atmospheres” have to be taken into account. In special cases or in case of doubt the determination is done by the supervising authorities.

2.2.1 Equipment group II, category 1 (Zones 0 and 20)

Equipment of this category is for use in areas where an explosive atmosphere consisting of gas, vapour, mist (zone 1) or of inflammable dust/air mixtures (zone 20) is present continuously or for long periods. Normally this applies only to the inside of containers or apparatus (vaporizers, pipe systems etc.). In these zones only electrical apparatus must be used carrying an EC type test certificate issued by an acknowledged authority and only those which have been explicitly approved for these zones.

2.2.2 Equipment group II, category 2 (Zones 1 and 21)

Equipment of this category is for use in areas where an explosive atmosphere consisting of gas, vapour, mist (zone 1) or a cloud of inflammable dust in air (zone 21) is likely to occur. This may be the case for the surroundings of zones of category 1, the surrounding area of filling or draining systems.

For zone 21 these are also areas where dust deposits occur and during normal operation may build up an explosive concentration of inflammable dust in combination with air.

2.2.3 Equipment group II, category 3 (Zones 2 and 22)

Equipment of this category is for use in areas where an explosive atmosphere consisting of gas, vapour, mist (zone 2) or a cloud of inflammable dust in air (zone 22) is unlikely to occur. If it does, it would be infrequent and for a short time. This may be the case for the surroundings of zones 0 and 1 as well as areas around flange connections or pipe lines in closed areas.

For zone 22 it could also be surroundings of dust-containing apparatus, protective systems and components which might lose dust from leakages and build up dust deposits (e.g. mill rooms, clean air side of filters in outlet air pipes).

(Information about zones and categories in accordance with EN 1127-1:2011 [detailed for inflammable gas, vapour and dust: EN 60079-0:2012], rules for avoid danger by explosive atmosphere and classification of explosion protection zones, with example library [BGR 104, Explosionsschutz-Regeln - EX-RL])

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For zone 22 it could also be surroundings of dust-containing apparatus, protective systems and components which might lose dust from leakages and build up dust deposits (e.g. mill rooms, clean air side of filters in outlet air pipes).

2.3 Materials used for calorimetric monitoring heads

The following information contains general recommendations which must be rechecked by the user for the individual application.

2.3.1 Stainless steel no. 1.4571 / AISI 316 Ti

⚠ The standard monitoring head material is stainless steel 1.4571, an austenitic, acid resisting stainless steel that is commonly used throughout industry. Manufacturers claim it also withstands oxidizing organic and anorganic acids, and partly even reductive media.

The resistance of this stainless steel should however be verified by the user, particularly when it is used in medium mixtures that may from time to time be exchanged with cleansing agents. Its chemical resistance also depends on temperature, flow rate and concentration of the medium.

Stainless steel owe their resistance to rust mainly to their alloy combination with chromium, the formation of chromic oxide on the steel surface resulting in a passive state. Contamination, deposits on the surface, or foreign rust may however neutralize the passivity. Therefore care should be taken to keep the surfaces clean.

Stainless steel heads must not get in contact with steel parts other than stainless steel or with chemically dissimilar metals, as this would cause electrolytic corrosion.

2.3.2 Nickel-based alloy Hastelloy C4, no. 2.4610

⚠ Hastelloy 2.4610 is a material with a chemical resistance generally exceeding that of stainless steel. It is particularly suitable for alkaline media (pH > 7). It should however be examined for suitability for each specific application using resistance tables and pragmatical values.

2.3.3 Titanium G7, no. 3.7235

Titanium is characterised by non-magnetizability and excellent corrosion resistance, particularly against oxidising media. The resistance is due to the fact that the surface of titanium immediately builds up an oxidation layer in presence of oxidation means protecting the material beneath against corrosion.

The technological characteristics of low-alloy titanium G7 are equal to those of plain titanium of the same strength category. Adding approximately 0.2 % palladium does not influence the mechanical properties, but also adds considerably to the corrosion resistance of plain titanium. So titanium G7 has proved to be extremely suitable for use in hydrochlorid or sulphuric acid solutions with little concentration as well as – with due care – in oxalic acid.

A wide range of applications is possible in aggressive media an zones endangered by sea water.

Please note that physical contact between titanium and magnesium, aluminium, copper or their alloys might lead to increased electrolytic corrosion of these materials.

2.4 Temperature limits

2.4.1 Gases

Maximum media temperature in zone 0 is 75°C. This value also depends on the medium used which might limit the actually allowed temperature.

According to valid standards for use in equipment group II, category 1 (zone 0) and with regard to avoiding potential ignition sources the temperatures of all surfaces – even with very rare operating troubles – must not exceed 80% of the ignition temperature of an inflammable gas, measured in °C.

Therefore the user has to take care that the temperature limits of his particular medium be expressly stipulated in accordance with the known ignition temperature (see DIN EN 1127-1:2011, German version, „Explosive atmospheres - Explosion prevention and protection - Part 1: Basic concepts and methodology;“ chapter 6.4.2: hot surfaces, category 1).

For applications in category 2 the special temperature limit must only be exceeded in rarely occurring operating troubles.

2.4.2 Dust

The labelling temperature (T100°C...T130°C) depends on the maximum admissible medium temperature, see table in special conditions.

Therefore the user has to take care that the temperature limits be expressly stipulated by means of the determined ignition temperature (to the method stipulated in EN 50281-2-1) of a cloud of dust or the smouldering temperature of a dust layer of his particular medium (see EN 50281-1-2, electrical apparatus for use in areas with inflammable dust, para 6: temperature limitation).

2.5 Cable length

The monitoring head CST-Ex is connected to the flow monitor FC01-Ex by means of an 8pole, paired connection cable with overall shield.

The shield is grounded on both sides, on the potentially explosive and the non-hazardous side, to prevent inductive interference. To prevent any potentially inflammable currents from flowing over the shield, it is imperative to observe the following:

Installation has to ensure to a high degree that there is equipotential bonding between each end of the circuit. In order to ensure that the shield will not become >1 Ohm and induce potential differences, it may be necessary to ground the shield at additional positions.

If this is technically not possible, the max. cable length has to be restricted to 50 m (ssee DIN EN 60079-14:2003, German version, Electrical installations in hazardous areas (other than mines), section 12.2.2.3, grounding inductive systems [with example]: special case b).

3 Installation - CST-Ex Sensor

3.1 Installation - calorimetric monitoring head

3.1.1 Mechanical installation - thread-mounted monitoring head CST-Ex

Application:

The monitoring head is designed for use as prescribed in explosive atmospheres to directive 2014/34/EU. The coated sensor tips are immersed into the medium of the equipment group II, category 1 (zone 0 and 20).

Process connectors:

G1/2“A (L = 27.5 mm)
G1/2“A (L = 36 mm)
1/2“NPT

Material of area exposed to medium:

stainless steel X6CrNiMoTi17 12 2, 1.4571 to DIN 17440 (V4A) (standard material for water, acids, alkalines, gases).
Nickel-based alloy Hastelloy alloy C4 2.4610
Titanium G7 3.7235

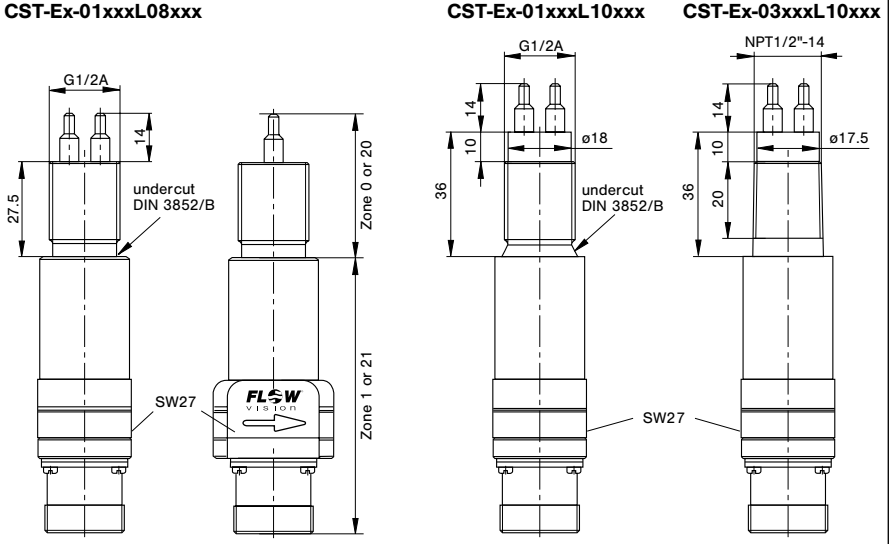


fig. 1

3.2 Mounting instructions

Check that the monitoring head is suitable for the medium to be monitored. The monitoring head must only be used for media against which the sensor material is sufficiently chemically or corrosion resistant.

When using titanium installation has to ensure that impact and friction sparks cannot occur.

- Compare monitoring head with pipe fitting and check, whether fitting or T-piece have the corresponding internal thread and whether the length of the process connection is correct.
- The two sensors (M) should be screwed into the pipeline far enough to ensure that they are aligned side by side directly across the direction of flow. The sensors are correctly positioned when the wrench flats (S) are aligned parallel with the pipeline.

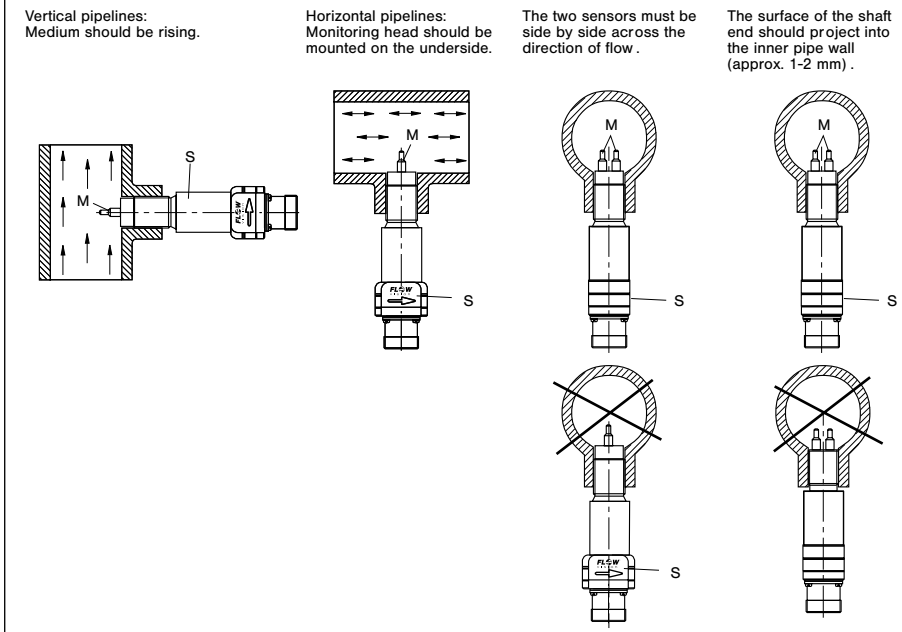


fig. 2

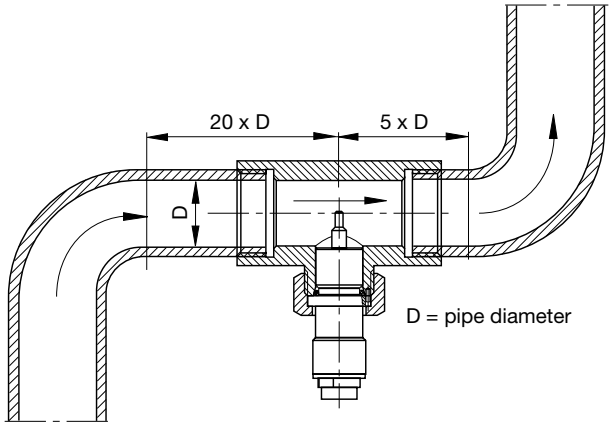
3.2.1 Point of installation for gases

The mounting attitude is unimportant. For much disturbed velocity profiles, above all for a superimposed swirl-flow, there should be a distance of 20 to 50 pipe diameters (D) before the monitoring head in order to eliminate high deviations in the values measured.

- The monitoring head should be installed only in a straight section of piping.
- Flow direction of the medium should correspond to the direction of the arrow on the sensor.

It is generally recommended to observe the following distances:

- distance before the monitoring head 15 ... 20 x D
- distance after the monitoring head 5 x D



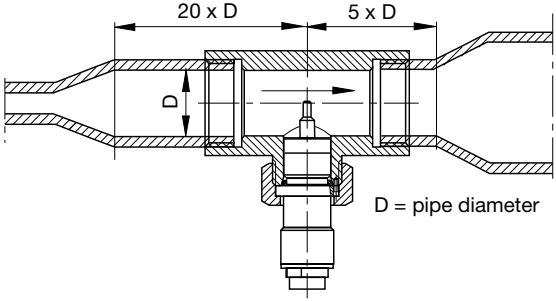


fig. 3

3.2.2 Depth of threading

The two sensors should be screwed into the pipeline far enough to ensure that the sensors are positioned fully in the flow stream. However, care should also be taken that the sensor is not screwed in too far, thus causing an undue restriction in the pipe bore. It is therefore recommended to connect a union of suitable length to the pipe.

If installed in fittings or T pieces with appropriate internal thread the max. length of the connection piece must be adjusted to the inner pipe wall.

The sensors must be positioned fully in the flow stream. Observe installation position, direction and required insertion depth. Ex monitoring heads must be screwed in at least 7 threads.

Installation depth:
Up to 56 mm inner pipe diameter the fitting of the monitoring head has to be flush with the inner pipe wall.

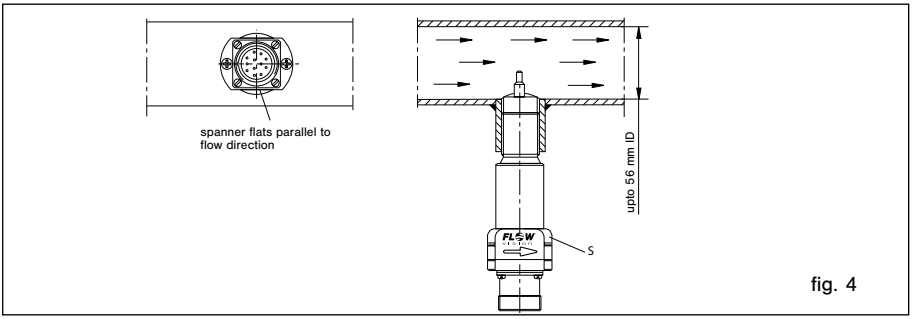


fig. 4

With inner pipe diameters of > 56 mm the middle of the probe (chamfer) must be screwed in to 1/8 of the inner pipe diameter.

