Flow Meter | **FC 01-CC**

USER MANUAL

M_FC01_CC_0108_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 1.31.

Equipment installation, connection and adjustment by qualified personnel only!

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Description

The Flow Meter FC01-CC (**C**ustomer **C**alibration) has been designed for applications where a customer-specific or media-specific calibration is required. Characteristic curves of specific media such as various oils (up to ISO VG 220) or water-glycol-mixtures will be established in the customer's laboratory with reference measuring sections and will be stored in the software of the FC01-CC.

Compared to the standard FC01 it is possible to achieve a much better accuracy as the corresponding CSx monitoring head will always be calibrated together with the electronic control unit so that they build up a complete measuring system.

The Flow Meter FC01-CC is designed to detect flow speed, flow volume and, if using a calorimetric type of monitoring head (type CSx), medium temperature.

These quantities are made available to the user as analogue electrical signals, physically isolated, as **current** or **voltage output** and may be monitored by means of a **limit monitor**.

As **relay outputs** or **transistor outputs** the digital signals enable the user to integrate the FC01-CC into a control and monitoring system.

The transistor outputs enable the user to additionally process **fault**, **status** and **volume pulse indications** in the control system.

The Flow Meter FC01-CC may be used with two different kinds of measuring sensors:

- calorimetric monitoring heads CSx (CST, CSF, CSP)

or

- turbine-type sensors TST

1.1 Measuring procedures

1.1.1 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 □□ and mass flow.

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

The temperature difference $\Delta\vartheta$ between the two sensors is kept constant and the mass flow is determined by measuring the calorific power.

Fig. 1 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 ϑ_M whilst heater resistor RH heats element RS to temperature ϑ_S. As a function of the medium, the temperature differential $\Delta\vartheta = \vartheta_S - \vartheta_M$ is preselected as a reference variable by the CTD control 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.

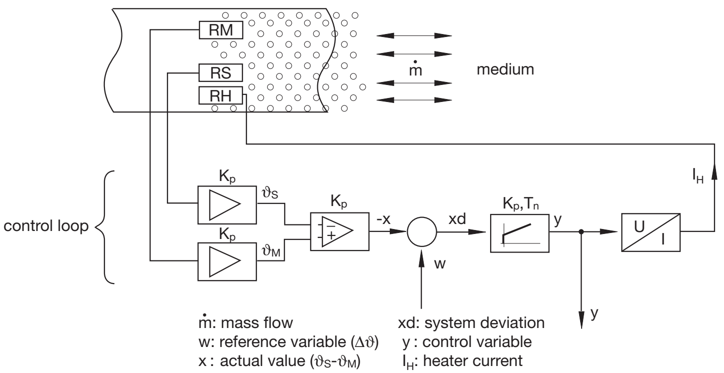


fig. 1

1.1.2 Mechanical procedure

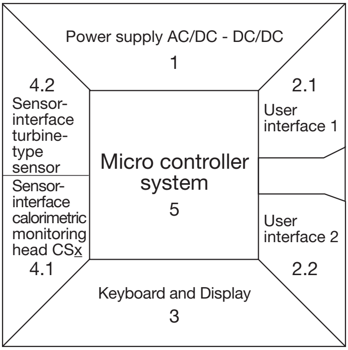
Model FC01-CC may be equipped with turbine-type sensors to provide true flow measurement.

The measuring principle of turbine-type sensors is based on the conversion of rotational speed into electrical signals. The flow stream will cause the turbine to rotate, converting the rotation inductively into an electrical signal in the form of pulses. The frequency of this signal is evaluated in the FC01-CC and indicated as flow rate.

1.2 System description

The system comprises the following hardware functional modules:

1 Input voltage:	DC or AC supply (terminal XV)	
2 User interfaces:	2.1 signal outputs	2-way or 4-way signal outputs (terminal XAH)
	2.2 analogue output	1 and 2 (terminal XAO)
3 Keyboard and display:	keypads	
	liquid crystal display	
4 Sensor Interfaces:	4.1 calorimetric monitoring head type CSx (terminal XSK)	
	4.2 turbine-type sensor TST (terminal XSF)	
5 Micro controller system:	signal processing and monitoring	



1	Input voltage:	24 V AC ±10% DC 19 … 32 V	
2.1	User interface 1	relay outputs: transistor outputs:	2 limit values 2 limit values + 1 error indication + 1 busy signal or frequency output (software selected)
2.2	User interface 2	analogue outputs current or voltage	
3	Keyboard/Display:	keypads LC display 2 x 16 digits	
4.1	Sensor interfaces	calorimetric monitoring head type CSx	
4.2	Sensor interfaces	turbine-type sensor TST	
5	Controller system:	signal processing I/O - controlling monitoring parameter memory	

fig. 2

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. 2.3.2 and circuit diagram 2.3.2.1/ 2.3.2.2.

System configuration and parameter setting are by means of the keyboard if **default values** need to be changed. (paras. 5 and 6)

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

1.2.1 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 para. 9.4.1 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 para. 9.4.2 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 para. 5.11)

Shield connections are ungrounded.

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

Power supply: DC 24 V or AC 24 V supply possible

Internal switch mode power supply with physical isolation of the primary and secondary side.

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

A PTC resistor provides protection from overcurrent. The element automatically resets upon removal of the disturbance or after disconnection of the supply voltage of the FC01-CC for approx. 1 s (e.g. remove terminal XV).

Please see para. 9.2.1 for technical characteristics.

1.3 Customer calibration

The FC01-CC functions are mere software functions which do not affect the FC01 hardware.

Characteristic curves can be reproduced by using either the calorimetric monitoring head or the turbine-type sensor head.

Calorimetric monitoring head

Generally, a flow characteristic value is assigned to each control variable of the temperature differential controller (with the variable equalling the heating power) by adjustments as described within the menu.

Up to 20 trim points can be assigned to the flow characteristic curve, i.e. the calibration range.

This distribution of the trim points being determined by user within certain ranges of the flow characteristic curve, resolution and accuracy are determined by that distribution. By extrapolation the measuring range is expanded beyond the max. flow value by 10 % of the upper trim point.

The lower trim point can be optionally set between the zero point of the characteristic curve and the last but one trim point. If the setting is selected above the zero point, the characteristic curve will be extrapolated by 10 % of the measuring range below the lower trim point or to the zero point. The limit values and the analogue outputs can be set, or scaled, between these limits.

Turbine-type sensor

When a turbine-type sensor head is used, its calibration is made in the same way as described for the calorimetric monitoring head. It is also possible to enter the turbine manufacturer's characteristic curve.

1.3.1 Options and benefits of customer calibration

Custom designed calibration allows for anomalies within medium or system variations, and the high repeatability of the measuring procedure makes it possible to measure and indicate flow conditions with a high degree of accuracy.

This requires that a higher-order measuring unit, or reference quantity, be available, from which the FC01-CC is then calibrated and set. The characteristic curve may be determined for each individual requirement or it can be transferred from one system to another with resultant lower accuracy.

Note:

- ❑ A suitable reference instrument is required in each case.
- ❑ **Adjustment in the field**: Consideration must be made as to the **medium and flow conditions** available;
  reference instrument required
- ❑ **E-T-A factory calibration**: **Calibration in measuring pipes** (integral system)
  Calibration of: water, various oils, air

1.3.2 Special flow and installation conditions

The measuring system generally implies defined flow conditions, to establish the flow characteristics of our standard characteristic curves. This requires that certain mechanical dimensions within the pipeline, such as distances before and after the monitoring head, before or after any bends and changes in pipe diameter, mounting attitude of the monitoring head (e.g. immersion depth), and any restrictions caused by turbulent or asymmetric flow be considered.

It is often difficult in compact systems to satisfy these requirements, or to judge the consequences when they are not fully met (e.g. missing flow straighteners). The FC01-CC allows the user to partially or completely eliminate any serious consequences by means of its calibration features.

1.3.3 How to achieve higher accuracy

As a result of the relevant physical properties and the characteristics of the monitoring head, any variations of control variables will be very small and nearly linear in the event of high flow velocities, whereas with low flow velocities there will be a high signal variation with resultant high non-linearity. By setting the interpolation trim points close enough, the error can be kept below 1 % over wide distances of the measuring range.

Another influence is that of the temperature difference selected. See section 7.2.1.

1.3.4 How to achieve the full scale range

As the trim points can be optionally distributed in a fixed sequence on the characteristic curve, together with the appropriate selection of the sensor temperature, that part of the curve which is most important for the application can be given a particularly high resolution.

Note:

- ❑ The accuracy is a function of how close the trim points are distributed. (See section 11 - Examples).

1.3.5 Pin-point adjustment (selective accuracy)

If one or several flow values (e.g. flow limits, cooling power limit etc.) are particularly important for the system, they can be assigned to one trim point each to achieve a high degree of dependability and accuracy in meeting the control criteria.

1.3.6. Reproduction of precise measuring instruments

The customer calibrated (-CC) version of the FC01 allows the user to reproduce expensive measuring instrument data in his characteristic curve. Thus expensive measuring instruments need only be purchased once, if at all.

1.3.7 Use of standard and special monitoring heads
(separate heads for gases and liquids)

Monitoring heads are not arbitrarily interchangeable with the FC01-CC. Therefore both the electronic control unit FC01-CC-…-abc and the special monitoring head CSx-01SM…-abc carry the 3-digit suffix number -abc. (e.g.-133: characteristic curve for motor oil SAE 30). I.e. when a fault arises, the complete combination of monitoring head and electronic circuitry must be replaced if the high accuracy (±1% MBE) of the characteristic curve cannot be compromised. It is, however, possible to interchange the monitoring heads if the standard accuracy (see error diagram 9.5.1) (3 m/s in water, 20 m/s in air) suffices.

The standard monitoring head types available for all media are types CST-01SM, CSF-01SM and CSP-01SM.

The CST standard monitoring heads are factory preset for water (Ref. CST-WM) or for air (Ref. CST-AM).

The factory preset C and T values (i.e. sensor-specific characteristic quantities) can then be used as guidance quantities.

2 Installation

2.1 Installation of calorimetric monitoring heads

These are general directions for the application of calorimetric measuring heads which from application to application should be reviewed by the user in accordance with individual requirements.

2.1.1 Selection of material

Stainless steel 1.4571/AISI 316 Ti

The standard monitoring head material is stainless steel 1.4571/AISI 316 Ti, 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 steels 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.

Nickel-based alloy (Hastelloy 2.4610)

Hastelloy 2.6410 is a material with a chemical resistance generally exceeding that of stainless steel and copper-based alloys. They are particularly suitable for alkaline media (pH > 7). They should however be examined for suitability for each specific application using resistance tables and pragmatical values.

2.1.2 Mechanical installation

2.1.2.1 Thread-mounted monitoring head CST-01

Application:	general industry
Medium:	gases and liquids
Styles:	G1/2A or 1/2"-14NPT
Materials of the area exposed to medium:	stainless steel 1.4571 /AISI 316 Ti (standard) nickel based alloy (Hastelloy C4 2.4610)

If installed in fittings or T pieces with appropriate internal thread the max. length of the connection piece should be 36 mm from the inner pipe wall.

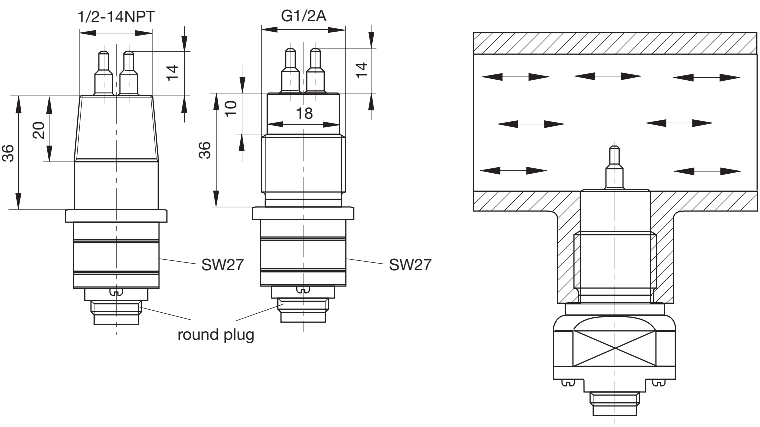


fig. 3

2.1.2.2 Monitoring head CSF-01 with adjustable immersion depth

Application: heating and air-conditioning systems

Medium: air, inert gases, liquids

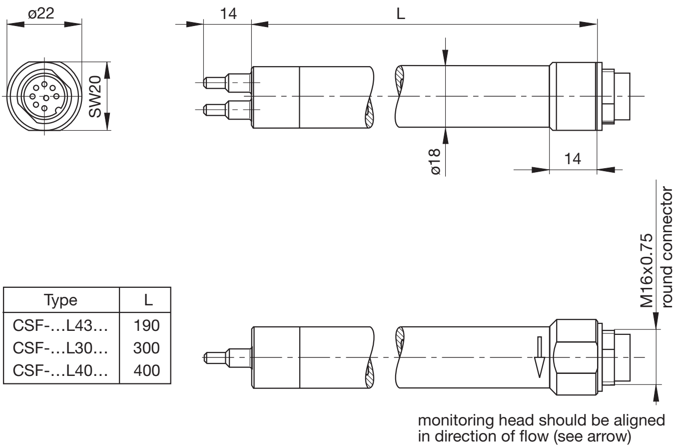
Style: smooth shank, 18 mm dia., immersion depth adjustable within the PG16 cable gland (accessory) or mounting in the stainless steel cutting ring gland