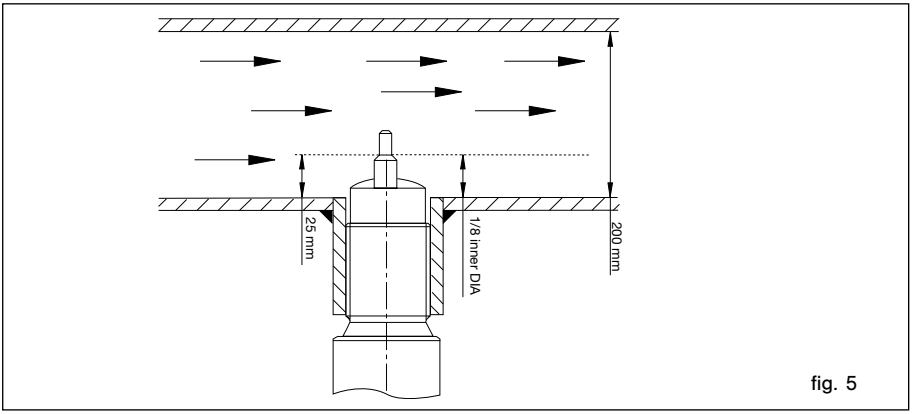
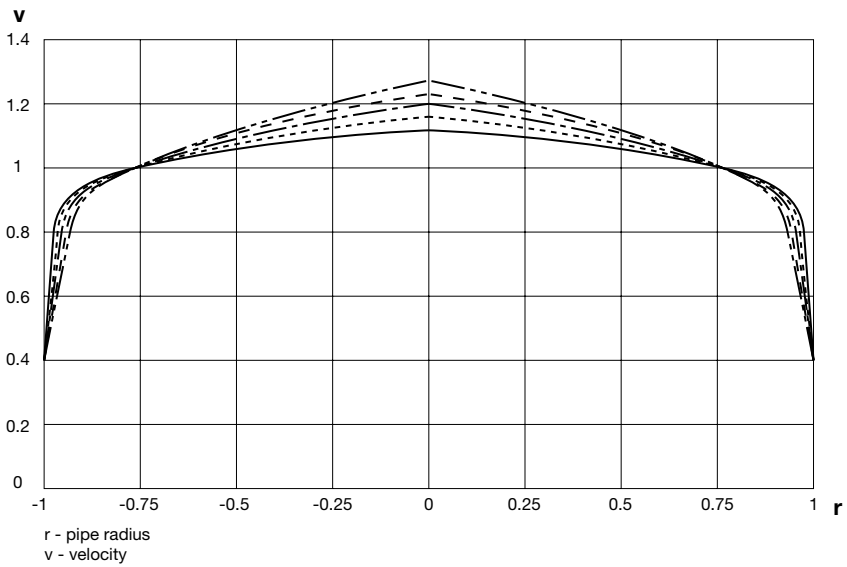


fig. 5

Example:
With an inner pipe diameter of > 56 mm the coupling should be pushed into the pipe to the calculated installation depth.

Standard velocity profiles:
(for pipe radius =1 and for velocity averaged via total pipe cross section = 1)



Velocity range at X = 1/8 dia.

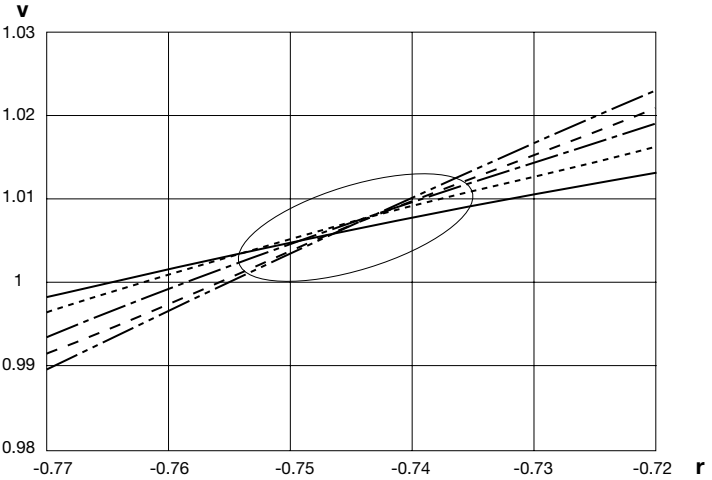


fig. 6

Max. accuracy is achieved with an insertion depth of x = 1/8 inner pipe dia. (fig. 7).

3.2.3 Sealing

Use suitable thread sealing, e.g. hemp, teflon band, sealing glue:

- with fitting to DIN 3852, form A (with O-ring) → length 36 mm
- with fitting to DIN 3852, form B (with sealing face) → length 27.5 mm

Please pressurize the pipe system and check with regard to leakages.

3.3 Electrical connection

The power supply to monitoring head CST-Ex is an intrinsically safe, ungrounded passive N-terminal output from XSK of the FC01-Ex via Stahl safety barriers, EG-TYPE-EXAMINATION CERTIFICATE PTB 01 ATEX 2053.

Connection is by means of a light-blue LiYCY cable, 4 x 2 x 0.75 mm^2, variable in length.

- Lay signal cable (shielded, blue) to DIN EN 60079-14:2003, chapter 12.2.2.3 (see also chap. 2.5).

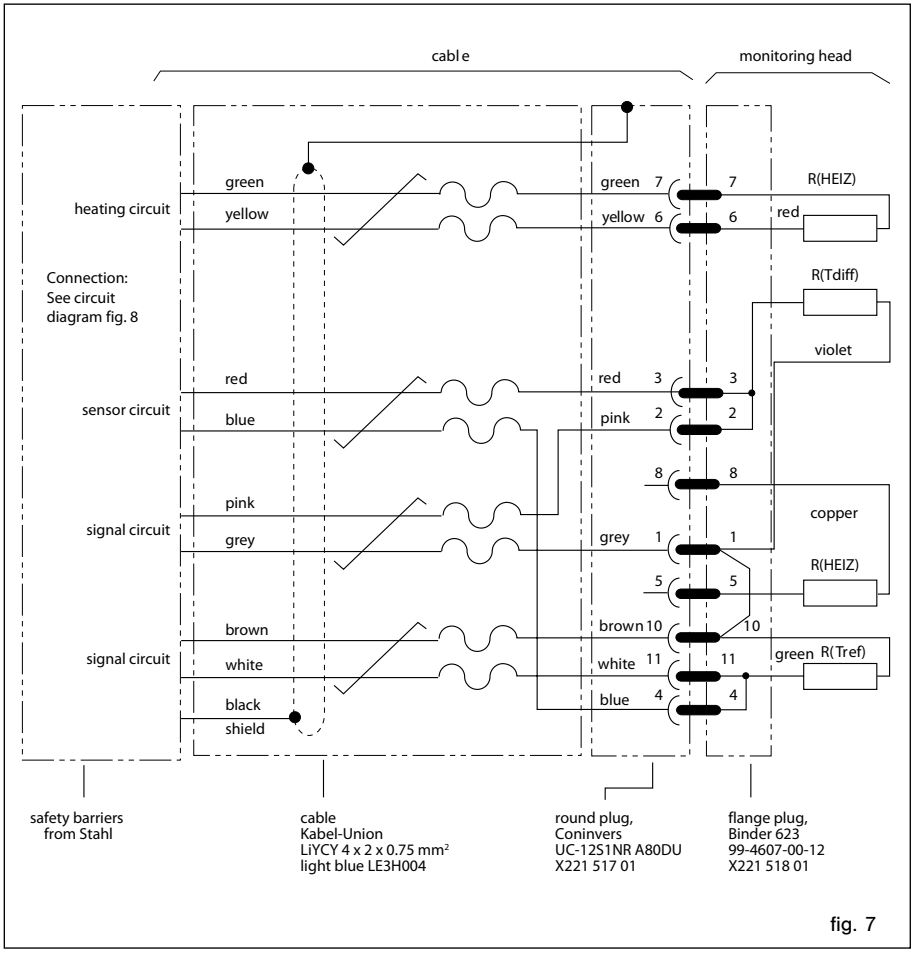
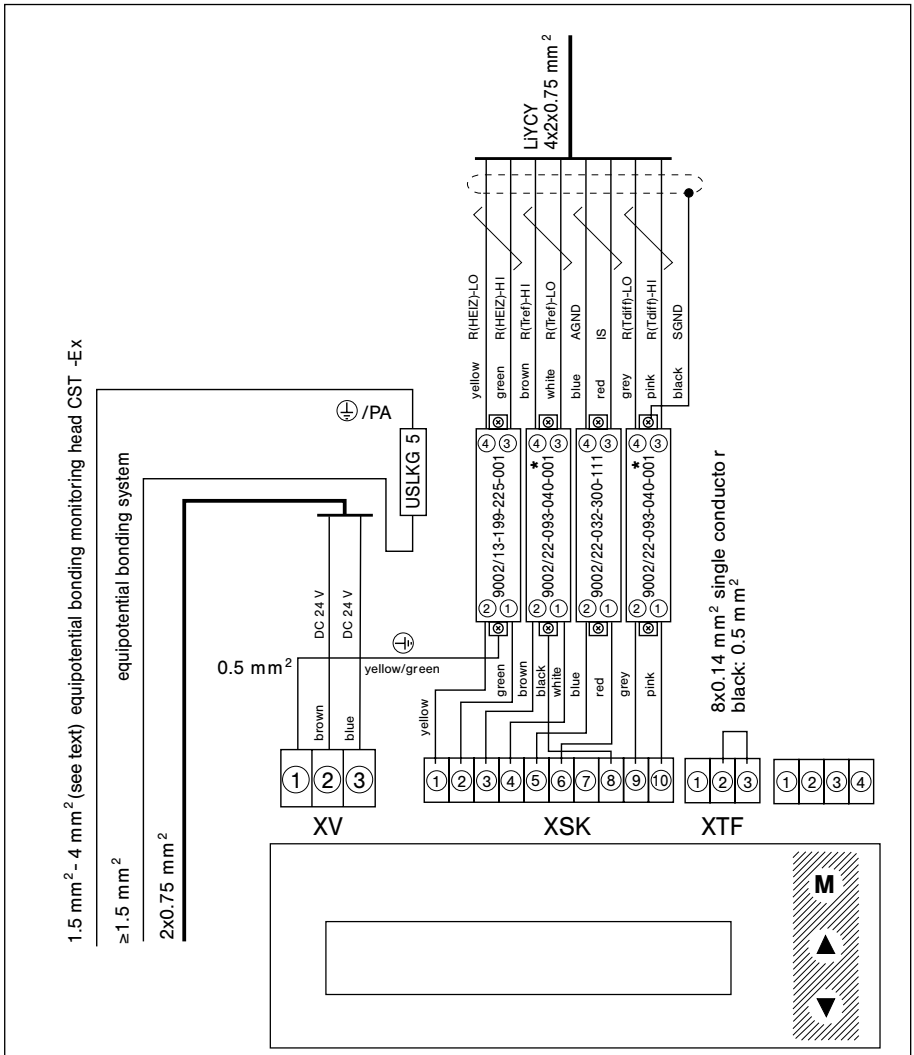


fig. 7

- Install equipotential bonding along the complete cable run of the intrinsically safe circuit from the monitoring head to the grounding system near the flow meter.
- Min. cross section for protected installation is 1.5 mm2, for unprotected installation 4 mm2.
- Hand tighten connector of the signal cable to the monitoring head.



*identical with 9002/77-093-040-001

fig. 8

4 Installation of electronic control unit FC01-Ex

4.1 Mechanical installation

- The enclosure is installed by 4 retaining screws.
- The surface mounted enclosure meets protection degree IP54.

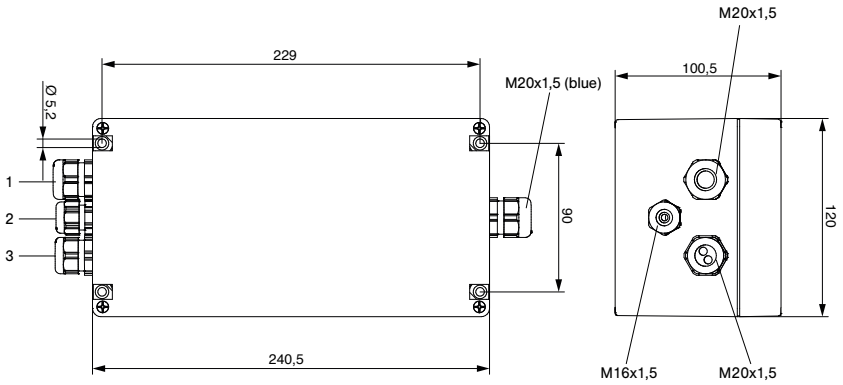


fig. 9

4.2 Electrical connection

- Take the FC01-Ex equipotential bonding cables (≥ 1,5 mm2) from the monitoring head through the cable gland 1 (fig. 8) and to the centre grounding system (fig. 9) and connect to terminal USLKG5.
- Take the cable of the monitoring head through the cable gland and connect to the barriers according to the connection scheme FC01-Ex (fig. 8).
- Take supply feed through cable gland 2 and further required connection cables through cable gland 3 (fig. 9) and connect to terminals XV (see connection scheme fig. 8).