Materials of the area exposed to medium:

- M1 sensor and shank stainless steel 1.4571 /AISI 316 Ti (sensor)

Accessories:

- cable gland PG16 nickel-plated brass (see fig. 12)
- threaded installation bush stainless steel 316 (cutting ring) (see fig. 12)



Type	L
CSF-…L43…	190
CSF-…L30…	300
CSF-…L40…	400

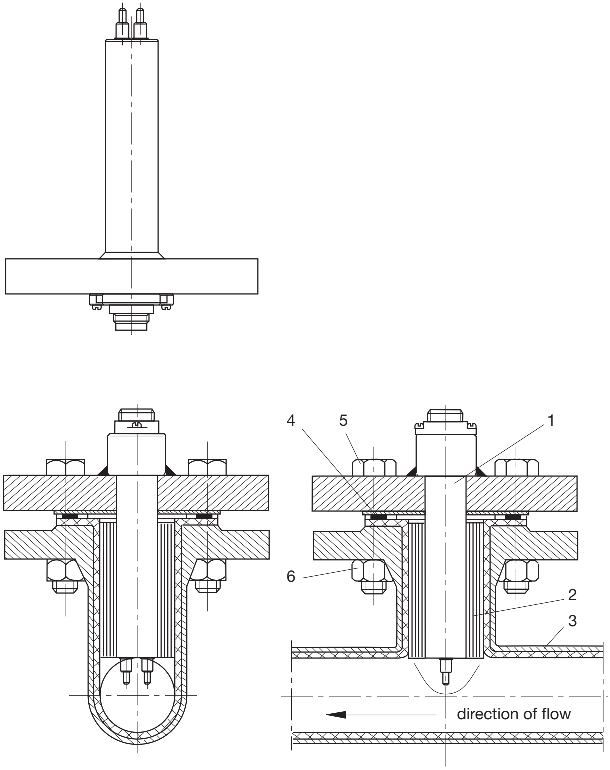
fig. 4

2.1.2.3 Flange-mounted monitoring head CSF-02

Application: chemical plants

Style: flange dimension to DIN 2500

Materials of the area exposed to medium: stainless steel 1.4571 /AISI 316 Ti or nickel based alloy (Hastelloy C4 2.4610)

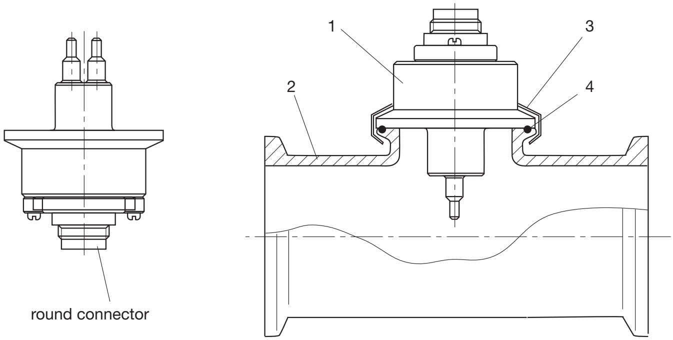


1 - flange-mounted monitoring head (E-T-A)
2 - deflector (customer)
3 - flange T piece (customer)
4 - flat gasket (customer)
5 - screw (customer)
6 - nut (customer)

fig. 5

2.1.2.4 Sanitary head CSF-03 (Tri-clamp)

Application:	food industry
Medium:	liquids or gases
Style:	Tri-clamp flange to DIN 32676 Tri-clamp for internal pipe diameter DN 1"
Materials of the area exposed to medium:	stainless steel 1.4571 /AISI 316 Ti electro-polished



1 - sanitary head (E-T-A)
2 - Tri-clamp - T piece (7MP-TEF) (customer)
3 - Tri-clamp - clamp (customer)
4 - Tri-clamp - sealing ring (customer)

fig. 6

2.1.2.5 Insertion head CSP for sensor adapter TP-..

Application:	general industry and installation
Style:	insertion-type for sensor adapter TP and ball valve
Material of the area exposed to medium:	stainless steel 1.4571/AISI 316 Ti electro-polished O-ring mat.: FPM (Viton)
Installation:	sensor adapter TP-.. (fig. 8) ball valve (fig. 9)

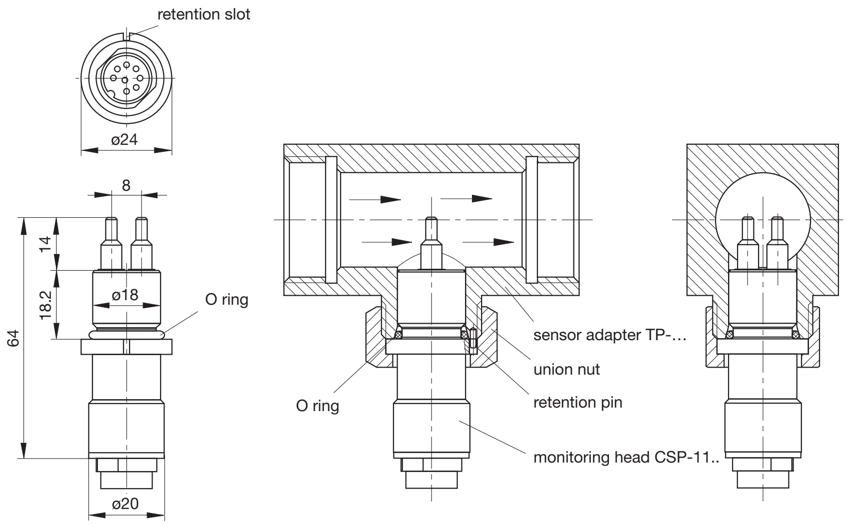


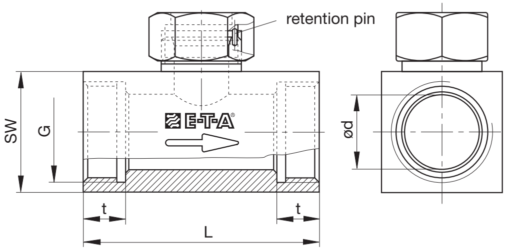
fig. 7

2.1.2.5.1 Sensor adapter TP-..

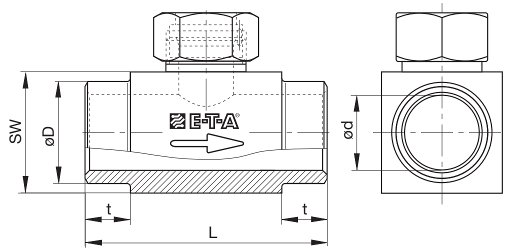
The sensor adapter TP-.. is available in 6 pipe diameters from 1/2" to 2".

Material of the area exposed to medium:

- brass or
- stainless steel 1.4571/AISI 316 Ti



Type	DN	ød	G	t	L	SW
TP-01 …	15	16	1/2"	11	50	27
TP-02 …	20	20	3/4"	12	64	32
TP-03 …	25	25	1"	14	78	40
TP-04 …	32	32	1 1/4"	15	94	50
TP-05 …	40	40	1 1/2"	15	110	55
TP-06 …	50	50	2"	19	138	70



Type	DN	ød	øD	t	L	SW
TP-01M1-SA	15	16	21.3	15	50	27
TP-02M1-SA	20	20	26.9	15	70	32
TP-03M1-SA	25	25	33.7	15	80	40
TP-04M1-SA	32	32	42.4	15	100	50
TP-05M1-SA	40	40	48.3	15	110	55
TP-06M1-SA	50	50	60.3	15	140	70

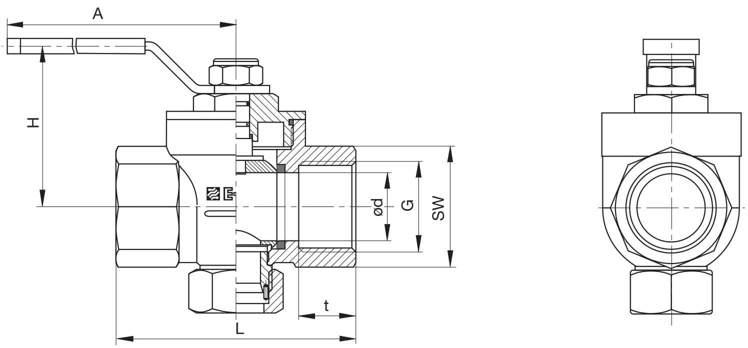
fig. 8

2.1.2.5.2 Ball valve

The ball valve is available in 4 nominal diameters from 1" to 2".

The ball valve ensures the sensors are fully immersed in the medium.

The monitoring head may also be replaced in pressurised pipe systems on duty.



Type	DN	ød	G	t	L	SW	H	A
BV-03M3	25	25	1"	21	88	41	59	115
BV-04M3	32	32	11/4"	24	100	50	65	115
BV-05M3	40	40	11/2"	24	110	54	77	150
BV-06M3	50	50	2"	28	131	70	85	150

fig. 9

2.1.3 Mounting instructions for monitoring head CST

Caution!

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.
The sensors must be positioned fully in the flow stream.
The surface of the shaft end must not be recessed below the inner pipe wall. Preferably the shaft surface of the monitoring head should project approx. 1-2 mm towards the pipe centre.

2.1.3.1 Liquid media

- In the case of vertical pipelines the monitoring head should be installed where the flow is rising, if possible.
- For horizontal pipelines the monitoring head should be mounted on the underside of the line (suspended).
- The monitoring head should be installed only in a straight section of piping. There should be a distance of at least 20 pipe diameters before the monitoring head, and 5 pipe diameters after the monitoring head before or after bends and changes in pipe diameter, to avoid any effects of turbulence (fig. 11).

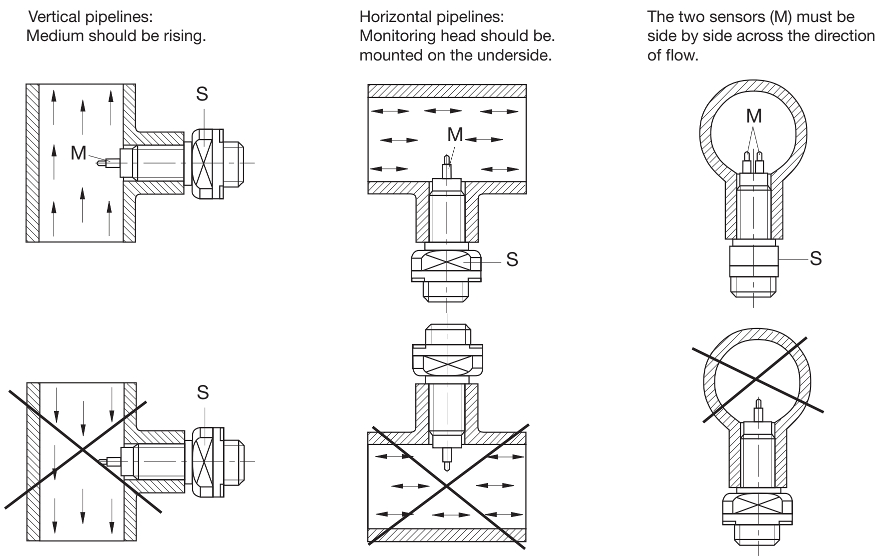


fig. 10

- When installing the monitoring head, please observe that the arrow corresponds to the flow direction.

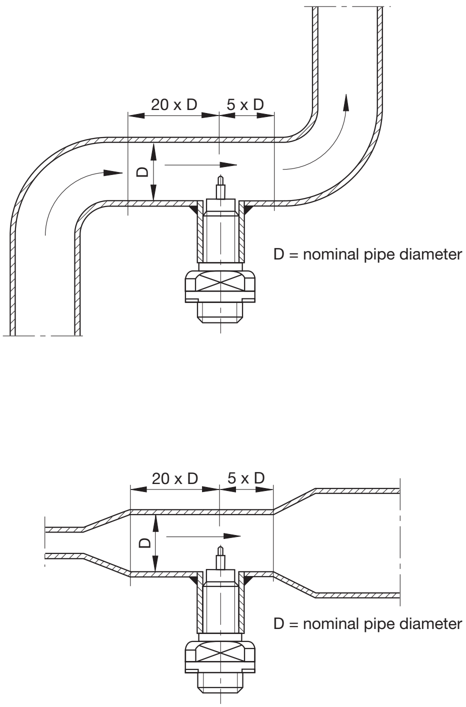


fig. 11

2.1.3.2 Gases

If gases are to be monitored, the mounting attitude of the monitoring head is unimportant in either vertical or horizontal pipelines. There should be a distance of at least 20 pipe diameters before the monitoring head, and 5 pipe diameters after the monitoring head before or after bends and changes in pipe diameter, to avoid any effects of turbulence.

2.1.3.3 Sealing

Use suitable thread sealing, e.g. hemp, teflon band, sealing glue:
- with fitting to DIN 3852, form B, (with sealing face) - length 36 mm
Put pipe system under pressure and check for leakages.

2.1.4 Mounting instructions for monitoring head CSF-01

Caution!

The monitoring head should only be installed or removed when the pipes are unpressurised.

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.

The shoulder of the sensor (7 mm from the tip) must be at the position 1/8 from dia. i.

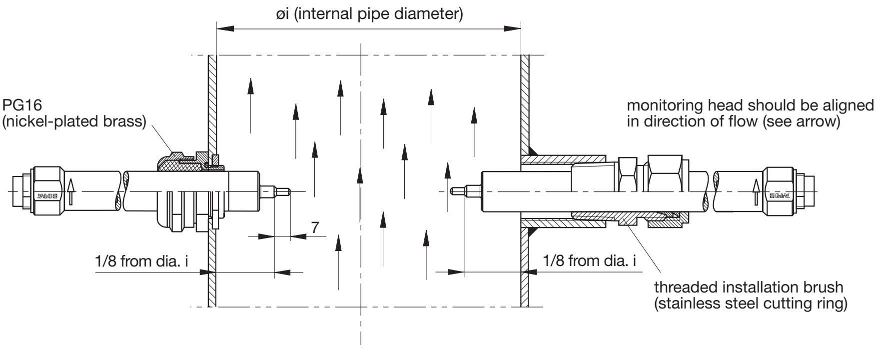


fig. 12

2.1.4.1 Point of installation and steadying zones (see 2.1.3.1 and 2.1.3.2)

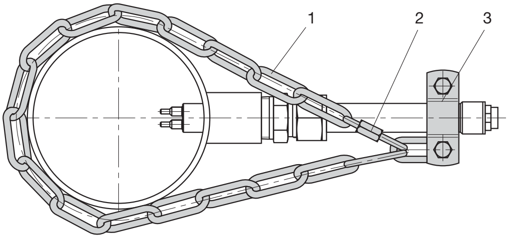
- Fit monitoring head with locking set as follows (fig. 13):
  - Fix first link of chain (1) into the clip (3) (tightening torque 10 Nm).
  - Put chain catch (2) into link and fasten with the tight chain.

Caution!

Check locking system with regard to strength!

The locking chain must be mounted as tightly as possible

Locking set 01



1 chain 4 x 32 DIN 5685 (approx. 1 m)
2 catch for chain NG 5
3 clip with screws and nuts DN15 to DIN 11850 (tightening torque 10 Nm)

fig. 13

2.1.5 Mounting instructions for monitoring head CSP-.. with sensor adapter TP-..

Caution!

The monitoring head should only be installed or removed when the pipes are unpressurised.

To ensure the safety label is clearly visible, it should be affixed on to or close to the measuring point.

- Insert the monitoring head with the O ring into the sensor adapter and tighten the union nut (observe correct retention).

  The retention pin ensures correct alignment of the monitoring head after the union nut has been tightened.

  Correct immersion depth of the monitoring head is ensured by the stop provided.

Sealing of the monitoring head in the sensor adapter is by means of the O ring provided (see fig. 7).

- Screw the sensor adapter into the pipe, using hemp, teflon tape or sealing glue (thread sealing glue) for sealing.

2.1.6 Electrical connection

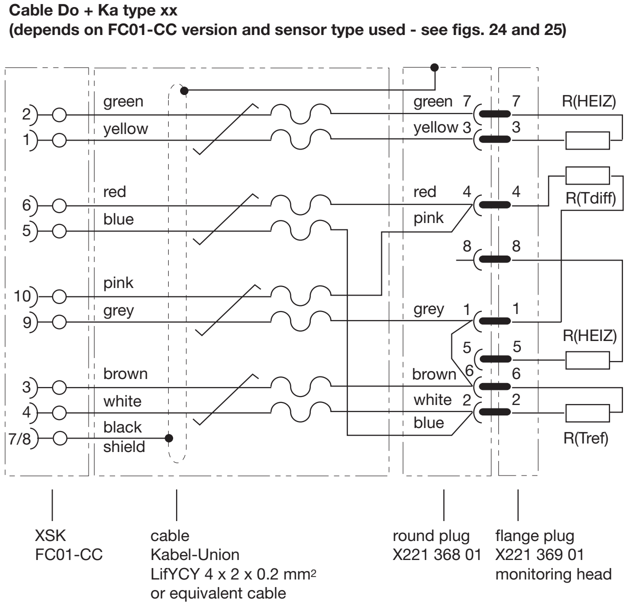


fig. 14

2.2 Installation of turbine-type sensor

2.2.1 Mechanical installation

2.2.1.1 Monitoring head TST..AM1/WM1

Application:		clean media, whenever fast response is required
Style:		G1/2A
Material of the area exposed to medium:		
- housing PSU:		TK-PSU, polysulfon, Udel
- sensor:		aluminium
- bearing:	bearing:	Berivac (beryllium alloy)
	tips:	Nivadur

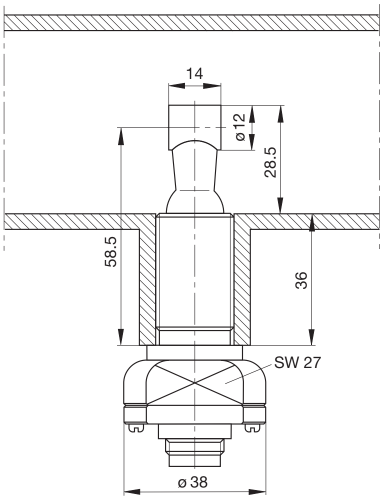


fig. 15

2.2.1.2 Monitoring head TST..HM2

Application:		clean media, in high temperature areas
Style:		G1/2A
Material of the area exposed to medium:		
- housing and sensor:		chrom-nickel/molybdene VUA
- bearing:	bearing:	saphir
	tips:	Nivadur

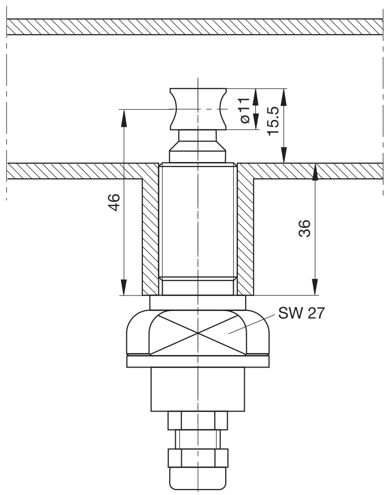


fig. 16

2.2.2 Mounting instructions

The turbine-type sensor can be mounted in any radial attitude and also allows oblique streaming (max. ±25°).

2.2.2.1 Mounting in the pipeline

- The sensor should be installed only in a straight section of piping. There should be a distance of at least 1 metre before or after bends and changes in pipe diameter.
- The sensor must be aligned in the range where it is intensive to oblique streaming (fig. 18). It is correctly positioned when the wrench flats (S) are aligned parallel with the pipeline (in direction of flow).

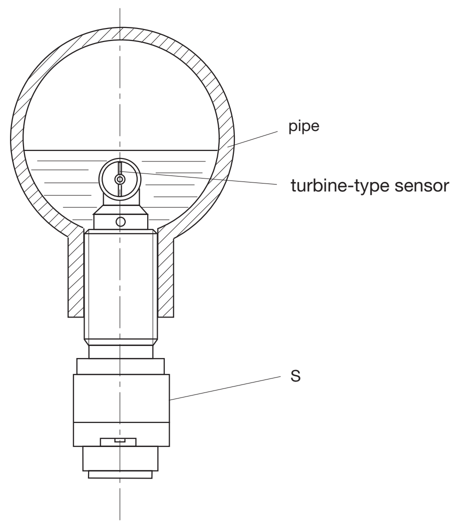


fig. 17

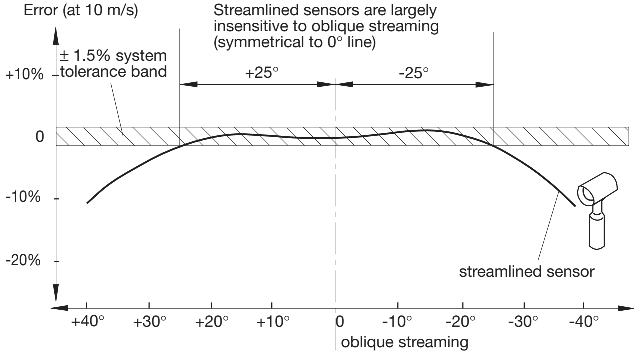


fig. 18

2.2.3 Electrical connection

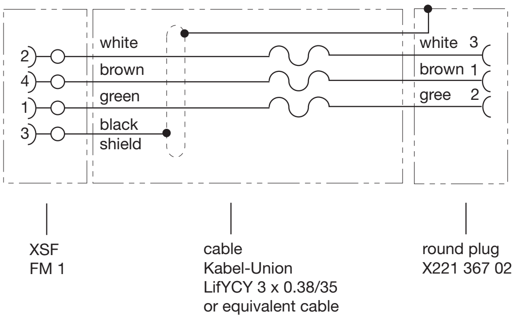


fig. 19

2.3 Installation of electronic control unit FC01-CC

2.3.1 Mechanical installation

2.3.1.1 Rail-mounted version FC01-CC-U1...

- The electronic housing is mounted on a symmetric rail to EN 50022.
- For thermal reasons, the modules should be spaced by at least 10 mm.
- Removal is by releasing the spring catch.

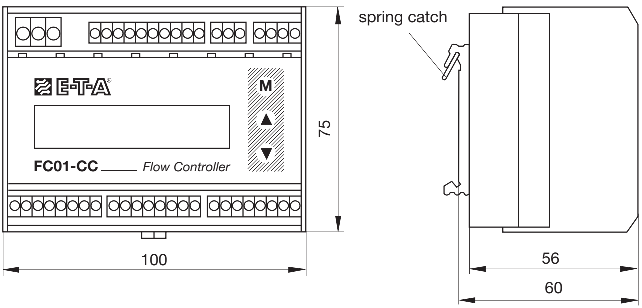


fig. 20

2.3.1.2 Surface mounted version FC01-FH-CC-U1...

- Remove the cover of the housing.
- Install the housing in place using the 4 self-tapping screws M4 (see fig. 21).
- Replace the cover and tighten the retaining screws.

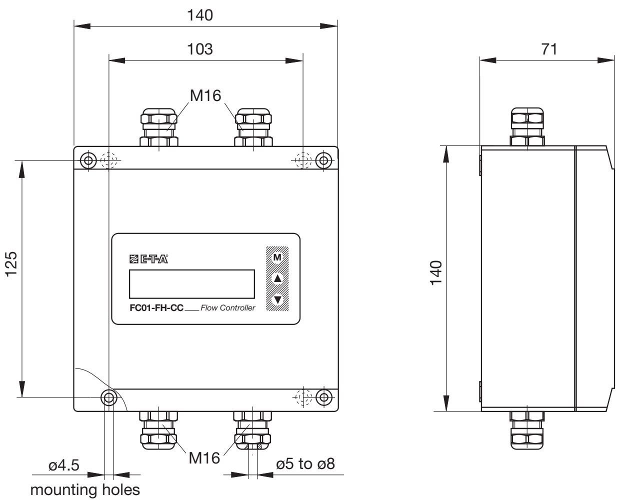


fig. 21

2.3.1.3 Front panel mounted housing FC01-ST-CC-U1...

- Insert housing into front of mounting hole and fix with 4 screws (see fig. 22) from the rear.