XV - Power supply

Connection:		3-pole connector; Amax = 1.5 mm²; 3 x 0.75 mm² cable recommended
Pin No.	Signal name	Function
1	SGND	general reference ground/shield ground
2	+UV	positive pol of supply voltage
3	-UV	negative pol of supply voltage

XTF - Keyboard release

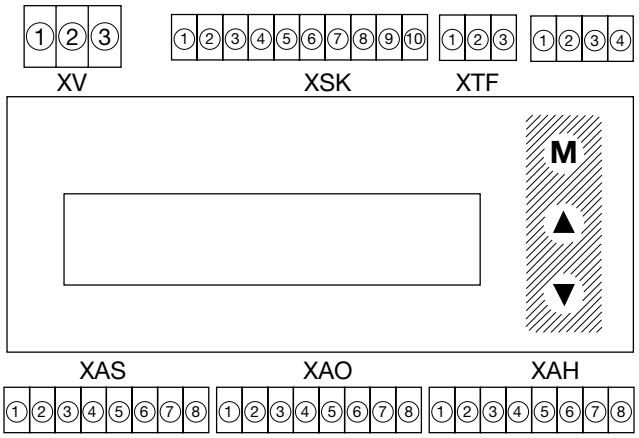
Connection:	3-pole connector, factory-wired

XAO - Analogue outputs

Connection:	8-pole connector; Amax = 1.5 mm²; LiYCY 2 x 0.25 mm² cable recommended, stripped length 6.5 mm

Pin selection for analogue outputs V1, V2, C1

Pin No.	Signal name	Function
1	NC	none
2	ANAO1	analogue output 1 - flow
3	ANA1GND	reference potential for analogue output 1
4	SGNDA1	shield for analogue output 1 (ungrounded)
5	SGNDA2	shield for analogue output 2 (ungrounded)



XV - power supply
XSK - calorimetric monitoring head
XTF - keyboard release
XAS - not released for user
XAO - analogue outputs
XAH - signal outputs

fig. 10

6	ANAO2	analogue output 2 - temperature
7	ANA2GND	reference potential for analogue output 2
8	NC	none

XAH - Limit value signal outputs - relay outputs - change over contacts

connection: 8-pole connector; A_{max} = 1.5 mm² ;
LiYCY 3 x 0.38 mm² cable recommanded,
stripped length 6.5 mm

Pin No.	Signal name	Function
1	SGNDL1	shield ground 1
2	LIM1	non-inverted signal output 1 (N/0)
3	LIM1COM	common change over input 1
4	/LIM1	inverted signal output 1 (N/C)
5	SGNDL2	shield ground 2
6	LIM2	non-inverted signal output 2 (N/0)
7	LIM2COM	common change over input 2
8	/LIM2	inverted signal output 2 (N/C)

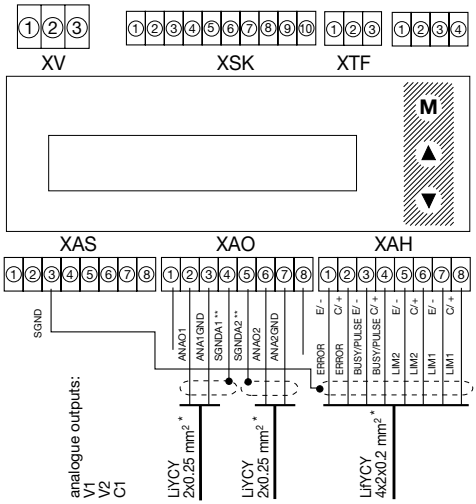
XAH - Signal outputs - transistor outputs (NPN, freely connectable)

Connection: 8-pole connector; A_{max} = 1.5 mm²;
LifYCY 4 x 2 x 0.2 mm² cable recommended,
stripped length 6.5 mm

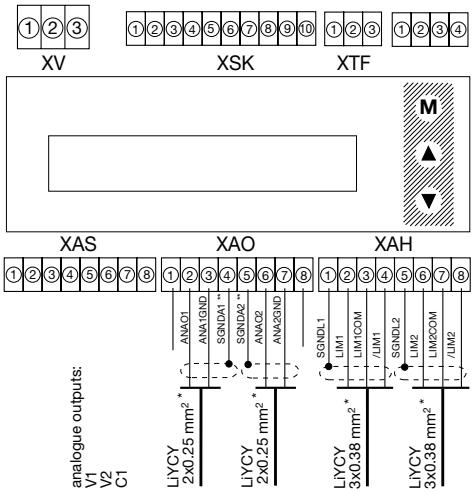
Pin No.	Signal name	Function
1	/ERROR E	summarized error indication - emitter terminal
2	/ERROR C	summarized error indication - collector terminal
3	/BUSY/PULSE E	availability signal or frequency output - emitter terminal
4	/BUSY/PULSE C	availability signal or frequency output - collector terminal
5	LIM2 E	limit value 2 - emitter terminal
6	LIM2 C	limit value 2 - collector terminal
7	LIM1 E	limit value 1 - emitter terminal
8	LIM1 C	limit value 1 - collector terminal

4.2.1 Circuit diagram FC01-Ex

Version: 24 V, open collector outputs



Version: 24 V, relay outputs



E/ - emitter terminal
C/+ collector terminal
* recommended
** SGNDA1, SGNDA2 } ungrounded

Apply shield on one side only.

fig. 11

4.2.2 Electrical connection - frequency output (version FC0 1-Ex-U1T4)

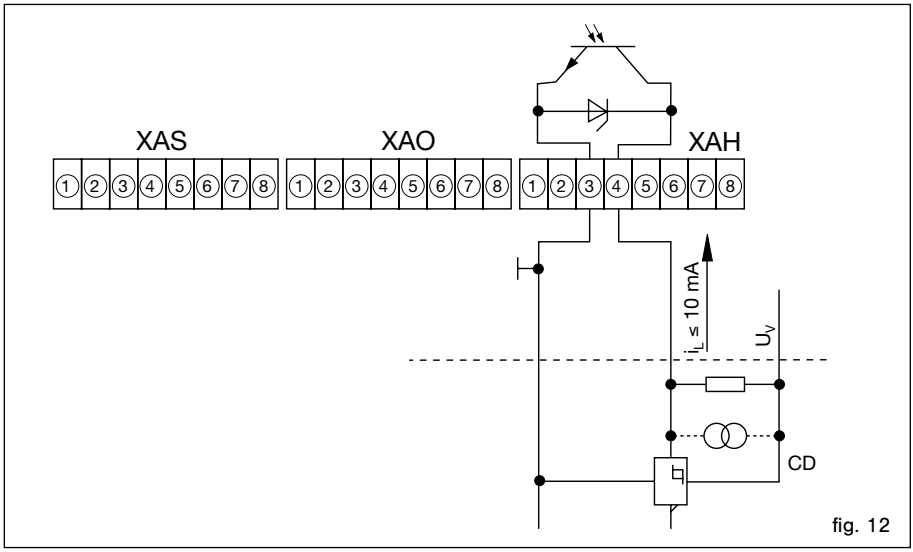


fig. 12

The quantity-dependent pulse to operate a counter or higher-order control is available at connector XAH /BUSY E/- and /BUSY C/+ (pins 3 and 4) (see fig. 11 - Circuit diagram FC01-Ex - open collector output).

Signal ground shall be connected to pin 3 (BUSY E/-) and the driving load to pin 4 (BUSY C/+).

Select cable size ≤ 1.5 mm² to make the connections.

The shield can be connected to connector **XAS**, pin 3.

Electronic signal processing
If the frequency output of the FC01-Ex-CA-U1T4 is connected to an electronic counter, computer or PLC, the load current should not exceed 10 mA so as to ensure low level is 0.8 V. The max. admissible voltage level of 48 V is irrelevant in this connection.

Typical circuit (example 1)
The FC01-Ex-CA-U1T4 driver output comprises an integral safety circuit which when isolating the counter operating coil will limit overvoltages caused by inductance and convert the energy stored.

The counter should be able of processing a counting frequency of ≥10 Hz.

Pulse duration is not dependent on frequency and maintained at 50 ms (±0.1%).

It should therefore be ensured that the counter can be increased by one during the time available.

If a separate relief network is preferred to the integral network, care should be taken when processing the max. frequency of 10 Hz to ensure the energy stored in the operating coil has dissipated by the time the counter output is reset. The time to do this should be below 40 ms, making due consideration to switching times and pulse variations.

Typical circuit (example 2)

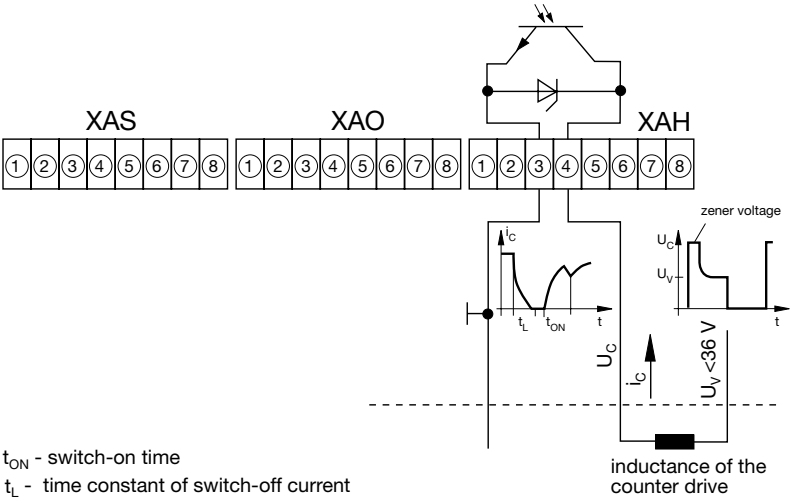


fig. 13

Note:

- As there will be a reset pulse available at the output in the moment the supply voltage of the FC01-Ex-CA-U1T4 is applied, make sure that the counter is switched on delayed or set to zero after it has been switched on.

5 Normal environment

5.1 Measuring procedure

5.1.1 Calorimetric measuring procedure

The calorimetric measuring procedure is based on the physics of heat dissipation, i.e. a body with a temperature higher than its surroundings supplies a medium flowing past that body with energy in the form of heat. The amount energy supplied is a function of temperature difference Δ and mass flow.

Flow Meter FC01-Ex operates on the CTD (Constant-Temperature-Difference) method:

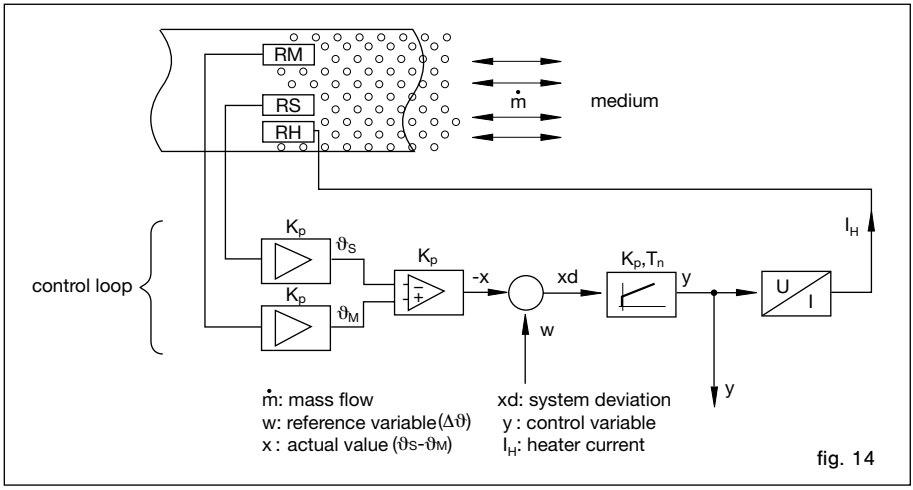


fig. 14

The temperature difference Δ between the two sensors is kept constant and the mass flow is determined by measuring the calorific power.

Fig. 14 is a schematic diagram of a CTD method based sensor. Two temperature-sensitive resistors (sensor elements RS and RM) are immersed in the medium. Sensor RM assumes the temperature of the medium $_{M}$ whilst heater resistor RH heats element RS to temperature $_{S}$. As a function of the medium, the temperature differential $\Delta = _{S} - _{M}$ is preselected as a reference variable by the CTD control with y characteristics and is kept constant. The required calorific power is a function of mass flow so that the control variable y of the control can be used for evaluation.

Major benefits of this method are:

- Fast response, particularly to sudden flow standstill.
- Medium temperature measurement, providing optimum temperature compensation.
- Increased safety because the sensor cannot be overheated during flow standstill.

The flow rate is determined by mass flow.

5.1.2 Physical principles of gas measurement

With the exception of Coriolis meters and calorimetric flow meters, flow meters used for gas measurement are pure volume flow meters that require density ρ to determine mass flow Q from the volume flow measured:

$$Q = V \times \rho$$

Coriolis meters are used for higher mass flow quantities and higher densities only, where density is directly proportional to pressure and inversely proportional to temperature (related to absolute Kelvin scale).

The quantity required in general practice is mass flow as it indicates the exact gas quantity, whereas volume flow only defines the volume the gas has adopted during the measurement

procedure.

5.1.3 Standard and operating volume flow

Standard volume flow

The calorimetric measuring procedure measures the existing standard volume flow or mass flow without requiring additional pressure and/or temperature measurements. Like velocity changes, pressure fluctuations cause fluctuations in standard volume flow which are indicated as such. The standard volume flow indicated relates to 1,013 mbar/ 14.89 PSI and a temperature of 0 °C.

Operating volume flow

The standard volume flow value is converted into operating volume flow by means of the “ideal gas equation”:

$$\frac{P \times V}{T} = \text{constant}$$

with P being pressure, V the volume and T the temperature (related to the absolute Kelvin scale). The pressure to be set on the electronic control unit FC01-Ex and the current temperature measured are taken into account and used as a basis. Calculating operating volume flow is only reasonable when pressure is known and constant.

The assigned velocity rates (averaged on the pipe section) are converted from standard conditions to operating conditions the same way as volume flow.

5.1.4 Consumption measurements

The FC01-Ex with CST-Ex-11AM - monitoring head is suitable for compressed air and other gases. Its electronic control unit comprises two freely scalable linearised analogue outputs, i.e. one for temperature, the other for mass flow, standard flow or operating volume flow. A pulse output and totalizer for consumption measurements are other added features. It also provides limit value monitoring of flow and temperature, ensuring reliable operation of the load.

5.1.4.1 Leakage measurements

When monitoring compressed-air flow at some selected points during a production-free period, you will realise that even in carefully maintained compressed-air systems there is still compressed air consumed. Reliably detecting even the smallest of such leakage losses can be facilitated by means of the adjustable zero suppression of the FC01-Ex. If the system is permanently monitored for leakage flow, leakages caused by valves left open etc. and new leakage points can easily be detected.

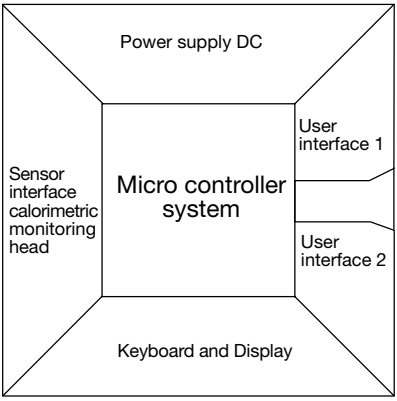
The FC01-Ex also allows the detection of leakages on duty by comparing two equal loads with each other. The difference measured can be directly assigned to the leakage flow.

Note:
Please observe the accuracy data of FC01-Ex and relevant CST-Ex monitoring head.