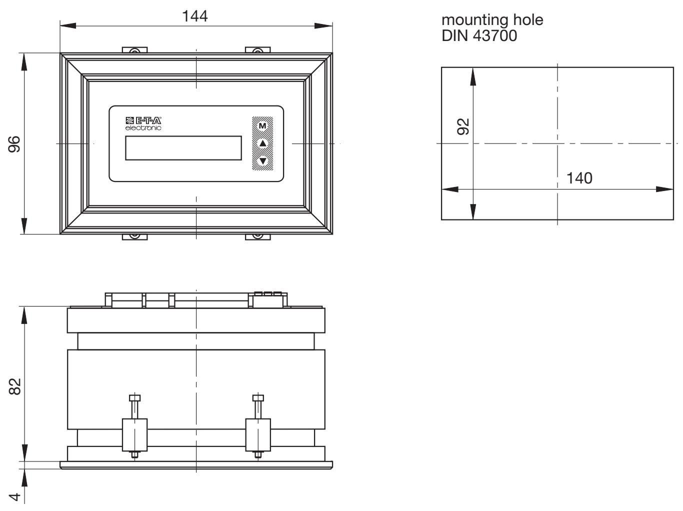


fig. 22

2.3.2 Electrical connection

Valid for all plug-in screw terminal strips:

Cable size:	0.14 mm^2 to 1.5 mm^2, single or stranded conductor
Stripping length:	6.5 mm
Clamping screw:	M2 (nickel-plated brass)
Contact material:	pre-tinned tin bronze

XV - Power supply

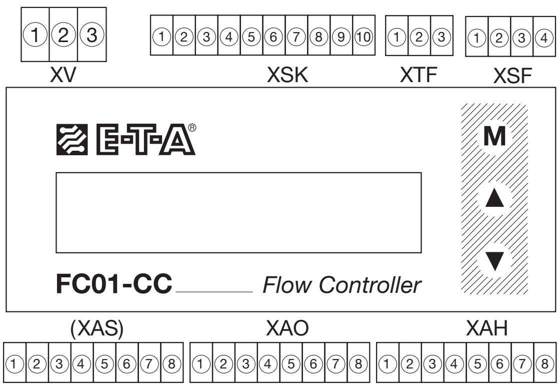
Connection by 3 pole connector; max. 1.5 mm^2; 3 x 0.75 mm^2 cable recommended

Pin No.	Signal name	Function
1	SGND	general reference ground/shield ground
2	$+U_V$	positive pole of supply voltage
3	$-U_V$	negative pole of supply voltage

XTF - Keyboard release

Connection by 3 pole connector; factory-wired

Bridge 2-3 inserted = keyboard blocked



XV	- power supply	(XAS)	- nor released for user
XSK	- calorimetric monitoring head	XAO	- analogue outputs
XTF	- keyboard release	XAH	- signal outputs
XSF	- turbine-type sensor		

fig. 23

XAO - Analogue outputs

Connection by 8 pole connector; max. 1.5 mm^2; LiYCY 2 x 0.25 mm^2 cable recommended for each analogue output

Pin selection for analogue outputs (option: 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 ground for analogue output 1 (ungrounded) *
5	SGNDA2	shield ground for analogue output 2 (ungrounded) *
6	ANAO2	analogue output 2 - temperature
7	ANA2GND	reference potential for analogue output 2
8	NC	none

*** Apply shield on one side only.**

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

Connection by 8 pole connector; max. 1.5 mm^2; LiYCY 3 x 0.38 mm^2 cable recommended for each signal output

Pin No.	Signal name	Function
1	SGNDL1	shield ground 1
2	LIM1	non-inverted signal output 1 (N/O)
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/O)
7	LIM2COM	common change over input 2
8	/LIM2	inverted signal output 2 (N/C)

XAH - Limit switch signal outputs - transistor outputs NPN, freely connectable as emitter (-) and collector (+) have been brought out separately.

Connection by 8 pole connector; max. 1.5 mm^2; LifYCY 4 x 2 x 0.2 mm^2 cable recommended

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

XSK - Connection of calorimetric monitoring heads type CSx

Pre-sized connecting cable Do+Ka type 15 or Do+Ka type 18 with plug-in screw terminal strip (see 2.1.6)

XSF - Connection of turbine-type sensors type TST

Pre-sized connecting cable Do+Ka type 16 with plug-in screw terminal strip (see 2.2.3)

(XAS - secondary current supply)

Only for connection of cable shield (not released for user)

Pin No.	Signal name	Function
3	SGND	/shield ground

2.3.2.1 Circuit diagram FC01-CC
Version: 24 V, relay outputs

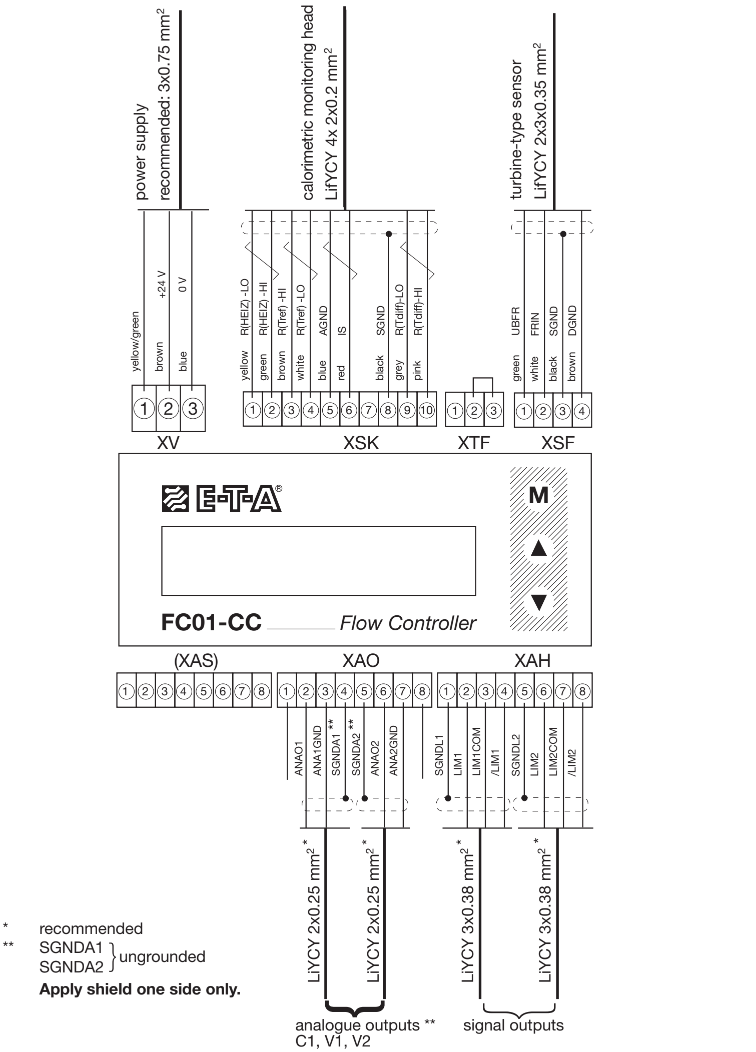
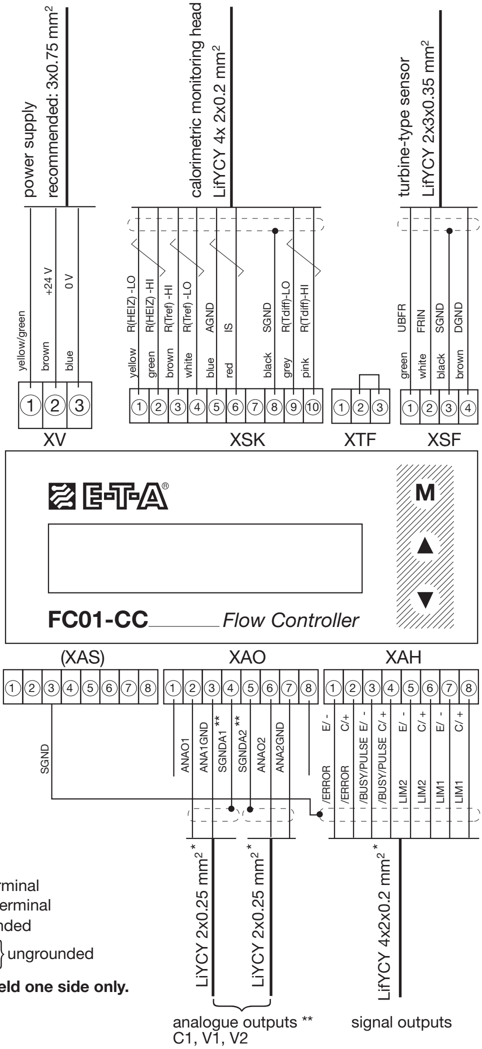


fig. 24

2.3.2.2 Circuit diagram FC01-CC
Version: 24 V, transistor outputs (NPN)



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

Apply shield one side only.

fig. 25

2.3.2.3 Electrical connection - frequency output (version FC01-CC-U1T4)

The quantity-dependent pulse may be selected in the menu item “DISPLAY SELECT”. A square pulse signal is available for driving a counter of a primary control at the plug **XAH** /BUSY E/- and /BUSY C/+ (pins 3 and 4) (see fig. 25 - circuit digram FC01-CC - transistor outputs).

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

The pulse length is 50 ms (±1%) continuously.

Select cable size 1.5 mm^2 to make the connections.

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

Electronic signal processing (fig. 26)

If the frequency output of the FC01-CC 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)

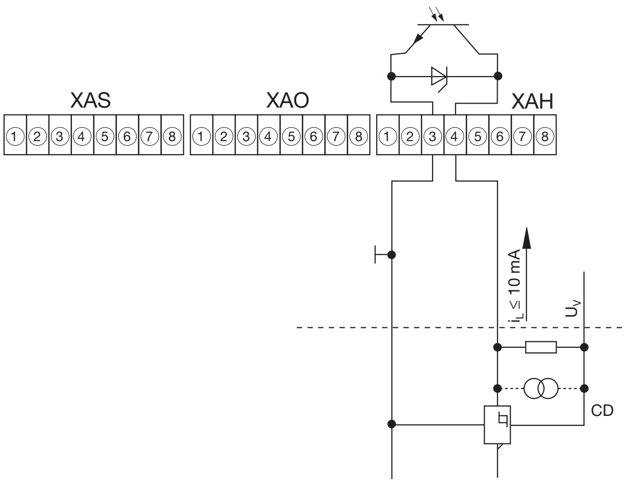


fig. 26

Electromechanical counter (fig. 27)

The FC01-CC 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** as the pulse length is 50 ms (±0.1%) continuously.

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)

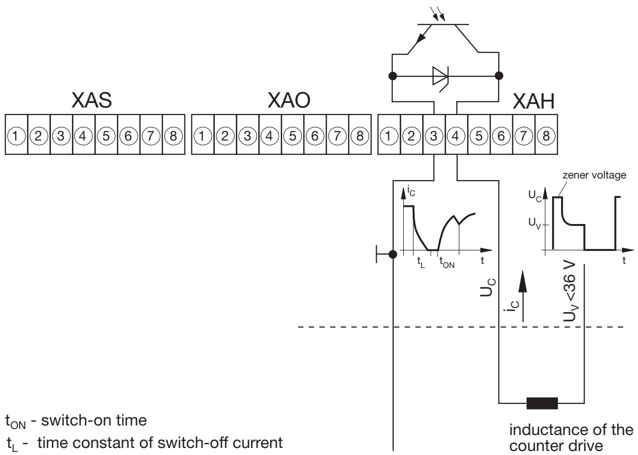


fig. 27

Note:

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

3 Operating system

Clear menu-driven control, via keyboard and display, enables easy definition of parameters and configuration.

This provides high system flexibility, making the FC01-CC the optimum solution for a wide variety of measuring, monitoring and display tasks.

When programming the FC01-CC 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 SELECTION LEVEL (MENU)

See Appendix 2 listing all functions available.

Keypads M MODE, ▲ UP and ▼ DOWN

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

Caution!

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

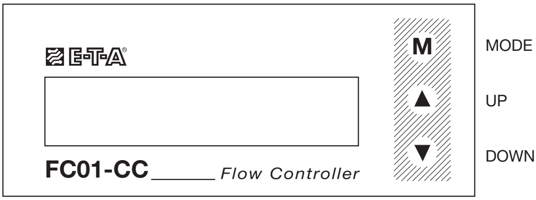


fig. 28

Menu paging

The next menu option is selected by pressing Ⓜ MODE (forward paging).

Pressing Ⓜ MODE after the last menu option will cause skipping to the first option of the menu.

Calling the menu option

Simultaneously pressing ▲ UP and ▼ 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 Ⓜ 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 are still available even after repeatadly switching the FC01-CC ON/OFF.

Deleting data

Selected data such as MIN, MAX values, totalized quantity or LAST ERROR can be deleted or reset by simultaneously pressing ▲ UP and ▼ DOWN = ▲ + ▼.

Caution!

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

4 Operation and main menu

4.1 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. 8.1, Test and diagnosis).

If during the test no error was found, the display will indicate either **HEATING UP** (if a calorimetric sensor has been selected) or **- - - - -** (if a turbine-type sensor has been selected).

If a calorimetric monitoring head has been selected, the FC01-CC will then be in the heating up period required for the measuring procedure.

4.2 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 and ▼ 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 (0.1 … 20 m/s for air, 0.05 … 3 m/s for water). The FC01-CC can thus be operated beyond the measuring values defined, i.e. up to 100 m/s for air, and up to 4 m/s for water. Außerdem ist es möglich, über die Sonderkalibrierung der CC-Software, eine Vergrößerung des Messbereichs (z.b. Medium Öl max. 5 m/s) zu erreichen.

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. 4.2.1

4.2.1 Operating data

4.2.1.1 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. 5.8 - 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. 5.8).

The following figures show the display variants under menu option “Measured value(s)” (para. 5.7 - menu option DISPLAY SELECT and 5.10 - menu option FREQUENCY OUTPUT).

Note:

- ❑ The limit switch for medium temperature is not available if a turbine-type sensor has been selected!