5.2 System description

The system comprises the following hardware functional modules:

Input voltage:	DC supply (terminal XV)
User interfaces:	
analogue output:	1 and 2 (terminal XAO)
signal outputs:	2-way or 4-way signal outputs (terminal XAH)
Sensor interface:	calorimetric monitoring head (via safety barriers)
Keyboard and display:	keypads liquid crystal display
µ controller system:	signal processing and monitoring



Input voltage:	DC 19 … 32 V	
User interface 1:	relay outputs:	2 limit values
	transistor outputs:	2 limit values + 1 error indication + 1 busy signal or frequency output (software selected)
User interface 2:	analogue outputs current or voltage	
Keyboard/Display:	keypads LC display 2 x 16 digits	
Sensor interface:	calorimetric monitoring head type CSx	
Controller system:	signal processing I/O - controlling monitoring parameter memory	

fig. 15

The power supply is physically isolated between power supply input and system power supply output. This also applies to the analogue outputs which are physically isolated from each other as well as from the other electronics and the signal outputs. The signal output channels are also separate and electrically isolated from the central electronic unit.

There is no electrical isolation between monitoring head and central electronic unit.

Connection of the monitoring heads is by means of precut cable links.

Cables and user interface connections are shown in para. 4.2 and circuit diagram 4.2.1.

System configuration and parameter setting are by means of the keyboard if default values need to be changed. (paras. 8 and 9,)

This mainly applies to monitoring head selection, signal outputs (switch point setting) and analogue outputs (zero point setting and scaling).

5.3 User interfaces

Signal outputs: (optional)

1. **R2** - Relays outputs (2 limit values)
   Two-channel physical isolation, relay change over contact.
   The channels may be assigned in menu “CONFIGURATION”, either individually or in pairs, to the physical quantities of temperature or flow. The switch on and off values can be set as desired in menu “PARAMETERS” (yet within the measuring range) for each contact.
   Please see chap. 12 for electrical connection.

2. **T4** - Transistor outputs (2 setpoints + 2 status outputs or 2 setpoints + 1 status output + 1 frequency output)
   Four-channel physical isolation, transistor output - collector/emitter freely connectable.
   Channel 1: common error signal
   Channel 2: busy signal or frequency output
   Channels 3 and 4: Both channels may be assigned individually or in pairs to the physical quantities of temperature or flow. The switch on or off values of each transistor output can be set as desired.
   Please see chap. 12 for electrical connection.

Analogue outputs: **Two-channel physical isolation**, current or voltage output
Please see the ordering number to find out whether it is a current or voltage output.

Output quantities:	0/1 - 5 V FS	(option V1)
	0/2 - 10 V FS	(option V2)
	0/4 - 20 mA FS	(option C1)

These FS (full scale) output quantities apply to both channels as standard.

20% zero elevation and FS value can be programmed. (See chap. 8.11)
Shield connections are ungrounded.

The shields of the signal cables should be applied on one side only.

Power supply: DC supply with physical isolation of the primary and secondary side. Power supply is by means of an isolating transformer. One of the secondary voltages is regulated as actual value. The control variable is fed, physically isolated, to the pulse duration modulator.

Noise emission on the connection cable is limited by circuit design and filter.

A PTC is used as overcurrent protection. After remedy of the failure it resets automatically. Please see para. 12 for technical characteristics.

6 Operation

Clear menu-driven control, via keyboard and display, enables easy definition of parameters and configuration. This provides high system flexibility, making the FC01-Ex the optimum solution for a wide variety of measuring, monitoring and display tasks. When programming the FC01-Ex the user is guided by plaintext in the display through menus in which he may enter or select the required functions.
All functions are distributed on the three following menu levels:

MAIN LEVEL (MENU)

CONFIGURATION LEVEL (MENU)

PARAMETER LEVEL (MENU)

See Appendix 2 listing all functions available.

Keypads Ⓜ MODE, ▲ UP and ▼ DOWN

Setting and configuration is by means of three front touch switches Ⓜ MODE, ▲ UP and ▼ DOWN. It is also required for setting the unit to simultaneously press ▲ UP and ▼ DOWN = ▲ + ▼

Caution!

The FC01-Ex can only be set or operated when connector XTF (keyboard release) is removed!

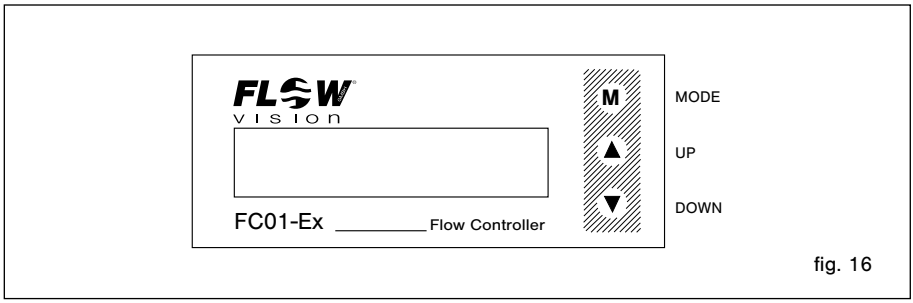


fig. 16

Menu paging

The next menu option is selected by pressing (M) MODE (forward paging).
Pressing (M) MODE after the last menu option will cause skipping to the first option of the menu.

Calling a menu option

Simultaneously pressing (▲) UP and (M) DOWN = (▲) calls the selected menu option, or causes skipping to the selected submenu.

Entry of numerals

Some menu options require numerical values to be entered. After selecting the appropriate menu option, the value indicated can be changed by pressing (▲) UP or (▼) DOWN.

Each time (▲) UP or (▼) DOWN are pressed, the value indicated will be increased and reduced respectively, by one numeral skip. The longer (▲) UP or (▼) DOWN are pressed, the faster the increase or reduction.

Transfer of entries

Pressing (M) MODE transfers the set value or the selected menu option to a volatile memory. A permanent transfer of settings and values is only effected when quitting the menu, after a plausibility check of all entries.

Afterwards the data will be available even after repeated on/off operation of the FC01-Ex.

Deleting data

Selected data such as MIN or MAX values can be deleted or reset by simultaneously pressing (▲) UP und (▼) DOWN = (▲ + ▼).

Caution!

After configuration and parameter selection re-connect plug XTF (keyboard release) to protect the system against unauthorised access.

7 Operation and main menu

7.1 Switch-on performance

Upon power application **POWER ON TEST** will be shown on the display for approx. 2 sec., with the **software version number** being indicated in the second line.

During this period, the integral controller will conduct test routines (see para. 11.1, Test and diagnosis).

If during the test no error was found, the display will indicate either **HEATING UP**. The FC01-Ex will then be in the heating up period required for the measuring procedure.

7.2 Measuring cycle

Upon completion of the heating up period (only applicable to calorimetric sensors) and availability of the first measured value, the display will change to measuring cycle, and the user interfaces such as analogue outputs or limit switches will be up-dated.

Note:
It is not possible to configure or select parameters of the system during the measuring operations! All options of the main menu may be addressed without affecting the measuring and monitoring function.

Menu option values:

PEAK VALUE MIN

PEAK VALUE MAX

LAST ERROR

TOTALISATOR

may be deleted simultaneously operating the ▲ UP und ▼ DOWN = (▲ + ▼) switches without affecting the measuring operations.

Over limits of the measuring range
Theoretically established measuring values will be used when the measuring range of calorimetric monitoring heads is exceeded (air 0 ... 50 m/s). The FC01-Ex can thus be operated beyond the measuring values defined, i.e. up to 75 m/s in the medium air for a standard flow speed of up to 75m/s.

Above 75 m/s the error message „ERROR 30“ indicates exceeding of the display range.

This feature will not affect the accuracy specified for the measuring ranges defined whilst no accuracy information can be given for conditions where the measuring ranges are exceeded.

Analogue output, limit switches etc. can be set beyond the measuring range. When per cent display is selected, the defined measuring range will correspond to 0 ... 100% (>100% when the defined range is exceeded).

The following operating data may be retrieved in the main menu during the measuring cycle: (see para. 7.2)

7.2.1 Operating data

9.2.1.1 Measured value(s)

Flow rate and medium temperature (not with turbine-type sensor) are indicated by the units selected in the upper line of the LC display.

The lower line of the display will optionally show the switching condition of the limit switches and an analogue bar with a 10-segment resolution, or the flow volume/time unit pertinent to the indicated flow rate or the totalized flow volume (totalizer function).

The analogue bar has different meanings, depending on its configuration (see para. 8.9 - menu option BARGRAPH).

The limit switches are identified according to their physical assignment, i.e. by **F** for flow rate and **T** for medium temperature, at the first or last place of the second line on the display.

If **F** and **T** are shown reversed, the limit switch is in the switch-on condition.

Limit switches lying within the analogue bar range are also represented at the appropriate place of the analogue bar (see para. 8.9).

The following figures show the display variants under menu option “Measured value(s)” (para. 8.8 - menu option DISPLAY SELECT and 8.10 - menu option FREQUENCY OUTPUT).

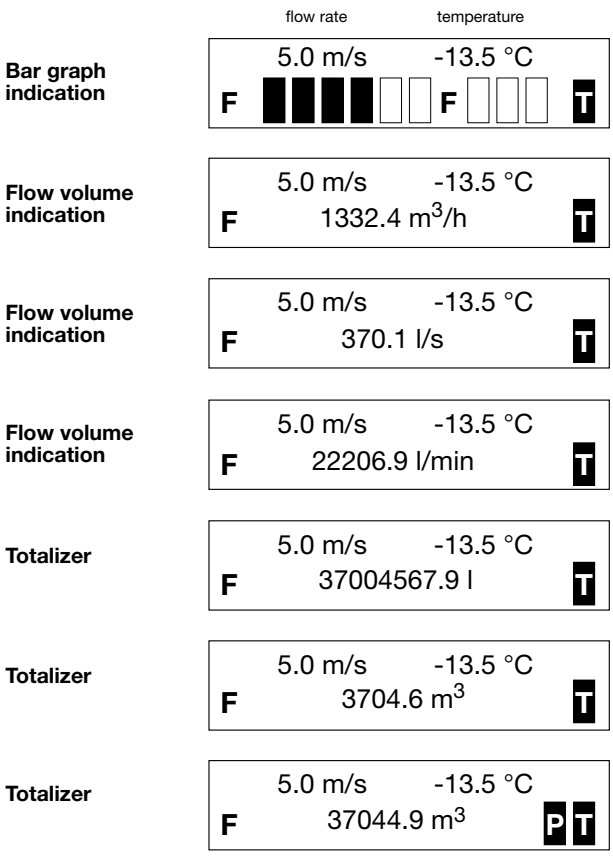

flow rate
temperature
Bar graph indication
5.0 m/s -13.5 °C
F F T
Flow volume indication
5.0 m/s -13.5 °C
F 1332.4 m3/h T
Flow volume indication
5.0 m/s -13.5 °C
F 370.1 l/s T
Flow volume indication
5.0 m/s -13.5 °C
F 22206.9 l/min T
Totalizer
5.0 m/s -13.5 °C
F 37004567.9 l T
Totalizer
5.0 m/s -13.5 °C
F 3704.6 m3 T
Totalizer
5.0 m/s -13.5 °C
F 37044.9 m3 P T
T Temperature, active (invers representation) „switch-on condition“
F Flow rate, passive
P Frequency output selected (invers representation) „switch-on condition“

fig. 17

7.2.1.2 Peak values

(menu option: PEAK VALUE MIN / PEAK VALUE MAX)

The FC01-Ex comprises four specific measured-values memories.

They store the lowest and highest value of flow rate and medium temperature.

After switch-on or NOT-BUSY indication, the minimum and maximum values are deleted and will be continuously updated (non-return pointer principle).

The peak values may be retrieved in the main menu and are deleted by simultaneously pressing (▲) UP und (▼) DOWN = (▲ + ▼).

Power failure or disconnection of the power supply will delete the contents of the four measured-values memories.

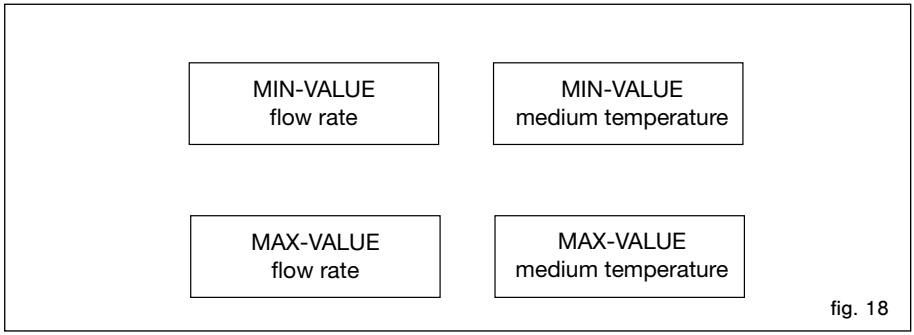


fig. 18

7.2.1.3 Low flow suppression (menu option: ZERO SUPP.)

The setting range for the low flow suppression option is between 1 and 10 % of the measuring range final value. This means that flow volumes measured below that limit value are set at zero.

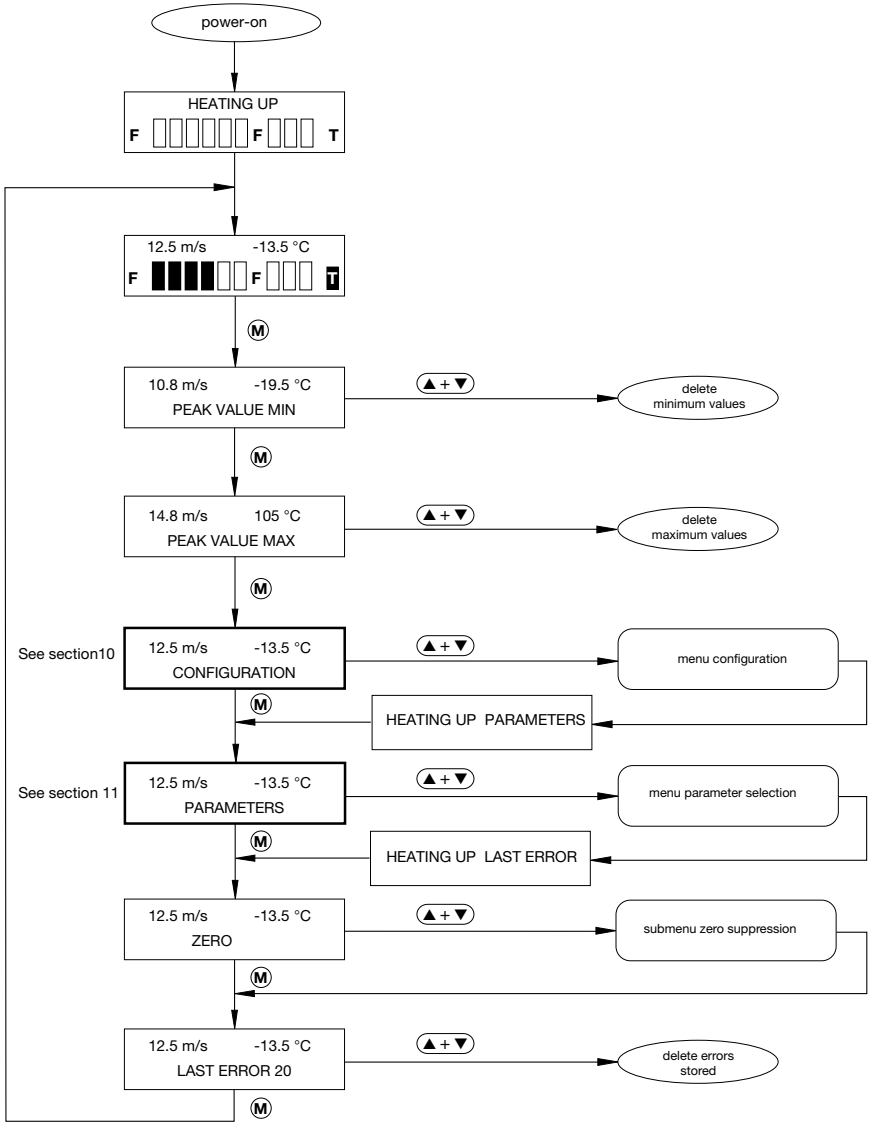
Selecting zero setting causes the current flow to be set at zero.

MIN. FLOW = xx%

7.2.1.4 Last error (menu option: LAST ERROR)

The last main menu option to be called is the error memory.
This error memory comprises the number of the last error (see section 11). It may be very helpful when commissioning the FC01-Ex.
Other than the peak value memories described above, the contents of this memory will be retained even upon power failure.
The user may purposely delete the error memory in the condition selected by simultaneously pressing (▲) UP and (▼) DOWN = (▲ + ▼)

7.2.1.5 Survey main menu



8 Configuration (menu option: CONFIGURATION)

The CONFIGURATION submenu serves to adjust the FC01-Ex to its application.

During system configuration, measuring operations are not possible (see Appendix 1).

Configuration possibilities are:

8.1 Selection of monitoring head (menu option: SENSOR SELECT)

This menu option allows the selection of the monitoring head types suitables for compressed air applications, that can be used with the FC01-Ex (issue 04.2006). The appropriate sensor can be selected from the following menu (for type designation see type label or CPI catalogue).

- TYPE CST-Ex-11 screw-in type monitoring head
- TYPE S-No. xxx custom designed monitoring head

Note:

- Monitoring head S-No. xxx is only available where a custom designed option has been ordered and integrated

Caution!

Menu option SENSOR SELECT may influence data in the parameter selection menu (see para. 8.13, Quitting the configuration menu).

- This menu option also allows to enter the C and T values ensuring the exchangeability of the monitoring heads.
- Pipe diameter assignment as required for volume flow measurements should also be entered.

Enter the following characteristics when selecting a **CSF monitoring head**. The setting is menu driven:

1. SENSOR CODE C xxx range: **001 … 999**
2. SENSOR CODE T xxx range: **500 … 999**

These characteristics are marked on the monitoring head.

Caution!

Observe correct settings as they have a major influence on measuring accuracy.

- PIPE SIZE (DIAM. = xxx.xx mm) range: 10.0 ... 999.9 mm for monitoring head CSF

8.2 Pressure range (menu option: PRESS. RANGE)

Pressure indication serves to correct the measured value and to convert standard volume flow to operating volume flow (see measuring procedure).

Setting range: 0.50 ... 100 bar / 7.35 ... 1470 PSI (absolute pressure)

Caution!

It is imperative to consider the approved pressure resistance of the sensors and adapters used.

8.3 Volume flow measuring mode (menu option: OPERAT. MODE)

Standard volume flow can be indicated either as:

- STANDARD FLOW — Standard volume flow equals operating volume flow at 1,013 mbar/14.89 PSI and 0 °C
- OPERATING FLOW — Operating volume flow is calculated by the standard volume flow, considering the pressure set (para. 8.2) and the medium temperature

The physical details are described in para. 5.1, Measuring procedures. The following volume flow and velocity values and those indicated on the display are set to standard and operating conditions by this setting.

Caution!

As under normal operating conditions pressure changes may arise, which cannot be taken into account when calculating operating volume flow, it is recommended to prefer the standard flow setting.

8.4 Gas selection (menu option: GAS SELECT)

This menu option allows the selection of the following gases:

- AIR
- OXYGEN O2
- NITROGEN N 2

Individual gas density is taken into account when calculating mass flow of air, oxygen and nitrogen (see DISPLAY SELECT).

Standard densities at 1.013 bar/14.89 PSI and 0 °C:

- Air 1.293 kg/Nm3
- Oxygen 1.429 kg/Nm3
- Nitrogen 1.250 kg/Nm3

This menu option allows the addition of other gases as required by customer.

8.5 Limit switches combinations (menu option: LIMIT SWITCHES)

The FC01-Ex comprises two limit switches (LS1 and LS2) which are assigned to the physical quantity/ quantities to be monitored in submenu LIMIT SWITCHES.

The following combinations are available:

- LS1 → F and LS2 → F
  limit switch 1 → flow rate
  limit switch 2 → flow rate

- LS1 → T and LS2 → T
  limit switch 1 → medium temperature
  limit switch 2 → medium temperature

- LS1 → F and LS2 → T
  limit switch 1 → flow rate
  limit switch 2 → medium temperature

- LS1 → T and LS2 → F
  limit switch 1 → medium temperature
  limit switch 2 → flow rate

Mode of operation, limit value and hysteresis of the limit switches are set in menu “PARAMETER SELECTION”.

Caution!

Menu option “LIMIT SWITCHES” may influence data in the parameter selection menu (see para. 8.13, Quitting the configuration menu).

8.6 Flow rate unit (menu option: FLOW UNIT)

At this point (1st line top left) the requested unit for the flow velocity will be set.

This menu option is used to set the desired flow rate unit:

- METRE/SEC [m/s]
- FEET/SEC [FPS]
- PERCENT [%]
- BLANK [no unit]

Any further entries relating to flow rate (e.g. limit value, analogue output etc.) refer to that unit.

Standard percent is displayed when BLANK (no unit) is selected.

When the flow rate unit is changed, all configuration and parameter data relating flow rate will automatically be converted!

8.7 Medium temperature (menu option: TEMP. UNIT)

This submenu is used to select the medium temperature unit (1st line top right).

Options are:

- GRAD CELSIUS [°C]
- GRAD FAHRENHEIT [°F]
- KELVIN [K]

All other entries relating to the medium temperature (limit value, analogue output, etc.) refer to the unit selected there. When the temperature unit is changed, all configuration and parameter data relating to medium temperature will automatically be converted.

8.8 Display (menu option: DISPLAY SELECT)

The FC01-Ex enables the user to define the 2nd line of the display in certain points.

When the first line of the LC display in the main menu indicates the flow rate in the unit selected as well as the medium temperature in °C, °F or K, it is possible to select the second line from the following menu options (see para. 8.15).

- BARGRAPH
- LITRE/SECOND [l/s]
- LITRE/MINUTE [l/min]
- METRE3 / HOUR [m3/h]
- GALLONS°/MINUTE
- FEET3/SECOND [F3/s]
- FEET3/MINUTE [F3/min]
- KILOGRAM/SECOND [kg/s]
- KILOGRAM/MINUTE [kg/min]
- KILOGRAM/HOUR [kg/h]
- POUND/SECOND [lb/s]
- POUND/MINUTE [lb/min]
- POUND/HOUR [lb/h]

Totalizer:

- LITRE [l]
- METRE3 [m3]
- FEET3 [F3]
- KILOGRAM [kg]
- POUND [lb]

Where totalizer function has been selected, the totalizer will start at zero counting in the unit selected (litre, m^3 or gallons).

When the display changes from m^3 to litre or gallons, or from litre or gallons to m^3, the value already counted will be converted.

The content of the totalizer is deleted by simultaneously pressing ▲ UP and ▼ DOWN = (▲ + ▼), or when the max. display value (99999999.9 l, m^3 or gallons) is reached. In both cases, the totalizer will restart from zero.

Caution!

The content of the totalizer is deleted in the event of power failure or disconnection of the power supply!

8.9 Bargraph (menu option: BARGRAPH)

This menu option allows the user to set the bar graph as desired. The following settings should be made:

- FLOW / TEMP (bar graph assignment: flow rate/medium temperature)
- ZERO (initial value of the bar graph)
- FS (final value of the bar graph)

Independent of its assignment, the bar graph has a constant resolution of 10 segments. When entering the initial or final value, the user should observe reasonable resolution! The bar graph also comprises the representation of the limit switch(es) as far as they can be indicated in the bar range selected.

The representation of the limit switches in the bar graph depends on the switch-on value of the limit switch.

For representation details see para. 7.2.1 (Operating data).

Example:

Limit switch assignment:	LS1 → F und LS2 → T
Switch-on value LS2:	23 °C
Switch-off value LS2:	29 °C
Analogue bar graph assignment:	medium temperature
Initial value - analogue bar graph:	20 °C
Final value - analogue bar graph:	30 °C
Instantaneous temperature value:	25 °C

→ resulting in the analogue bar graph display shown below:

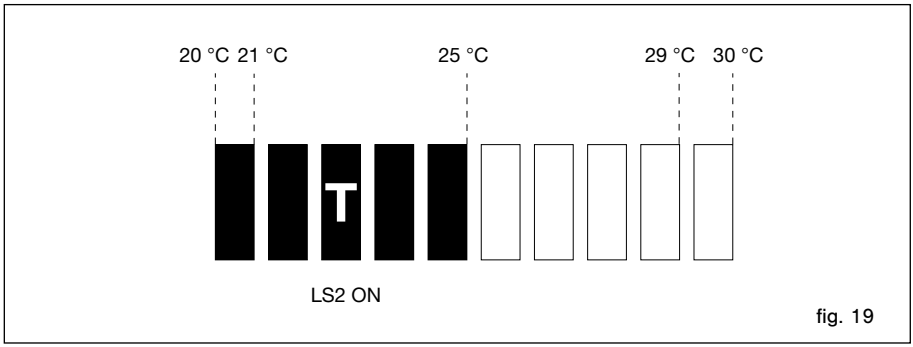


fig. 19

8.10 Frequency output (menu option: FREQUENCY OUTPUT)

Version FC01-Ex-CA-U1T4 allows the output of proportional quantity pulses. The proportional quantity pulses have been determined as follows:

1 pulse / quantity (totalizer unit selected)

Example: 1 pulse / 10.0 [Liter]

The frequency output will supply 1 pulse per 10 litres (totalized quantity).

When the quantity-proportional pulses are assigned, the frequency of the frequency output must no exceed 10 Hz. The limits that can be displayed are determined by the flow velocity range and the pipe diameter.

Potential setting range of the frequency output: 1 pulse per 0.1...999.9 [Liter], [m^3], [F^3], [kg], [lb]

Behaviour of the frequency output when the max. frequency is exceeded

The max. frequency being exceeded will not cause the measurement to stop but will rather cause the error output to signal error 60 on the display. This error is included in priority group III.

If a combination of priority III errors occurs simultaneously, they are indicated or stored in the error memory observing the following sequence:

Error No. 20, 30, 60, 40, 41.

Behaviour of the frequency output when the measurement is stopped

When the measurement is stopped (as caused by priority II error and calling the configuration or parameter selection menus), the pulses for the quantity already counted will be available. Thereafter the output of pulses will be stopped, with the frequency output becoming high-

resistive until the measurement is restarted.

Behaviour of the frequency output when the content of the totalizer is deleted

The content of the totalizer may be deleted by simultaneously pressing ▲ UP and ▼ DOWN = (▲ + ▼) in the main menu.

As the frequency output refers to the content of the totalizer, although its operation is not dependent on the content of the totalizer, a totalized quantity that is smaller than that set per pulse will not be lost.

This means that only the content of the totalizer is deleted.

8.11 Analogue output - flow rate (menu option: ANA OUT FLOW)

This menu option allows adjustment of the flow rate analogue output specifically to the requirements of the entire system.

Options are:

- OFFSET = 0%/20% FS (0/4 ... 20 mA, 0/1 ... 5 V, 0/2 ... 10 V)
- ZERO = (**initial value** 0(20) % corresponds to a flow rate of _ [m/s] [%] [FPS])
- FS = (**final value** 100% corresponds to a flow rate of _ [m/s] [%] [FPS])

When entering the initial or final value, the user should observe a reasonable resolution! With a flow volume/time unit selected in menu DISPLAY SELECT and when setting the initial and end values, the pertinent flow volumes will also be indicated.

8.12 Analogue output - medium temperature (menu option: ANA OUT TEMP.)

In conformance with the configuration “Flow rate analogue output” it is possible to adjust the medium temperature analogue output to the requirements of the entire system.

Options are:

- OFFSET = 0%/20% FS (0/4 ... 20 mA, 0/1 ... 5 V, 0/2 ... 10 V)
- ZERO = (initial value 0(20) % corresponds to a medium temperature of ... [°C] [°F] [K])
- FS = (final value 100% corresponds to a medium temperature of ... [°C] [°F] [K])

When entering the initial or final value, the user should observe a reasonable resolution!

8.13 Quitting the configuration menu

Upon configuration of the analogue outputs, the menu may be quitted or re-set to the start (SENSOR SELECT).

To quit the configuration menu, the controller will check the data entered for plausibility. “CONFIG. OK!” is indicated when the data are found to be correct. The menu may than be quitted by pressing (M) MODE.

Errors found during the plausibility check are indicated in the following sequence of priority.

Priority of entry errors in the CONFIGURATION menu:

- ERR. SENSOR SEL. SENSOR <> GAS
  (the selected sensor has not been released for this application)
- ERR. A-OUT FLOW OUT OF RANGE
  (flow analogue output outside measuring range)
- ERR. A-OUT FLOW ZERO ≥ FS
  (initial value ≥ final value with flow analogue output)
- ERR. A-OUT TEMP. OUT OF RANGE
  (temperature analogue output outside measuring range)
- ERR. A-OUT TEMP. ZERO ≥ FS
  (initial value ≥ final value with temperature analogue output)
- ERR. BARGRAPH OUT OF RANGE
  (bar value outside measuring range)
- ERR. BARGRAPH ZERO ≥ FS
  (bar initial value ≥ bar final value)

The menu can only be quitted after correction of the error(s). To do this, return to the beginning of the configuration menu by pressing ▲ UP or ▼ DOWN and select the menu option with the incorrect entry for correction.

Caution!

If during the configuration data are affected which are accessible in the parameter selection menu, (which may be the case for the options Sensor Selection, Medium Selection and limit Switch Assignment), the option "PARAMETERS" in the main menu will be flashing.