4.2.1.1.1 Calorimetric monitoring head CSx

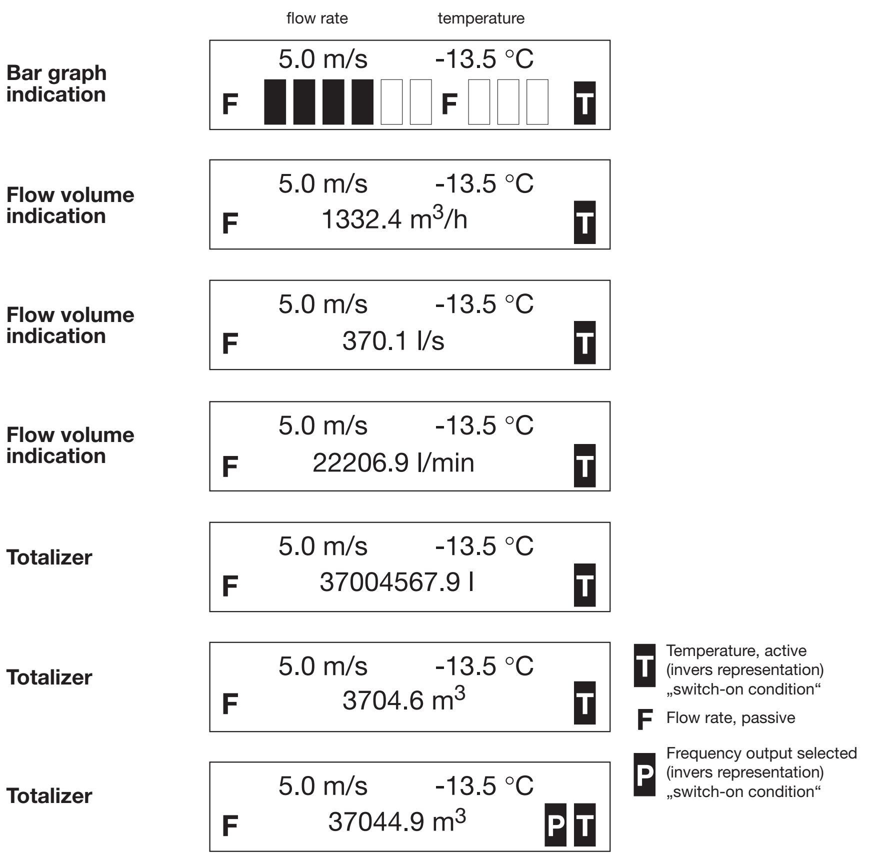


fig. 29

4.2.1.1.2 Turbine-type sensor TST

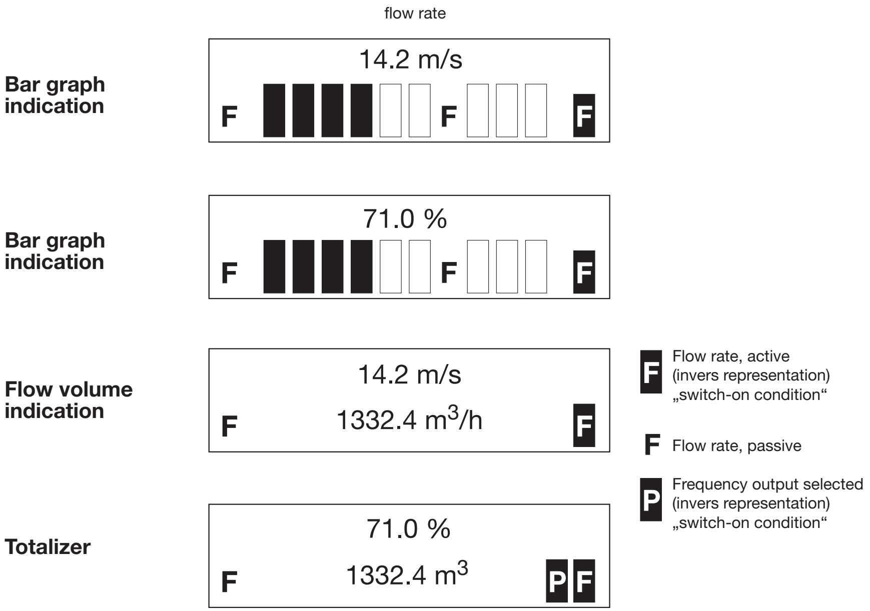


fig. 30

4.2.1.2 Peak values (menu option: **PEAK VALUE MIN / PEAK VALUE MAX**)

The FC01-CC 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 and ▼ DOWN = ▲ + ▼.

Caution!

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

Note:

- The measured-value memories for medium temperature are not available if a turbine-type sensor has been selected.

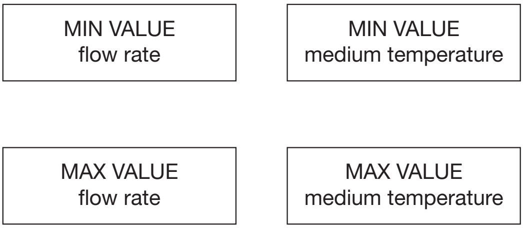


fig. 31

4.2.1.3 Last error (menu option: **LAST ERROR**)

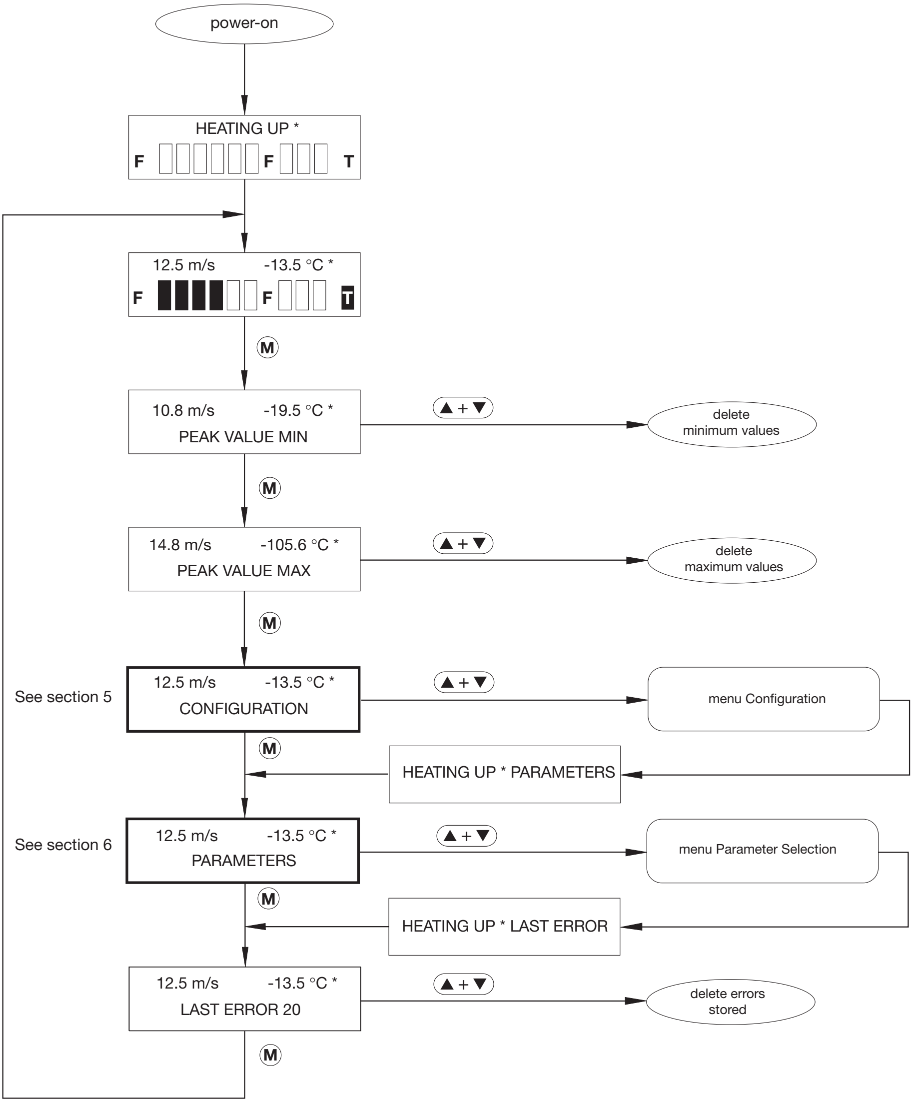
The last main menu option to be called is the error memory.

This error memory comprises the number of the last error (see section 8). It may be very helpful when commissioning the FC01-CC.

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 = ▲ + ▼.

4.2.1.4 Main menu



* not available with turbine-type sensor

5 Configuration (menu option: **CONFIGURATION**)

The CONFIGURATION menu serves to adjust the FC01-CC to the application within the entire system.
During system configuration, measuring operations are not possible (see Appendix 1).
Configuration possibilities are:

5.1 Selection of monitoring head (menu option: **SENSOR SELECT**)

This menu option allows the selection of two types of monitoring heads:

- calorimetric monitoring head (TYPE CALORIM.)
- turbine-type sensor (TYPE TURBINE)

It is not necessary to enter further details about the head selected.

Note:

❑ If a turbine-type sensor is selected, the functions relating to medium temperature are not accessible.

5.2 Monitoring head data (menu option: **SENSOR CODE**)

To operate the FC01-CC with a calorimetric sensor, it is necessary to set sensor-specific characteristics (see para. 7.2.6).

The characteristics are specified by the sensor code which together with the monitoring head type number is marked on the monitoring head housing.

Setting is menu driven two steps:

1. Setting of the C characteristics C range: **700 … 1300**
2. Setting of the T characteristics T range: **01 … 99**

Caution!

⚠ Take care to repeat these settings after replacing the monitoring head or electronic module (FC01-CC), as the accuracy of measurements is determined by the sensor code.

Note:

❑ This submenu is not available if a turbine-type sensor has been selected, in which case the sensor code has no influence on the measuring accuracy.

5.3 Custom designed calibration (menu option: **CUSTOMER TRIM**)

5.3.1 Acces to menu option CUSTOMER TRIM

Access to the calibration menu is provided by answering **CUSTOMER TRIM?** with **yes**, and entering the fixed 3-digit **ACCES CODE**.

Note:

ACCESS CODE to be entered ➡ 987

Entering an incorrect code will cause skipping to the next option of the configuration menu; another access to CUSTOMER TRIM can only be started after running through the entire configuration menu.

5.3.2 Old curve / new curve

If the inquiry about the **CHARACTERISTICS** of the curve is answered by **new**, the selected trim points are assigned to default data (see para. 7.2.5).

If a field curve needs to be corrected or expanded, the above inquiry should be answered by **old**.

In that case, the trim points already stored will not be affected.

This menu option does not apply if a custom designed curve has not yet been entered.

5.3.3 Number of trim points

The number of trim points **NUMBER OF TRIM POINTS** can be selected between 2 and 20 (see para. 7.2.2).

5.3.4 Determining the temperature differential

The TEMPERATURE DIFFERENCE setpoint can be set at 10 °C ≤ ▯▯ ≥ 23 °C.The limit conditions defined in para. 7.2.1 shall be observed.

This menu option does not apply if a turbine-type sensor has been selected.

5.3.5 Automatic calibration

After the TEMPERATURE DIFFERENCE has been determined, the TRIM POINT with the highest number will appear when the first adjustment is made. It corresponds to the number of trim points selected (**TRIM POINT. .**).

The highest flow velocity shall be assigned to that trim point.

The flow velocity can be between 0.00 m/s and 90.00 m/s.

Before starting the automatic calibration by simultaneously pressing ▲ UP and ▼ DOWN = (▲ + ▼) the flow velocity at which the trim point shall be determined must have been available at the sensor for more than 10 seconds.

If calorimetric monitoring head has been selected, the heating period required by the measuring procedure is started before the first trim point is set. The remaining heat-up time is displayed in seconds (**REST TIME . . sec.**).

Once the heat-up period is over, the FC01-CC will start the setting routine for the set flow velocity.

The calibration time is 20 seconds.

Note:

- ❑ Both flow and temperature shall be kept constant during that period as otherwise the heating power (of calorimetric monitoring heads) or the frequency (of turbine-type sensors) cannot be correctly determined.

The display will therefore indicate index quantity **xd = ...** for constant flow (with calorimetric monitoring heads). During the calibration time of 20 seconds, that quantity should be between -0.10 and +0.10.

Upon completion of the calibration, the program will return to menu option **TRIM POINT . .**, either with the heating power determined (calorimetric monitoring head) or with the frequency determined (turbine-type sensor).

The integer value determined will be flashing on the display.

After confirmation. a selection menu is inserted allowing the calibration of the next, same or previous trim point (not with the first trim point).

When the next trim point is selected, the trim point number is reduced by one. The trim point is again assigned to a flow velocity, and the automatic calibration is started.

This procedure is repeated until the last trim point - **TRIM POINT 01** - has been calibrated.

The custom designed characteristic curve has now been established and entered.

5.3.6 Manual calibration

If a custom designed characteristic curve has already been established and the curve shall be duplicated on an other FC01-CC, it is possible to enter the data for the various points by hand.

The method is largely identical with that for automatic calibration.

The heating power (calorimetric monitoring heads) or frequency (turbine-type sensors) belonging to the flow velocity is not determined automatically but rather entered on the FC01-CC by hand.

It is also possible to make the calibration combining automatically determined and theoretically calculated trim points.

5.3.7 Calibration temperature

After confirmation of the last trim point, **TRIM IS READY!** is displayed.

The second line on the display will show the medium temperature in °C at which the calibration was made. With automatic calibration, the calibration temperature is displayed non-flashing and cannot be changed by hand.

If the calibration data were entered by hand, the calibration temperature must also be set by hand. In that case the temperature value will be flashing.

Note:

- ❑ The medium temperature must be kept constant over the entire calibration process!

5.3.8 Storing the characteristic curve

Before quitting the CUSTOMER TRIM menu, the FC01-CC shall be informed whether the custom designed curve determined or entered shall be stored in a permanent (touch switch M), or volatile way (▲ UP or ▼ DOWN).

If the characteristic curve shall be stored in a volatile way, it will be deleted upon failure or power disconnection.

Note:

- ❑ If a power failure occurs during the calibration, the entire calibration must be repeated!

5.3.9 Potential errors during the calibration

All errors found during the calibration are indicated with their relevant number.

If one of the following errors occurs, it is not necessary to repeat the entire calibration but rather the calibration of the trim point where the error occurred.

Error	Cause	Rectification
No. 10	Sensor not connected, or cable between FC01-CC 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	
No. 20	Medium temperature too low	
No. 30	Temperature difference selected is too high	Correct temperature difference.

5.4 Limit switch combinations (menu option: **LIMIT SWITCHES**)

The FC01-CC 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”.

Note:

❑ This submenu is not available if a turbine-type sensor has been selected, in which case the two limit switches are assigned to the flow rate.

Caution!

⚠ Menu option LIMIT SWITCHES may influence data in the parameter selection menu (see para. 5.13, Quitting the configuration menu).

5.5 Flow rate unit (menu option: **FLOW UNIT**)

At this point (1st line top left with calorimetric monitoring head and 1st line with turbine-type sensors) 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!

5.6 Medium temperature unit (menu option: **TEMP. UNIT**)

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

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.

Note:

❑ This submenu is not available if a turbine-type sensor has been selected!

5.7 Display (menu option: **DISPLAY SELECT**)

The FC01-CC 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 (if a calorimetric monitoring head is used), it is possible to select the second line from the following menu options (see para. 5.15).

- BARGRAPH
- LITRE/SECOND [l/s]
- LITRE/MINUTE [l/min]
- METRE^3 / HOUR [m^3/h]
- GALLONS°/MINUTE

Totalizer:

- LITRE [l]
- METRE^3 [m^3]
- GALLONS° [° = US-GALLONS]

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!

Skipping to the submenu BARGRAPH or PIPE SIZE is effected depending on the selected menu option.

5.8 Bar graph (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. 4.2.1 (Operating data).

Note:

❑ This submenu is available only in part if a turbine-type sensor is used. The option “Analogue Bargraph Assignment” is not applicable.

Example:

Limit switch assignment:	LS1 → F and 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:

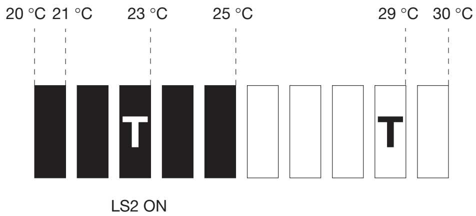


fig. 32

5.9 Pipe diameter (menu option: **PIPE SIZE**)

If flow volume/time unit display has been selected, it is necessary to indicate the pipe diameter to calculate mass flow.

This is provided by selecting the pipe diameter in menu option PIPE SIZE comprising pipe diameter from: **10.0** to **999.9** mm.

5.10 Frequency output (menu option: **FREQUENCY OUTPUT**)

The totalizer function has been expanded by the output of **proportional quantity pulses**. It can only be displayed by version **FC01-U1T4** (transistor outputs).

The proportional quantity pulses have been determined as follows:

1 pulse / quantity (totalizer unit selected)

Example: 1 pulse / 10.0 [litre]
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 not 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 puls per 0.1 … 999.9 [litre], [m^3], [gallons]

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, 31, 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.

5.11 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 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.

5.12 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 _ [°C] [°F] [K])
- FS = (**final value** 100% corresponds to a medium temperature _ [°C] [°F] [K])

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

Note:

❑ This submenu is not available if a turbine-type sensor has been selected!

5.13 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 data are found to be correct. The menu may then be quitted by pressing Ⓜ MODE.

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

Priority of entry errors in the CONFIGURATION menu:

- 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 Select, Custom Designed Calibration 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 1: Changing the limit switch assignment from **LS1 → F / LS2 → T** to **LS1 → F / LS2 → F**

affects
Parameter data: **LS2 ON** = 0.00

LS2 OFF = end of measuring range (depending on the selected medium)

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

Example 2: Changing sensor type from **CST-01AM1** (calorimetric monitoring head) to **TST-01HM2** (turbine-type sensor) with limit switches assigned to medium temperature.

affects
Parameter data: **LS1 ON** = 0.00

LS1 OFF = end of measuring range (depending on the medium selected)

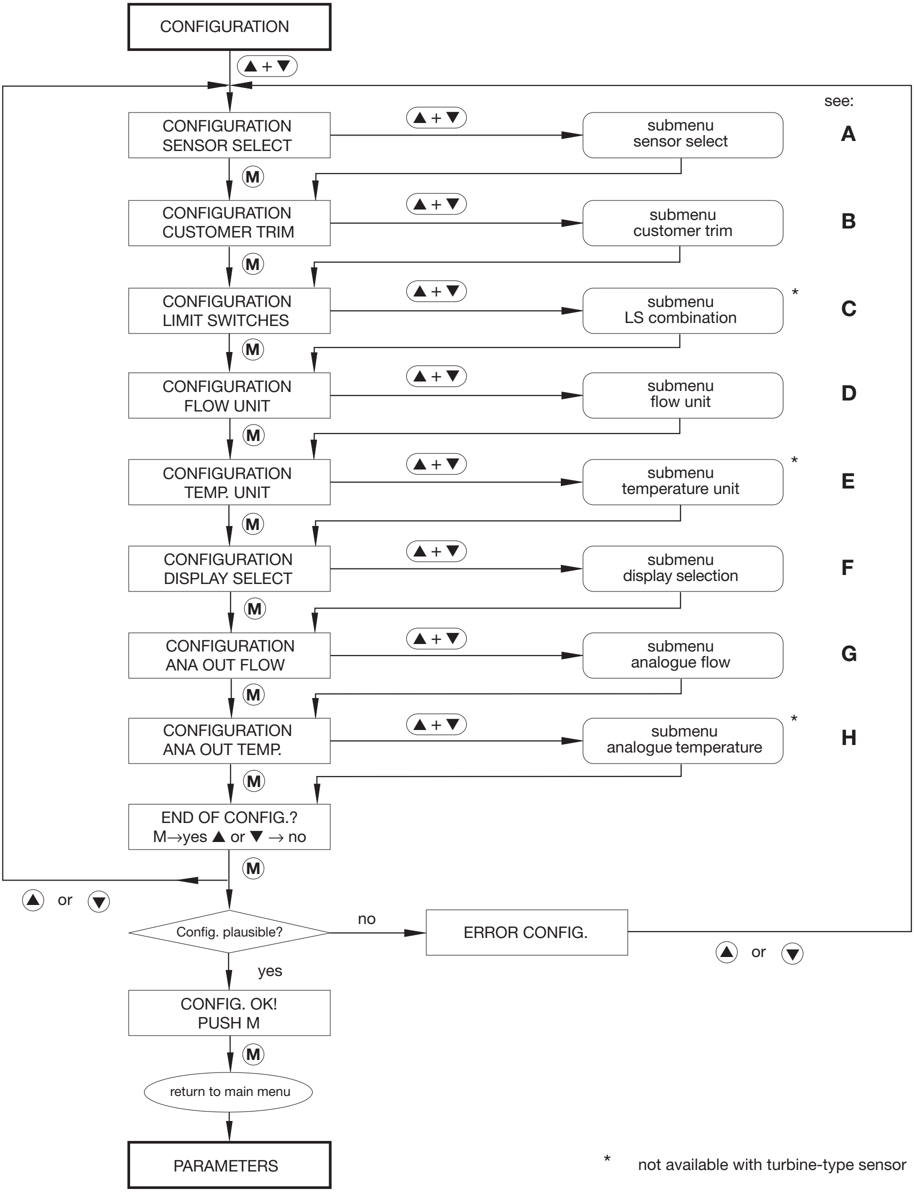
LS2 ON = 0.00

LS2 OFF = end of measuring range (depending on the medium selected)

Reason: As with a turbine-type sensor both limit switches are permanently assigned to flow rate, the switch-on and switch-off values of both limit switches will be affected.

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.