In this event it is imperative to branch into parameter selection menu to set the data in conformance with the desired application.

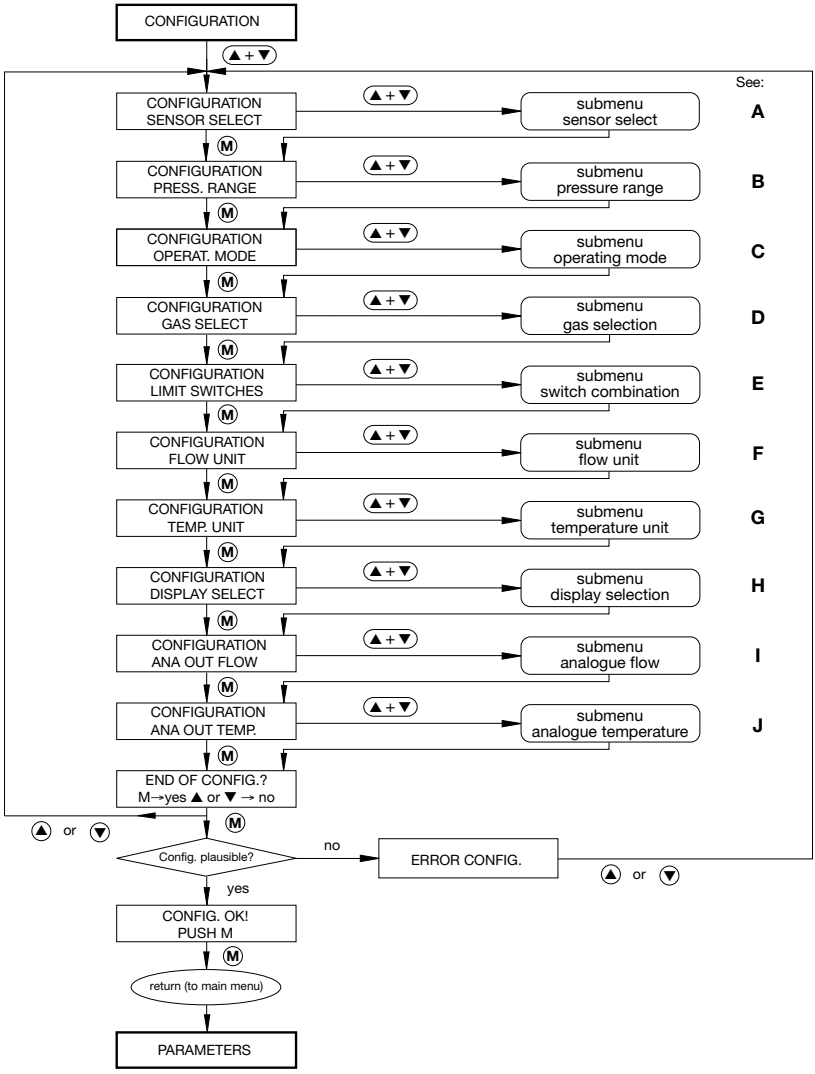
Example: Changing the limit switch assignment from **LS1 → F** / **LS2 → T** to **LS1 → F** / **LS2 → F**.

Effects on parameter data: **LS2 ON** = 0.00
LS2 OFF = end of measuring range (depending on the medium selected)

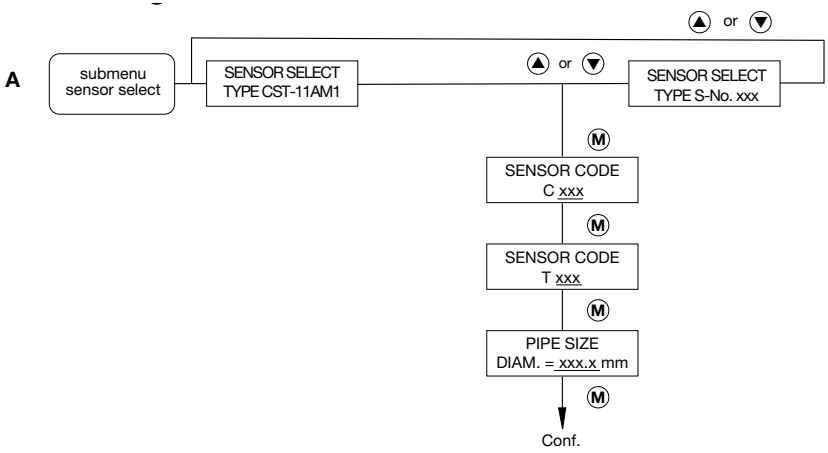
Reason: Changing the physical assignment of limit switch 2 will adjust its switch-on and switch-off values to the new assignment (flow rate).

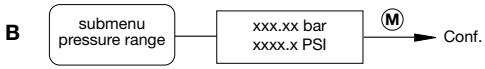
An overview of the configuration menu and a summary of the measuring ranges and menus available for the sensor type selected are shown on the following pages.

8.14 Configuration menu



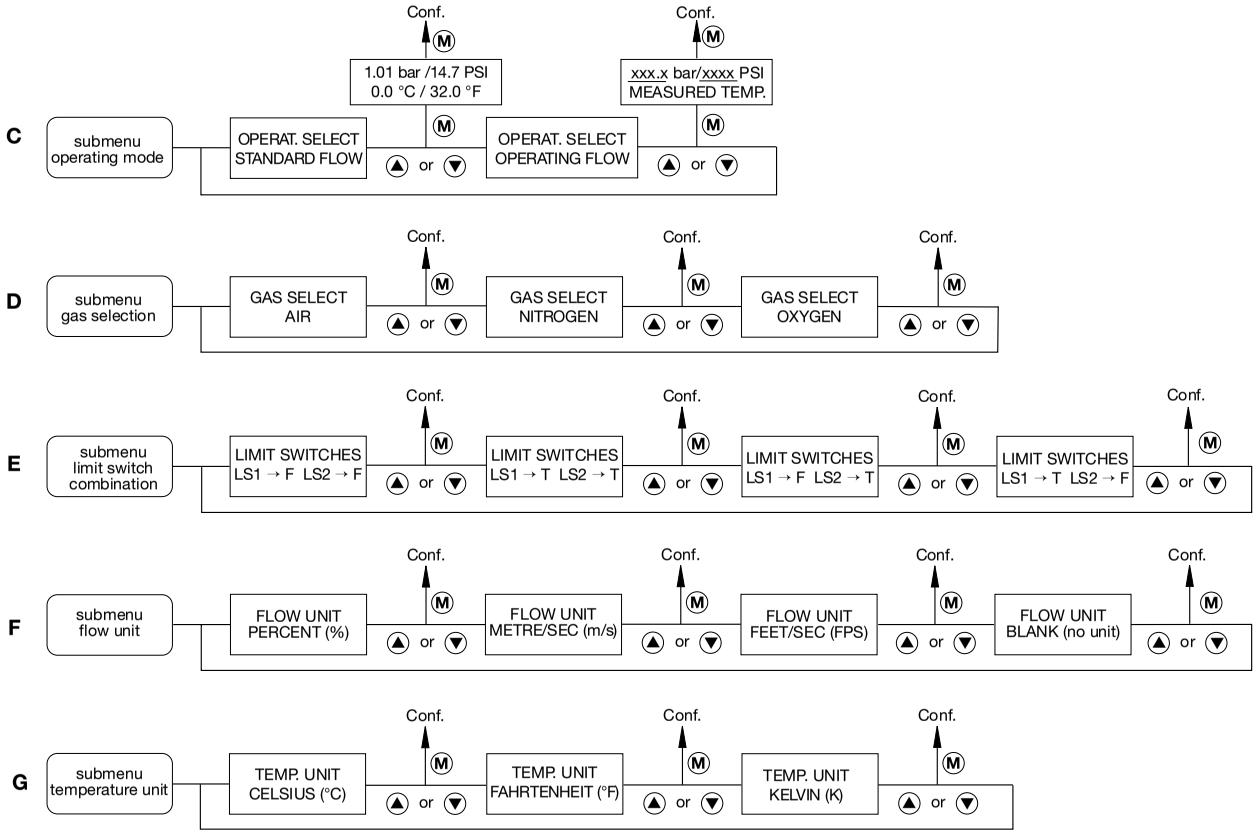
8.15 Configurations submenues





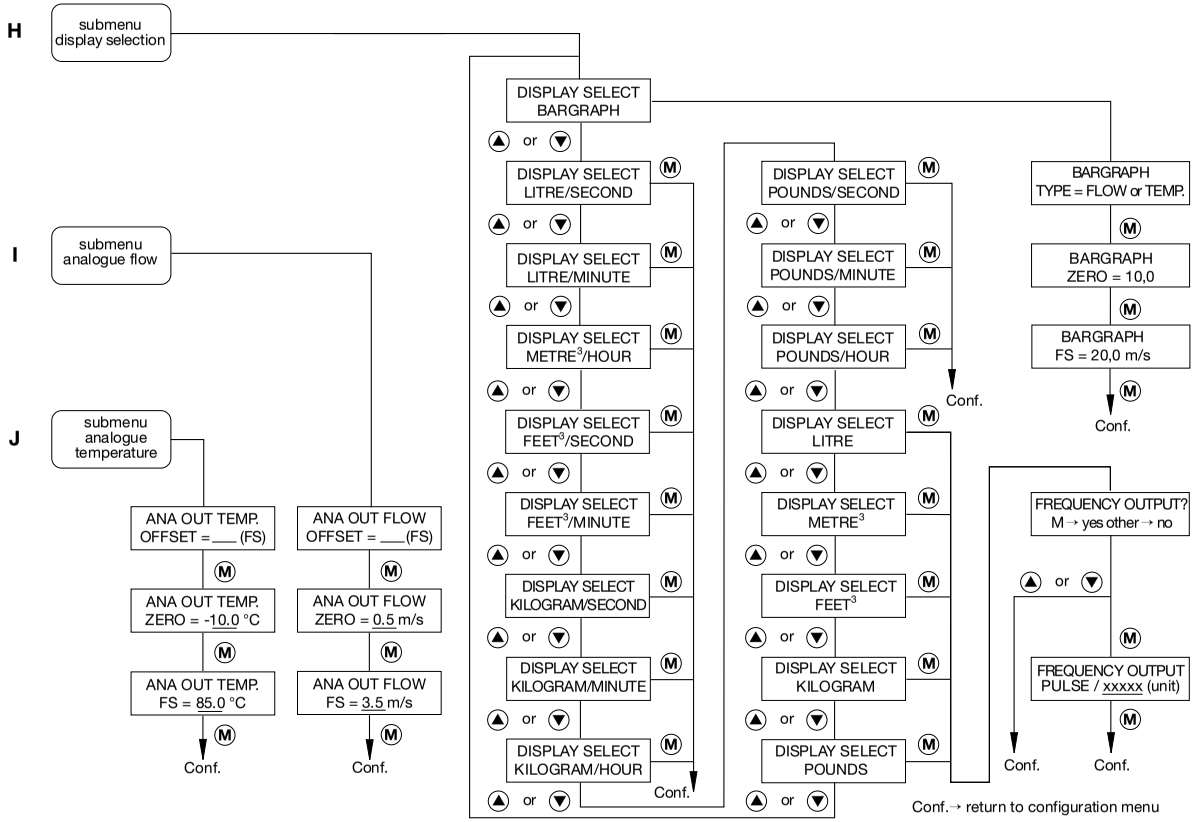
Conf.→ return to configuration menu

Configuration submenus (cont'd)



Conf.→ return to configuration menu

Configuration submenus (cont'd)



9 Parameter selection (menu option: PARAMETERS)

After configuration of the FC01-Ex in conformance with its application (configuration menu), it is possible to set parameters (e.g. limit values).

During parameter setting, measuring operations are not possible (see Appendix 1).

The following parameters may be set in the parameter selection submenu:

9.1 Measuring time (menu option: MEAS. TIME)

The measuring time may be between 1 and 30 sec., referring both to flow rate and medium temperature.

The effect of the measuring time may be compared to that of a filter; it is used to determine the average of the last measured values after each measurement.

The set measuring time does not influence the measuring rate and display up-date.

9.2 Limit switch 1 - switch-on value (menu option: LS1 ON = ...) Limit switch 1 - switch-off value (menu option: LS1 OFF = ...)

Depending on the configuration (see configuration menu) limit value 1 may be set either for flow rate or medium temperature.

The limit value may be set over the entire measuring range and is always related to the display value.

Limit switch up-date is by measuring rate, independent of the set measuring time.

The hysteresis is determined by entering different switch-on and switch-off values. Its magnitude should be reasonably adjusted to current operating conditions.

A specific definition of the operation (closed-current or open-circuit principle) may be dropped by separately entering the switch-on and switch-off value of the limit switch, because the definition is deducted from the switch-on and switch-off value.

Example 1: Switch-on value lower than switch-off value

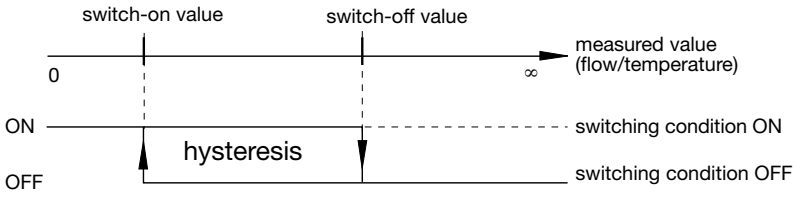


fig. 20

Example for ON:
FC01-Ex with relay outputs (option R2):

- LIM1 - LIM1COM = closed
  /LIM1 - LIM1COM = open

FC01-Ex with transistor outputs (option T4):

- LIM1E - LIM1C = switched

Example 2: Switch-on value higher than switch-off value

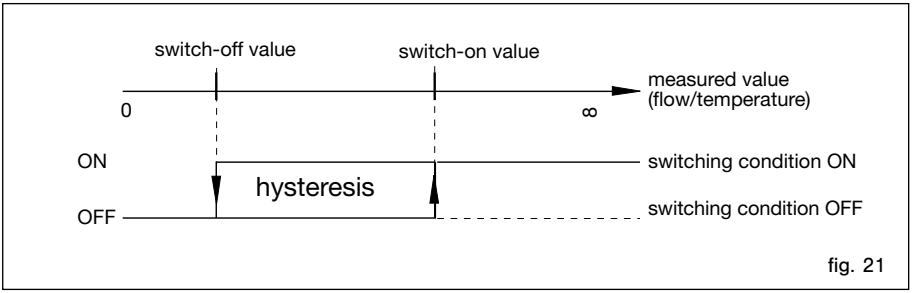


fig. 21

Example for ON: as described in example 1 (fig. 20)

With limit switch 1 set for flow rate and a flow volume/time unit selected in menu DISPLAY SELECT, and when setting the switch-on and switch-off value, the pertinent flow volumes will also be indicated.