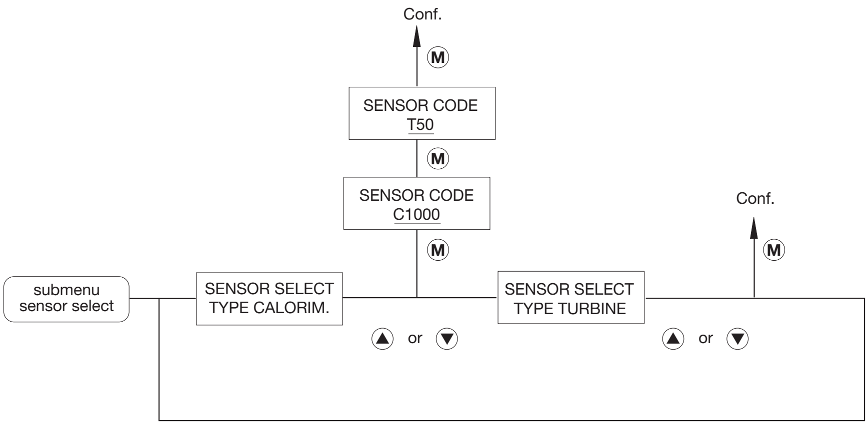
5.14 Configuration menu



* not available with turbine-type sensor

5.15 Configuration submenus

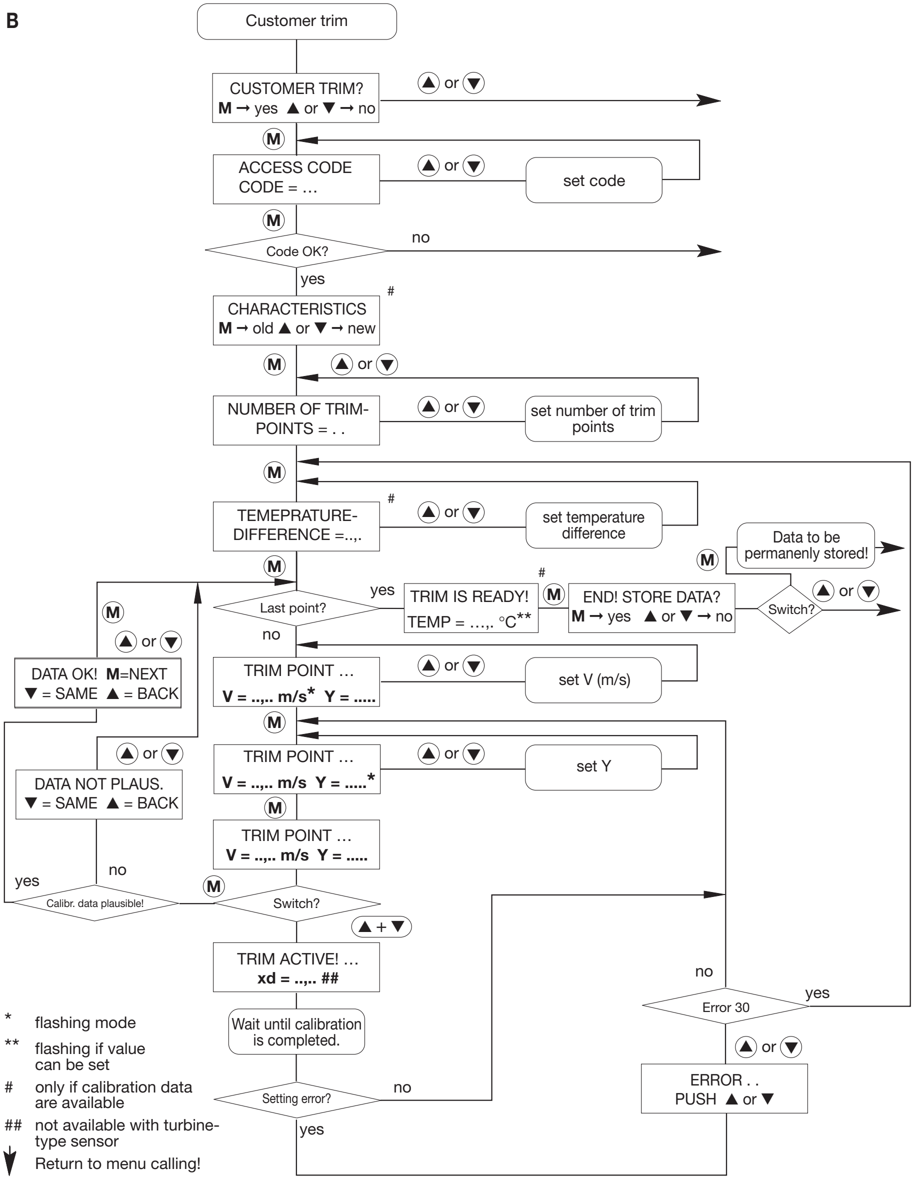
A



Conf.→ return to configuration menu

Configuration submenu CUSTOMER TRIM

B



* flashing mode

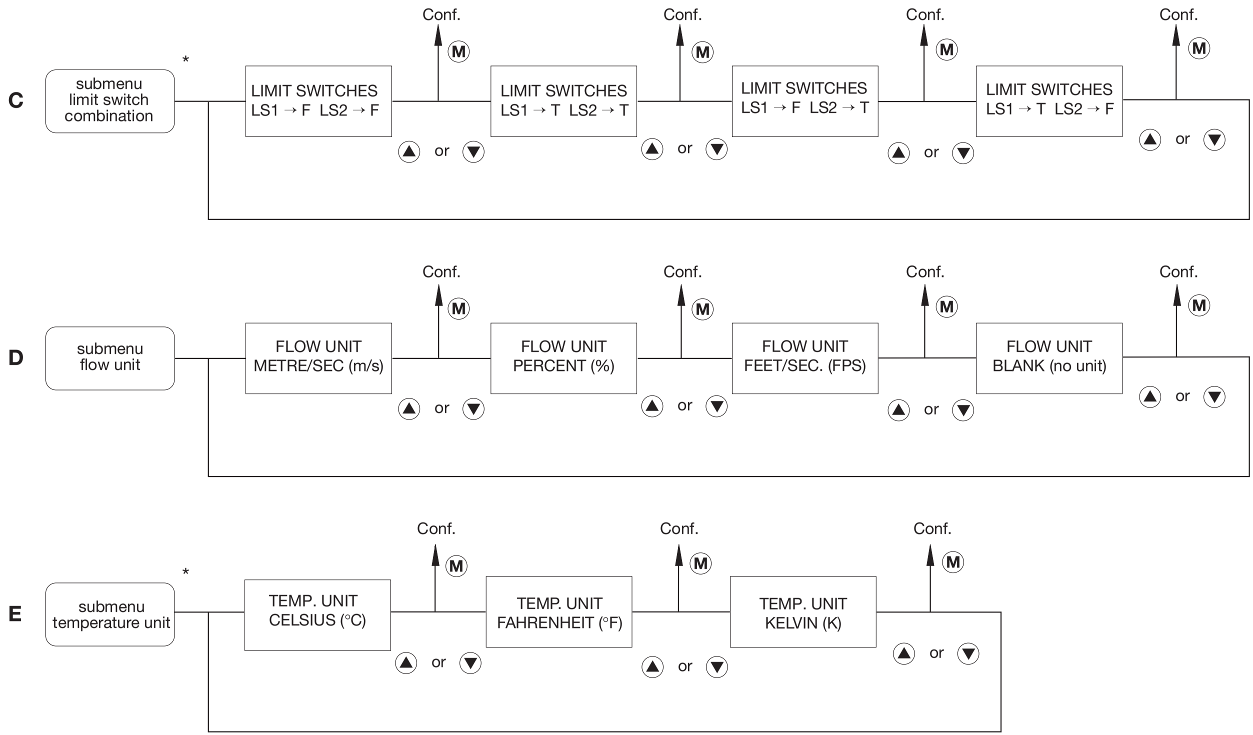
** flashing if value can be set

\# only if calibration data are available

\#\# not available with turbine-type sensor

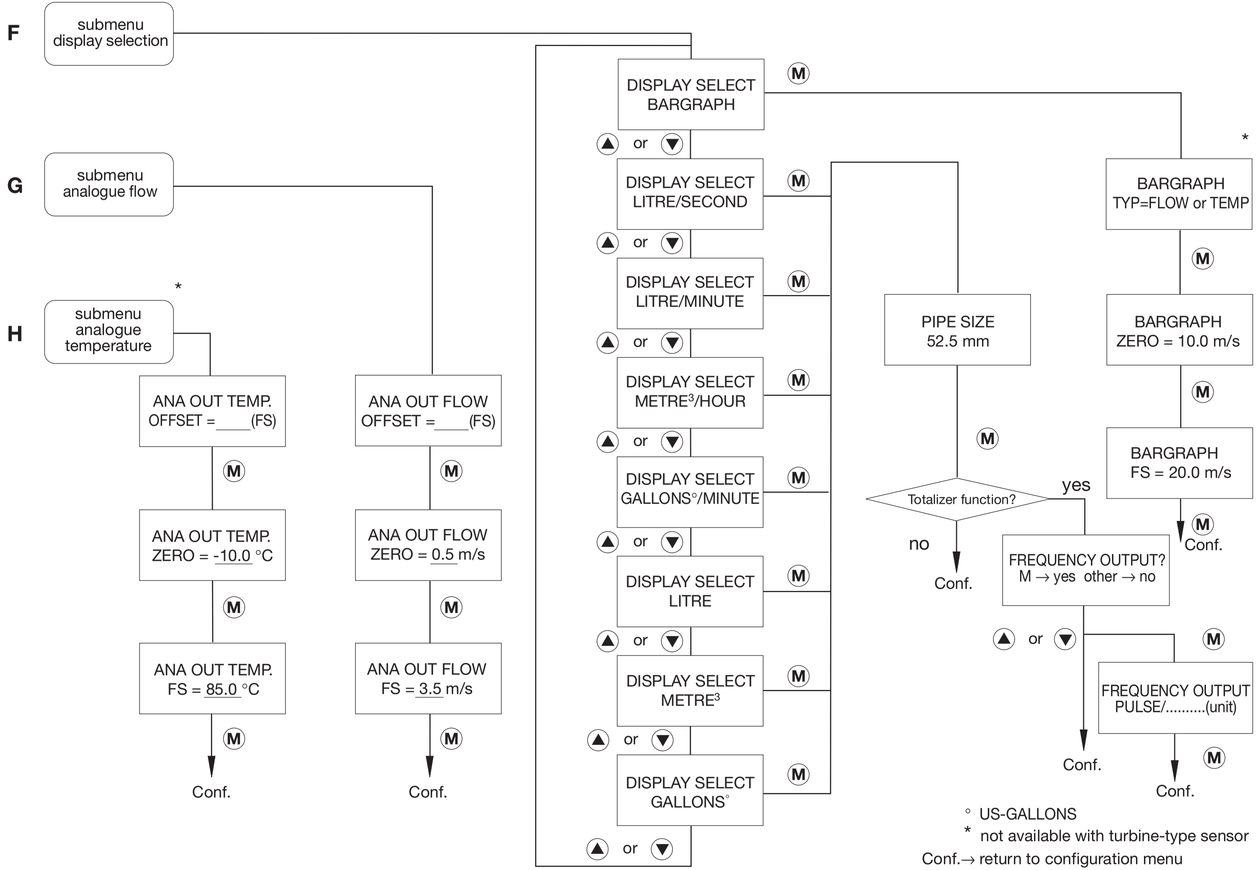
↓ Return to menu calling!

Configuration submenus (cont’d)



* not available with turbine-type sensor
Conf.→ return to configuration menu

Configuration submenus (cont'd)



6 Parameter selection (menu option: **PARAMETERS**)

After configuration of the FC01-CC 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 menu:

6.1 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 (measuring rate 100 ms).

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

6.2 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

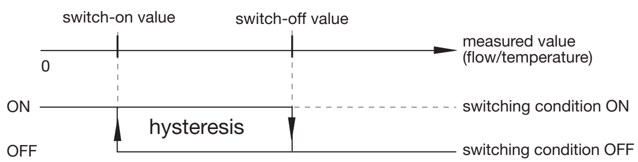


fig. 33

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

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

FC01-CC with transistor outputs (option T4):

- LIM1E - LIM1C = switched

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

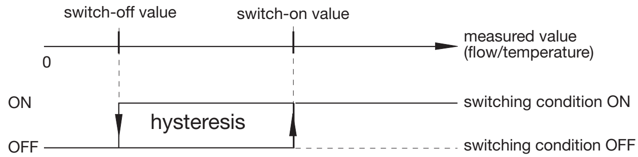


fig. 34

Example for ON: as described in example 1 (fig. 33)

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.

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

See limit switch 1!

6.4 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.

6.5 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.

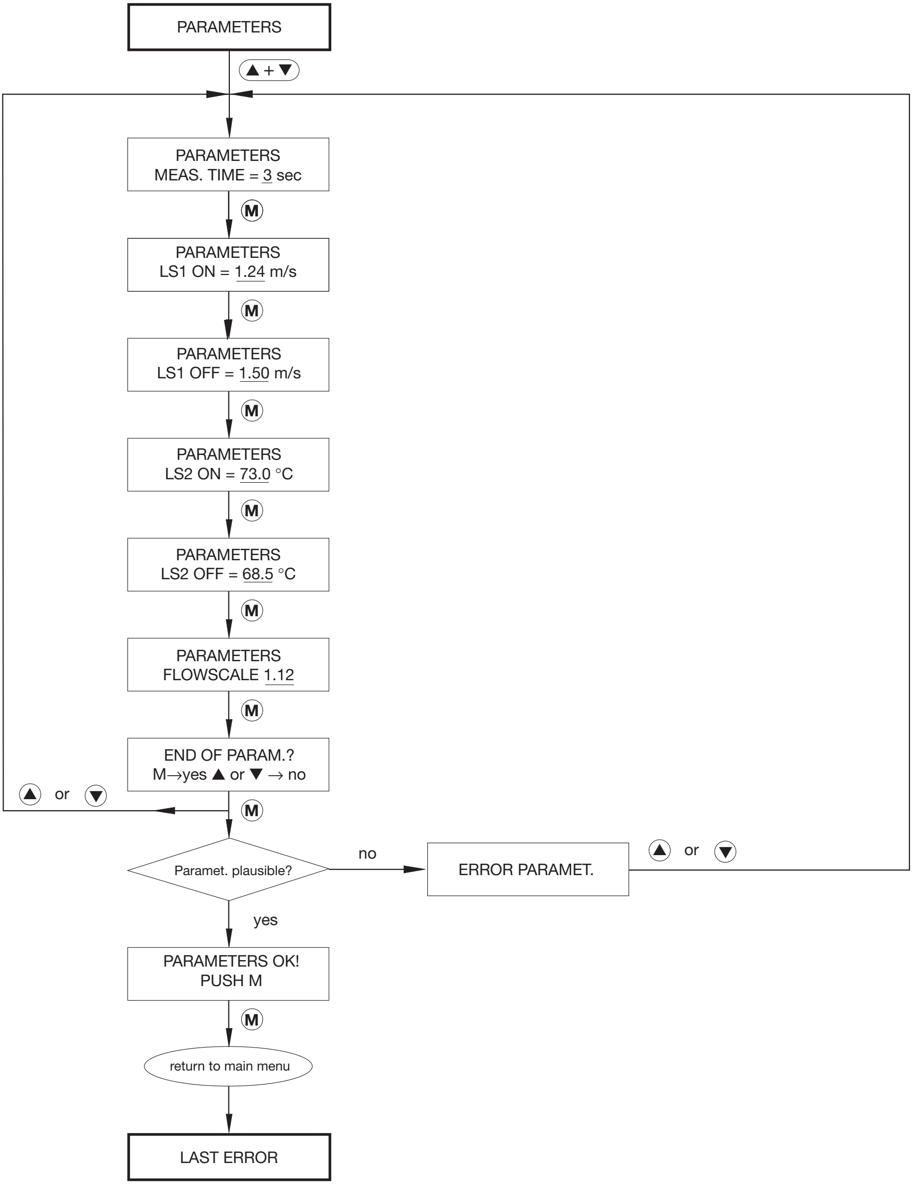
Priority of entry errors in the PARAMETER SELECTION menu:

- 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.

6.6 Parameter selection menu



7 Technical implementation of customer calibration

The FC01-CC can be used to establish a new pipe-depending curve, or to enter or store it as a theoretical curve.

7.1 Calculation

Interpolation between the trim points is linear. This applies both to the velocity values and the control variables to be assigned by the user, i.e. the velocity-dependent heating power required to maintain a constant temperature differential between the medium and the heated probe in the case of a calorimetric sensor, or the frequency in the case of a turbine-type sensor.

Beyond the maximum and minimum trim point, extrapolation is made by 10 % each of the applicable upper measuring range value. As the sensor is not direction-sensitive, the minimum flow value displayed will be zero.

Maximum number of trim points: 20

Minimum number of trim points: 2

The maximum trim point is assigned to the maximum velocity; the assignable velocity decreases with a descending trim point index.

Definition:

V_n (velocity assigned to setpoint n)

n = 2 … 20 (trim point index)

Condition for the trim points:

$V_n < V_{(n+1)} ..... \geq 0$

7.2 Calibration: calorimetric monitoring head

7.2.1 Selection of CTD value (temperature differential)

It is possible to select an optional temperature differential setpoint, within a temperature limit of 10 °C and 23 °C, providing that 90 % I_{max} of this current heating power is not exceeded, to indicate the temperature differential at max. flow velocity (90% $I_{max} \hat{=} Y = 36864$ digits).

Error (error 30) will be indicated if this limit is not observed during calibration. The user will then have to select a lower temperature differential.

As different media have different heat transfer capacities (specific heat) and densities, CTD value selection also depends on the medium to be measured.

Please see the following table and assignment list for guidance.

Class 1: gases

Class 2: granules, dust and other mixtures containing solids

Class 3: water and similar media, oils and other homogenous liquids, and liquid mixtures

Note:

- ❑ The measuring procedure necessitates a homogenous distribution of substances/mixture. Varying mixtures can only be detected by higher-order systems.