9.3 Limit switch 2 - switch-on value (menu option: LS2 ON = ...) Limit switch 2 - switch-off-value (menu option: LS2 OFF = ...)

See limit switch 1!

9.4 Scaling factor (menu option: FLOWSCALE)

The scaling factor influences flow rate indication.

The factor, which may be set between 0.01 and 9.99, allows flow rate indication changes (increasing or reducing the measured value in the display).

For example, the scaling factor may be used to indicate the average flow rate in the pipeline rather than that available at the sensor.

9.5 Quitting the parameter selection menu

Before the parameter selection menu can be quitted, the controller will conduct a plausibility check of the data entered.

“PARAMETERS OK!” is indicated when the data are found to be correct. The menu may then be quitted by pressing (M) MODE.

Errors found during the plausibility check are indicated in the following sequence of priority.

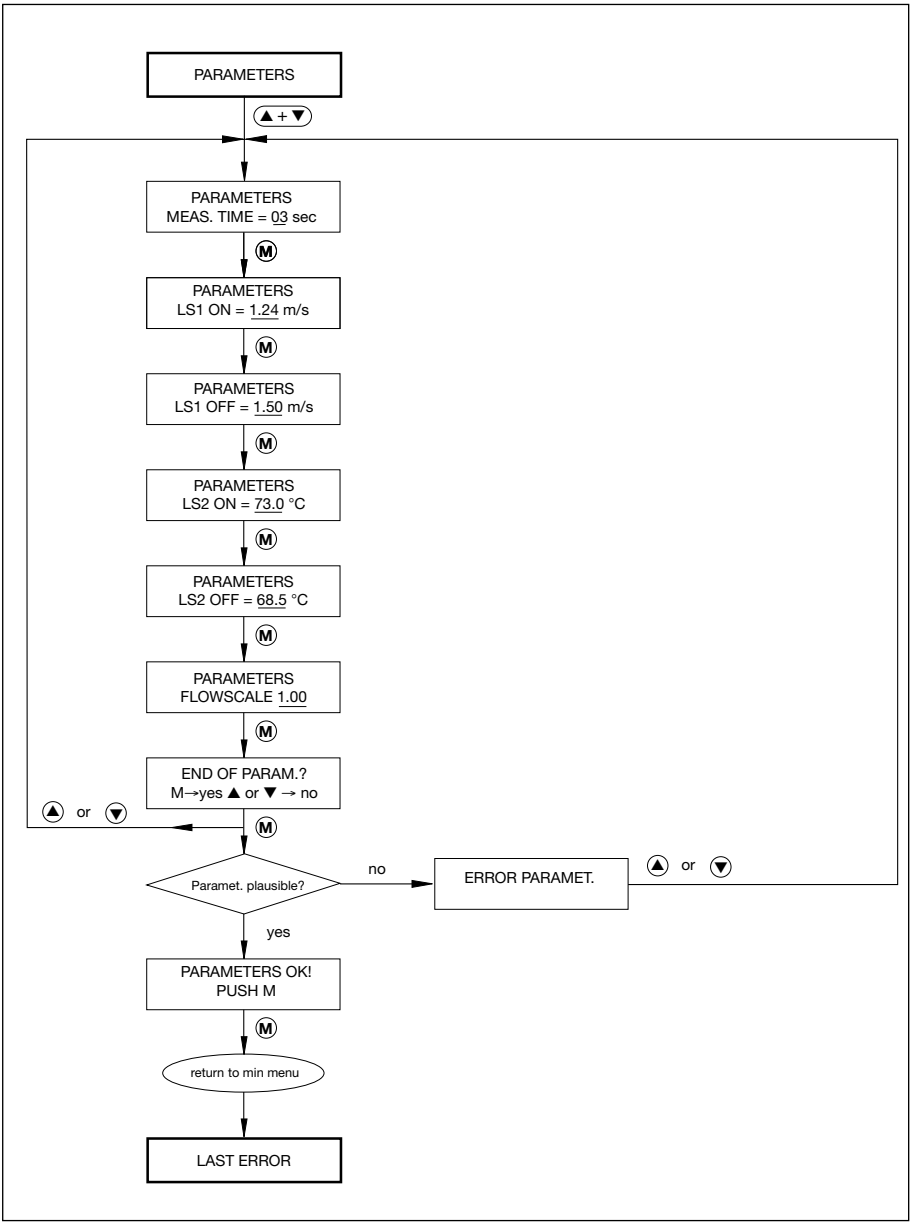
Priority of entry errors in the PARAMETER SELECTION menu:

- ERROR LS1 OUT OF RANGE
  switch-on and/or switch-off value for limit switch 1 outside measuring range
- ERROR LS2 OUT OF RANGE
  switch-on and/or switch-off value for limit switch 2 outside measuring range
- ERROR LS1 ON = OFF
  switch-on value for limit switch 1 equals switch-off value for limit switch 1
- ERROR LS2 ON = OFF
  switch-on value for limit switch 2 equals switch-off value for limit switch 2

The menu can only be quitted after correction of the error(s). To do this, return to the beginning of the parameter selection menu by pressing (▲) UP or (▼) DOWN and select the menu option with the incorrect entry for correction.

An overview of the parameter selection menu is shown on the following page.

9.6 Survey parameter selection menu



10 Low flow suppression

The low flow suppression menu option serves to suppress small flow quantities and to detect leakages. Menu settings can be changed during the measuring operation, requiring no additional heating period.

10.1 Low flow suppression

The low flow suppression option ranging from 1 to 10 % of the measuring range final value can be used to eliminate false measurements as may arise upon (small) reverse flow quantities, for example. If flow velocity is less than the value set, the flow velocity and the applicable flow is set at zero. This also applies to all subsequent quantities such as analogue output, bar graph and limit switches which are defined in the other menus.

10.2 Zero adjustment

Although because of its very special characteristic curve in the lower flow range the calorimetric procedure implies a higher resolution than other measuring procedures, it is not possible to exactly measure zero flow, the reason for this being that in the lower flow range (<1 % of measuring range final value) current flow is superimposed by convection flow around the heated monitoring head sensor. Convection flow is very difficult to theoretically detect for all measuring systems (monitoring head and FC01-Ex); it is determined by installation and current pressure and temperature, etc. Selecting 0 % will therefore always result in zero adjustment.

To ensure correct zero adjustment, the pipeline should be operated under the desired pressure and temperature conditions, and a waiting period of approx. 2 ... 5 minutes should be observed after the pipe system has been closed (zero volume flow) to ensure correct setting. If the FC01-Ex indicates flow after pipeline has been opened, there is definitely flow available.

After this adjustment even smallest volume flow quantities can be reliably indicated.

Caution!

No plausibility test to ensure there is no volume flow is conducted for zero adjustment. The volume flow available at that time is set at zero. This should be considered above all for untight valves in which case the zero volume flow determined this way may even be greater than 1 %. Accuracy in the lower measuring range will decrease then. To be on the safe side, the lower limit should therefore be set at 1 % if no reliable zero adjustment can be made.

11 Errors

11.1 Test and diagnosis

The FC01-Ex is provided with extensive test and diagnosis functions.

All faults found will be shown in the display with the corresponding error number (e.g. ERROR 10).

If the FC01-Ex is fitted with a T4 option (4 transistor outputs), the output ERROR will additionally be activated.

The functions may be classified in three priority groups.

11.1.1 Priority group I

Priority group I comprises the switch-on test routines (FC01-Ex self-test) which are carried out when the system is switched on.

Their implementation is indicated.

Errors No. 1 to 5 do not allow system operation.

The test routines may be repeated by pressing any of the switches.

If even after several trials the switch-on test cannot be conducted without error indication, the system should be returned to the supplier for rectification, indicating the error number.

Priority I errors cannot be rectified by the user!

11.1.2 Priority group II

These test functions are continuously carried out during operation. The occurrence of errors

No. 10 and 21 will cause measurements to stop, indicating the error and monitoring the source of the error. Upon rectification of the error, the system will automatically return to measuring operation.

11.1.3 Priority group III

These test routines are also continuously carried out during operation.

Other than the above priority groups, errors No. 20, 30, 60, 40 and 41 will not cause measurements to stop; the error output will indicate and the number of the error will be shown on the display.

11.2 Potential Errors

Independent of the priority group, all errors found are indicated with their relevant number.

In order to facilitate operation, the last error is stored in a non-volatile memory. The stored error may be retrieved and deleted in the main menu.

If a combination of errors occurs simultaneously, they are indicated or stored in the error memory observing the following sequence.

Priority group I

Error	Cause	Rectification
No. 1	No system parameter available	Return to supplier.
No. 2	Incorrect test sum of parameter memory	Return to supplier.
No. 3	Incorrect test sum of program memory	Return to supplier.
No. 4	Incorrect test sum of data memory	Return to supplier.
No. 5	Internal controller error	Return to supplier.

Priority group II

Error	Cause	Rectification
No. 10	Sensor not connected; or cable between FC01-Ex and sensor defective; or defective sensor	Check cable or replace sensor.
	Sensor selected (configuration) differs from sensor connected	Correct sensor selection in configuration menu
No. 21	Medium temperature too high	

Priority group III

Error	Cause	Rectification
No. 20	Medium temperature too low	
No. 30	Over limits of flow rate	
No. 60	Assignment of quantity per pulse too low *	
No. 40	Controller error (oscillator-watchdog) Admissible EMC levels may have been exceeded	
No. 41	Controller error (watchdog timer) Admissible EMC levels may have been exceeded	

* Error No. 60 can only occur with selected frequency output.

12 Technical data

12.1 Ambient conditions FC01-Ex

Storage temperature: - 20 ... +70 °C
Ambient temperature: * +10 ... +43 °C
Degree of protection: IP54
* Only if the modules are spaced by at least 10 mm.

12.2 Sensor CST-Ex

Temperature measuring I (medium): -40 ... +75 °C
Temperature measuring II (sensor): -30 ... +75 °C
Temperature measuring III (cable): -10 ... +80 °C
Pressure resistance: 100 bar (1470 PSI)
Degree of protection (housing): IP67 (connection cable in locked condition)
Pollution degree (cable(head connection): 2
(to DIN VDE 0627)

12.3 Electrical characteristics

12.3.1 Power supply

DC-supply

Pin selection:

Signal name	Pin XV
+UV	2
-UV	3

12.3.1.1 DC voltage supply

Supply voltage:	U_{VN} = 24 V
Input voltage range:	U_V = 19 V to 32 V
(ripple incl.)	(12 V only possible voltage output)
Admissible ripple:	w = 20 % U_V
Rated current consumption:	
analogue output V1 and V2:	I_{vnk} = 170 mA ± 10%
	with zero flow
	I_{vnk} = 200 mA ±10%
	with zero flow (end of measuring range)
analogue output C1:	I_{vnk} = 185 mA ± 10%
	with zero flow
	I_{vnk} = 230 mA ±10%
	with zero flow (end of measuring range)
Inrush current:	I_p = 3 A (20 µs)
Switch-off current:	I_{klpp} = 0,75 A
Rated power consumption:	P_n = 4.1 W
	(with zero flow, voltage outputs
	P_n = 4.8 W
	(with max. flow end of measuring range),
	voltage outputs
Insulation voltage:	supply input - central electronic unit ≥ 500 V

12.4 Analogue outputs

The analogue outputs are physically isolated from each other as well as from the electronic control unit FC01-Ex.

Pin selection for analogue outputs V1, V2 and C1

Signal name	Pin XAO
NC	1
analogue output 1 - flow rate	2
reference ground 1	3
shield 1 *	4
shield 2 *	5
analogue output 2 - temperature	6
reference ground 2	7
NC	8

NC - not used

Analogue output 1 - ANA OUT FLOW (flow output)

Analogue output 2 - ANA OUT TEMP. (temperature output)

*** Shield ungrounded - apply on one side only.**

Insulation voltage: analogue output - analogue output 500 V
analogue output - central electronic unit 500 V
shield potential - supply voltage of
analogue output ≤ 48 V DC

12.4.1 Voltage output V1 - 5 V FS

Signal voltage range: U_s = 0 V bis 5 V ± 2% FS
Max. signal ripple: dU_s = 5% FS
Min. admissible load resistance: R_l = 1 kΩ
Max. admissible load capacity: C_l = 1 nF
Max. admissible load inductance: L_l = 100 nH
Short circuit proof: yes (XAO - between all terminals)

12.4.2 Voltage output V2 - 10 V FS

Signal voltage range: U_s = 0 V bis 10 V ± 2% FS
Max. signal ripple: dU_s = 5% FS
Min. admissible load resistance: R_l = 1 kΩ
Max. admissible load capacity: C_l = 1 nF
Max. admissible load inductance: L_l = 100 nH
Short circuit proof: yes (XAO - between all terminals)

12.4.3 Current output C1 - 20 mA FS

Signal current range: I_s = 0 mA to 20 mA ± 2% FS
Max. signal ripple: dI_s = 5% FS
Min. admissible load resistance: R_l = 0 Ω
Max. admissible load resistance: R_l = 250 Ω

12.5 Signal outputs

The signal outputs are physically isolated from each other as well as from the electronic control unit FC0 1-Ex.

12.5.1 Relay output (change over contacs DC or AC switching voltage)

Pin selection:

Signal name	Pin XAH
Limit Switch 1 / shield	1
Limit Switch 1 / N/O	2
Limit Switch 1 / common	3
Limit Switch 1 / N/C	4
Limit Switch 2 / shield	5
Limit Switch 2 / N/O	6
Limit Switch 2 / common	7
Limit Switch 2 / N/C	8

Resistive load
Max. admissible switching capacity: 50 W
Max. admissible switching current: 1 A
Max. admissible continuous current: 1 A
Max. admissible switching voltage: 50 V
Contact life at 1 A: 3 x 10^5 cycles

Inductive load - with safety circuit - AC voltage
Max. admissible switching capacity: 125 VA
Max. admissible switching current: 1.25 A
Max. admissible continuous current: 1.25 A
Max. admissible switching voltage: 100 V
Contact life cos Ω = 0,5: 2.4 x 10^5 cycles
Insulation voltage: signal contact - central electronic unit DC 500 V
signal contact - signal contact DC 500 V

12.5.2 Open-collector outputs (DC switching voltage)

Pin selection:

Signal name	Pin XAH	Polarity
/ ERROR emitter	1	-
/ ERROR collector	2	+
/ BUSY / PULSE emitter	3	-
/ BUSY / PULSE collector	4	+
Limit Switch 2 emitter	5	-
Limit Switch 2 collector	6	+
Limit Switch 1 emitter	7	-
Limit Switch 1 collector	8	+

Voltage level
Low level - active: U_{ce} < 0,8 V at I_C < 10 mA
U_{ce} < 1 V at I_C < 100 mA
High level - passive: U_{ce} < 48 V
U_{ce} max = 60 V
max. leakage current ≤ 25 µA
Reverse polarity protection: yes - I_{max} < 1 A
Short circuit protection: yes - I_{max} < 1 A

Resistive load
Max. admissible switching capacity: 1.5 W
Max. admissible switching current: 150 mA
Max. admissible switching voltage: 36 V

Inductive load - L < 100 mH
(DC voltage - without external safety circuit)
Max. admissible switching capacity: 1.5 VA
Max. admissible switching current: 40 mA
Max. admissible switching voltage: 36 V

Capazitive load - C < 20 µF
Max. admissible switching capacity: 1.5 VA
Max. admissible switching current: 1.5 A
Max. admissible switching voltage: 36 V
Insulation voltage: signal contact - central electronic unit DC 500 V
signal contact - signal contact DC 500 V

12.6 Metrological data

12.6.1 Flow rate measurement

Medium:	air
Measuring range:	0 ... 50 Nm/s
Display range:	0 ... 75 Nm/s
Accuracy:	± 5% MW ** [1]/ ± 0,5% MBE *
Repeatability:	± 1% MW **
(5% MBE – 100% MBE)	

12.6.1.1 CST-Ex Sensor

Flow measurement ranges:

The flow measurement range is determined by the inner pipe diameter (see table). It can be calculated with the following equation:

$$\mathbf{Q = V_N \times A_R}$$

Q [Nm³/h] - flow quantity
V_N [m/h] -average standard velocity
A_R [m²] - inner pipe cross-section

Inner pipe diameter D in mm	Measuring range in Nm³/h	Display range in Nm³/h
20	57	84
30	127	190
40	226	339
50	353	530
60	509	763
70	693	1039
80	905	1357
90	1145	1717
100	1414	2120
150	3180	4771
200	5655	8482
250	8836	13253
300	12723	14080
400	22620	33900
500	35343	70685
600	50900	53000
700	69270	103900
800	90500	135700
900	114500	171700
1000	141400	212000

Setting range for internal pipe diameter: 10.0 mm ... 999.9 mm
Velocity range: 0 ... 50 Nm/s (75 Nm/s)
Accuracy[1] : ± 5% MW ** / ±0.5% MBE *
Repeatability: ± 1% MW / ±0.5% MBE
(5% MBE – 100% MBE)
Temperature drift: ± 0.,05%/K/MBE

12.6.2 Temperature measurement:

Measuring range: -40 ... 90 °C
Accuracy: ± 1% MB ***

12.6.3 Electronic control unit FC01-Ex

Temperature drift of the electronic: ± 0.1%/K/MBE *
Heating up period until full accuracy is reached: 15 min

* MBE - of final value
** MW - measured value
*** MB - measuring range
1) Please enquire for higher accuracy

12.7 Sensor interface - Electrical data

Terminal	Mnemonics	Data
XSK1	R(HEIZ)-LO	Function: terminal for negative pole of heater element Drain output of heating current control Max. sink current: I_{sink} = 88 mA Dielectric strength: -0.5 V ... +20 V DC
XSK2	R(HEIZ)-HI	Function: terminal for positive pole of heater element Hi-potential of heater source Output voltage range (load dependent) U_a = 21 V ... 24 V DC Max. current output: I_{max} = 100 mA Not short-circuit proof
XSK3	R(Tref)-HI	Function: terminal for positive RTD * pole for medium temperature measurement Input resistance: > 1 GΩ Dielectric strength: -17 V ... +30 V DC
XSK4	R(Tref)-LO	Function: terminal for negative RTD * pole for medium temperature measurement Input resistance: > 1 GΩ Dielectric strength: -17 V ... +30 V DC
XSK5	AGND	Function: analogue ground Reference potential of exitation current source for RTD * operation
XSK6	IS	Function: output of exitation current source for RTD * operation Exitation current: 1 mA ± 1% Admissible load range: R_{last} = 0 ... 2 kΩ Dielectric strength: ±15 V DC
XSK7	SGND	Function: shield ground
XSK8		Terminals for sensor cable shielding
XSK9	R(Tdiff)-LO	Function: terminal for negative pole of the heated RTD * Input resistance: > 1 GΩ Dielectric strength: -17 V ... +30 V DC
XSK10	R(Tdiff)-HI	Function: terminal for positive pole of the heated RTD * Input resistance: > 1 GΩ Dielectric strength: -17 V ... +30 V DC

Appendix 1 -Performance of the digital and analogue outputs during the operating and error modes

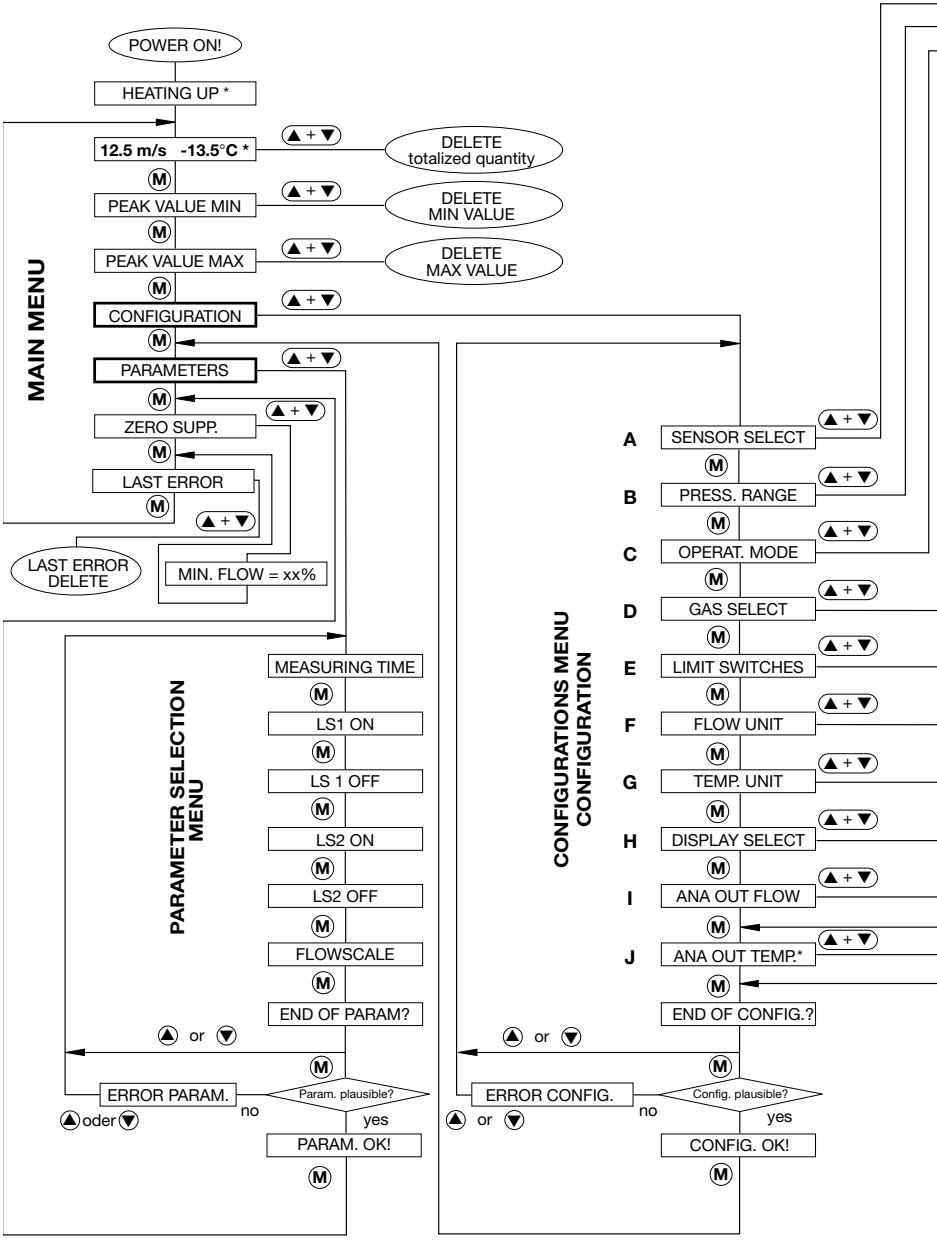
Duty-/ Error status	LIMIT SWITCH 1	LIMIT SWITCH 2	NO ERROR	NOT BUSY and FREQUENZY OUTPUT	ANA OUT FLOW	ANA OUT TEMP.
Start-up (Reset)	ON	ON	ON	ON	MAX	MAX
Start-up test active	OFF	OFF	OFF	OFF	MIN	MIN
Error No. 1	OFF	OFF	OFF	OFF	MIN	MIN
Error No. 2	OFF	OFF	OFF	OFF	MIN	MIN
Error No. 3	OFF	OFF	OFF	OFF	MIN	MIN
Error No. 4	OFF	OFF	OFF	OFF	MIN	MIN
Error No. 5	OFF	OFF	OFF	OFF	MIN	MIN
Heating period active	OFF	OFF	ON	OFF	MIN	MIN
Normal duty	**X**	**X**	**ON**	**ON**	**X**	**X**
Configuration active	OFF	OFF	ON	OFF	MIN	MIN
Parameter selection active	OFF	OFF	ON	OFF	MIN	MIN
Error No. 50	OFF	OFF	OFF	OFF	MIN	MIN
Error No. 10	OFF	OFF	OFF	OFF	MIN	MIN
Error No. 20	X	X	OFF	ON	X	X
Error No. 21	OFF	OFF	OFF	OFF	MIN	MIN
Error No. 30	X	X	OFF	ON	X	X
Error No. 31	X	X	OFF	ON	X	X
Error No. 60 *	X	X	OFF	FA	X	X
Error No. 40	X	X	Y	ON	X	X
Error No. 41	X	X	Y	ON	X	X

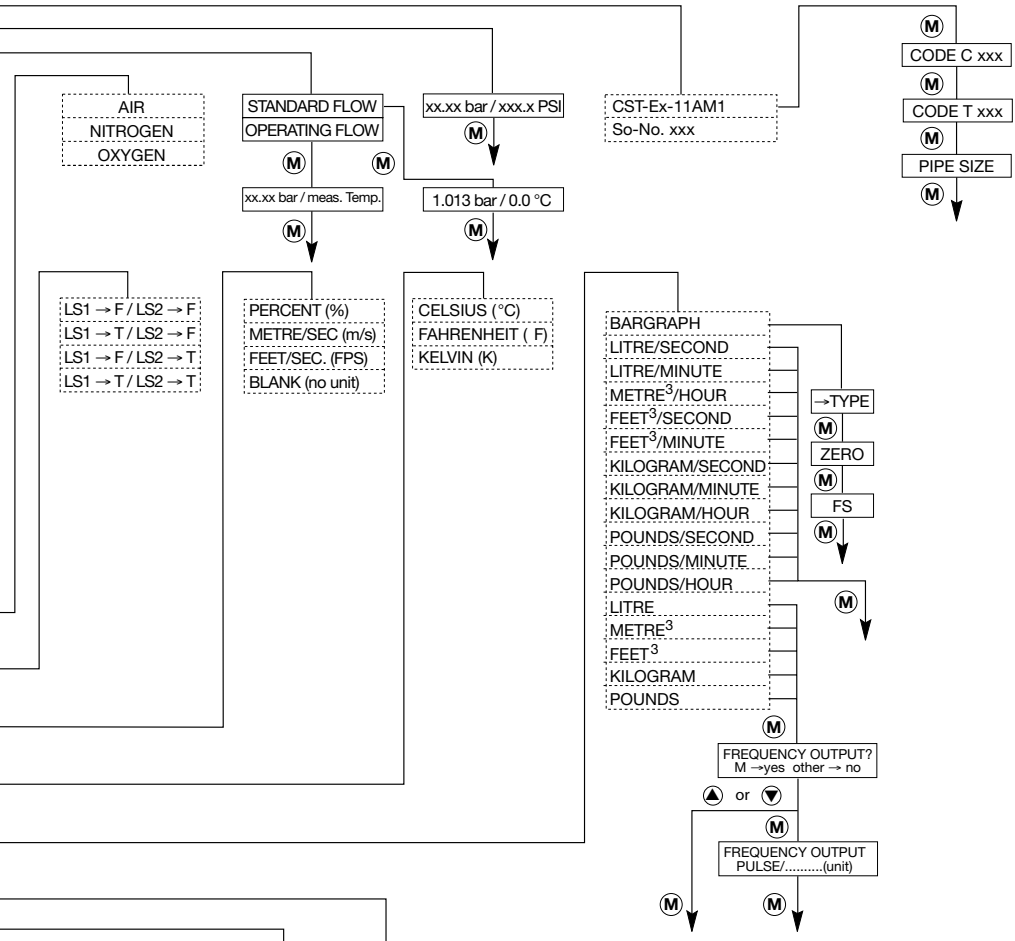
X = standard performance
Y = OFF pulse
FA = frequency output 10 Hz

* When frequency output has been selected.

Note: The occurence of error No. 40/41 will always cause an internal reset.
Status of the outputs prior to the error status described → see start-up (reset)

Appendix 2 - Menu structure of the FC01-Ex-CA (operator dialog)




AIR
NITROGEN
OXYGEN
STANDARD FLOW
OPERATING FLOW
xx.xx bar / xxx.x PSI
xx.xx bar / meas. Temp.
1.013 bar / 0.0 °C
CST-Ex-11AM1
So-No. xxx
CODE C xxx
CODE T xxx
PIPE SIZE
LS1 → F / LS2 → F
LS1 → T / LS2 → F
LS1 → F / LS2 → T
LS1 → T / LS2 → T
PERCENT (%)
METRE/SEC (m/s)
FEET/SEC. (FPS)
BLANK (no unit)
CELSIUS (°C)
FAHRENHEIT (F)
KELVIN (K)
BARGRAPH
LITRE/SECOND
LITRE/MINUTE
METRE3/HOUR
FEET3/SECOND
FEET3/MINUTE
KILOGRAM/SECOND
KILOGRAM/MINUTE
KILOGRAM/HOUR
POUNDS/SECOND
POUNDS/MINUTE
POUNDS/HOUR
LITRE
METRE3
FEET3
KILOGRAM
POUNDS
→TYPE
ZERO
FS
FREQUENCY OUTPUT?
M →yes other → no
or
FREQUENCY OUTPUT
PULSE/.....(unit)
OFFSET
ZERO
FS
OFFSET
ZERO
FS
return to configuration menu
action
menues
page up
page down
select and return to config. menu
call menu or delete function

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