The particle size of class 2 media must not exceed 2 mm.

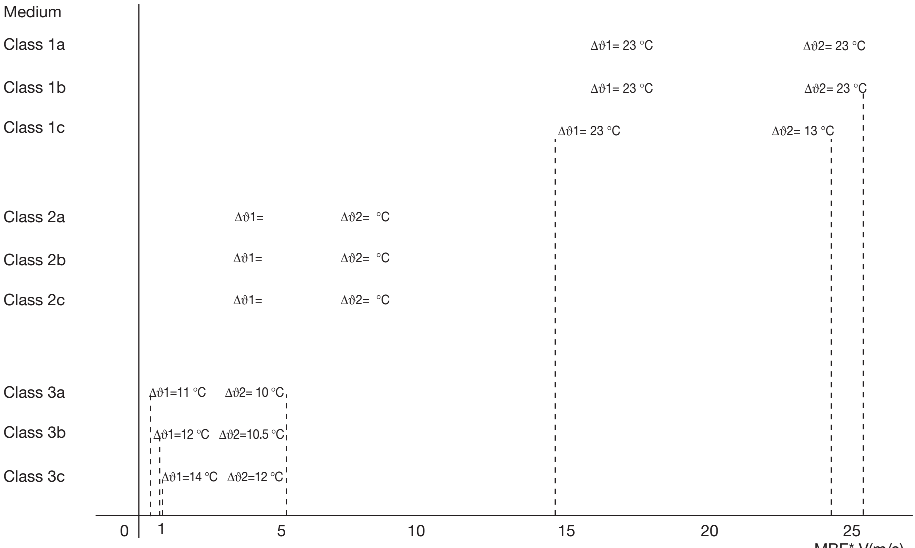
Medium:	Med
Flow velocity:	V
Temperature differential:	$\Delta\vartheta$
Mass:	m
Specific heat:	c
Density:	ρ

Assignment table - Medium / Flow velocity / Temperature differential

Class/Medium	Chemical symbol	V [m/s]	$\Delta\vartheta$ [°C]	ρ [g/dm^3] 0 °C, 1 bar	c [cal/g °C] 20 °C, 1bar
Class 1					
a: air		25	23	1.293	0.24
oxygen	O2	25	23	1.429	0.219
nitrogen	N2	25	23	1.25	0.249
nitro oxide	NO	25	23	1.34	0.237
carbon monoxide	CO	25	23	1.25	0.249
deuterium		25	23	0.1798	1.731
fluorine	F2	25	23	1.696	0.197
hydrogen	H2	25	23	0.08991	3.42
hydrogen bromide	HBr	25	23	3.646	0.086
hydrogen chloride	HCl	25	23	1.639	0.191
hydrogen fluoride	HF	25	23	0.8926	0.348
hydrogen iodide	HI	25	23	5.799	0.054
b:					
c: argon	Ar	14	23	1.784	0.124
helium 3	3He	14	23	0.1346	1.654
krypton	Kr	14	23	3.749	0.059
neon	Ne	14	23	0.9002	0.246
xenon	Xe	14	23	5.899	0.038
Class 2: We currently don’t have much experience with the use of such media, but generally the FC01-CC can certainly be used.					

Class/Medium	Chemical symbol	V [m/s]	$\Delta\vartheta$ [°C]	ρ [g/dm^3] 0 °C, 1 bar	c [cal/g °C] 20 °C, 1bar
Class 3				4 °C	20 °C
a: tap water		3	10	1	1
high-purity water		3	10	1	1
seawater		3	10	1.03	1
b: water glykol (1:1 … 2,5:1)		3	10.5		
c: oils:					
Esso cutting oil DN38		5	12	0.874 (20 °C)	
Mobil HLP46-C		5	12	0.881 (15 °C)	
Shell Diala G		5	12	0.882 (20 °C)	
Shell Thermina A		5	12	0.890 (20 °C)	1.853 (20 °C)
Shell Thermina B		5	12	0.863 (20 °C)	1.882 (20 °C)
Shell Thermina E		5	12	0.904 (20 °C)	1.839 (20 °C)
Shell Turbo T32		5	12	0.862 (20 °C)	1.883 (20 °C)
Shell Turbo T46		5	12	0.869 (20 °C)	1.875 (20 °C)
Shell Turbo T68		5	12	0.870 (20 °C)	1.874 (20 °C)
Shell Turbo T78		5	12	0.870 (20 °C)	1.874 (20 °C)
Stuart Excelene 416		5	12	0.850 (20 °C)	

Assignment graph - Medium / Flow velocity / Temperature differential



* MBE = upper measuring range value

7.2.2 Trim point selection - Number and position

Between 2 and 20 trim points can be set.

They are addressed in a “downward” sequence to ensure the user can recognize the trim points still available by the trim point index indicated.

A reasonable distribution on the characteristic curve depends on the desired accuracy, the required measuring range or continuity criteria such as differentiating criteria. These issues are addressed in section 11.

Generally, there are fewer trim points needed in the upper characteristic curve range than in the lower range, the reason for this being the flattening characteristic curve (see section 11).

Depending on the medium and the measuring range, it is possible to use different procedures in selecting the trim points.

A linear preselection of the trim points has been provided for in the FC01-CC. With the appropriate number of trim points set, this procedure achieves good results over the entire velocity range (5 m/s with water, 25 m/s with air).

A trim point distribution which significantly reduces the measuring error when compared to a linear distribution, can be determined by the following formula (see 11.4 - Example 4):

$$\boxed{\mathbf{MB = ME - MA}}$$

$$\boxed{\begin{array}{c}\mathbf{AB = MA + (MB \times (1 - e^{-(((SP-1) \times g)/SG)}))} \\ \mathbf{g = 2,5 \times (SP - 1)/SG}\end{array}}$$

AB -	trim value [m/s]	SP -	trim point No. SP = 1 … SG
MA -	lower measuring range value [m/s]	SG -	overall number of trim points
ME -	upper measuring range value [m/s]	g -	distribution coefficient
MB -	measuring range [m/s]		

7.2.3 MAX-MIN calibration procedure

The MAX/MIN calibration procedure has been selected because the critical parameter (max. heating power) is determined in the computer background after the first calibration step (max. flow velocity).

If too high a temperature differential has been selected for the heater control to indicate, this is displayed as “error 30”. It is then immediately possible to reduce the temperature differential to a value the controller is able to indicate (see para. 7.2.1, Selection of CTD value).

It is thus verified and ensured when starting the calibration that the flow characteristics can be displayed, eliminating that a curve must be dropped because its last trim point(s) cannot be indicated.

7.2.4 Zero point, directional discrimination and upper characteristic curve value

The zero point of the characteristic curve and the zero point of flow need not be identical. If the zero point of the characteristic curve - lowest trim point - is above the zero point of flow, the characteristic curve is linearly extrapolated down by 10 % MBE (= upper measuring range value) so as to extend the calibration range of the FC01-CC.

However, the extrapolation is only effected to the theoretical zero point as the measuring system does not operate in a direction-selective way.

If the zero point of flow and the zero point of the characteristic curve are identical, the control variable should be increased by 300 to 400 digits to suppress the convection-related variation of the zero point.

In the same way that the calibration range can be extrapolated downward by 10 % MBE, so can the upper calibration range be extrapolated by 10 % MBE above the upper trim point. Error indication because of minor over limits of the upper calibration range values can thus be eliminated. The extended characteristic range will then be fully available when determining the analogue output, the limit values and the bar graph.

7.2.5 New curve / Old curve

7.2.5.1 New curve

The following automatic processes have been provided for to facilitate and accelerate the calibration or manual entry of a new curve.

1. **Preloading of zero point control variables**

   As a result of parasitic heat transfer points a big part (approx. 50 %) of the heating power is not transported through the medium but rather through the housing and the electrical cables. The heating power control variable with zero flow has already a value above 25,000 digits.* Preloading the setting value for the lower trim point with that value obviates the need for passing through a wide setting range (time-saving benefit).

   * Provided the temperature differential has been selected appropriately (see para. 7.2.1 for recommended values).

2. **Linear preloading of interim values for velocity and control variable**

   The calibration range left between the last addressed and established trim point and the zero point is linearly divided among the remaining trim points. This applies both to velocity quantities and control variables. It generally ensures that only a small calibration range needs to be passed (provided that 1. has been satisfied).

   In this operating mode - new curve - an already existing curve (old curve) would be deleted. If the new curve is completely entered by hand, it is necessary to enter the TK reference temperature (see 5.3.7) when quitting the menu.

   The TK reference temperature is the medium temperature at which the curve was established under normal operating temperature conditions.

   If the calibration of a new curve is made selecting temperature differences which are essentially smaller than the values recommended, the zero point on the characteristic curve will be displaced towards smaller control variables. It may happen then that the first trim value is below or on the preloaded zero point value, in which case the software will provide that the initial values for further control variables are below the established preceding value.

7.2.5.2 Old curve

In this operating mode, each trim point can be corrected without jeopardizing other existing data.

Changes are limited by the general calibration conditions. This means that the values assigned to a trim point can never be higher than the values assigned to the trim point above, or lower than the quantities assigned to the trim point below.

Caution!

Changes/expansions of old curves must only be made whilst maintaining the temperature differential.

7.2.6 Transfer of C and T values - Re-establishment of T value

As the monitoring heads are factory preset for air or water, their C and T values apply only to those media.

When the heads are used in gases or gas mixtures similar to air (see table page 64), these values can be transferred. The same applies to heads monitoring water.

In that case the temperature difference (water 10 °C, air 23 °C) must be set in the CUSTOMER TRIM menu to calibrate a characteristic curve.

The following medium characteristic quantities should however harmonize as far as possible:

a. density ρ

b. specific heat c

The calibration, which is not dependent on the C and T values given, is described in paras. 5.3.6 and 5.3.7.

When other media are used, the C value may be transferred, but the T value should be separately established and set for recording the new curve at T = 50.

7.2.6.1 Establishing the T value - general

The T value should be established at a velocity in the upper third of the calibration range.

When recording the characteristic curve, the temperature and the control variable at a trim point located in the upper third of the characteristic curve (70 - 80 % V_{max}) should be noted.

T1 = ... , . °C	medium temperature when recording the new curve
Y_{T1} = ... digits	control variable
V_{T1} = . . , . . m/s	flow velocity at temperature T1

Control variable Y_{T2} is then established at the same flow velocity $V_{T2} = V_{T1}$, ideally at the highest medium operating temperature.

Conditions: $V_{T1} = V_{T2}$

$T2 > T1$

The following quantities are recorded:

T2 = ... , . °C	upper setting temperature of the medium
Y_{T2} = ... digits	control variable with T2

The T value is calculated by:

$$\boxed{T = 50 + (Y_{T2} - Y_{T1}) / (T2 - T1)}$$

The resultant T value is filed in the configuration menu under SENSOR SELECT - TYPE CALORIM- CODE T….

7.2.6.2 Establishing the new T value

At first, a **new curve** has to be recorded by setting the **T value** in the SENSOR SELECT menu at **T = 50**.

With heads monitoring water or air (see introduction to this section) it is possible to use the **C value** if similar media are to be monitored. It is necessary to set **C1000** as a basic value if the characteristic quantities of a medium cannot be assigned to a medium group.

After setting the **C** and **T values**, the number of trim points and the temperature difference shall be defined in the CUSTOMER TRIM menu.

Record the new curve as described, observing constant temperature conditions (T1, Y_{T1}, V_{T1} as described).

After establishing and storing the new curve, the medium shall be heated to setting temperature (T2).

Then turn to the CUSTOMER TRIM menu and select option **old curve**.

Address the trim point the control variable of which you wish to establish at temperature T2 and the same velocity as when recording the new curve.

Compare the following values displayed:

TRIM POINT …

V = . . , . . m/s

Y = ... (Y_{T1}) with the values noted.

These values shell still be assigned to the old curve which was recorded at temperature T1. Then set velocity **V** at the higher temperature T2.

Activate the automatic control variable determination in menu **TRIM ACTIVE**.

When the FC01-CC has determined the new Y value, it is displayed and recorded (Y_{T2}) as it is needed for subsequently calculating the T value.

Temperature T2 (please note) which will also be included in the calculations is displayed before the calibration menu is quitted.

Then quit the menu without storing the data (▲ UP or ▼ DOWN) to prevent overwriting the old curve.

The new **T value** value is calculated by inserting the values determined for Y_{T1}, T1, Y_{T2}, T2 into the formula.

Set the new T value in the configuration menu under SENSOR SELECT.

7.2.7 Expanding the characteristic curve

The characteristic may easily be extended upward when the temperature difference has been selected so as provide sufficient reserve heating power (normally ensured by the curve getting flat at higher velocities).

Note:

- ❑ Consider some reserve for the heating power (7.2.1, Selecting the temperature differential) when establishing a curve that is intended subsequently to be extended.

The extension can be made either by manually entering quantities Y and V to be assigned, or in menu point TRIM ACTIVE giving a flow velocity.

Note:

- ❑ It is not possible to include new trim points in an existing characteristic curve!

7.3 Calibration: Turbine-type sensor

Calibrate the turbine-type sensors observing the same instructions as for calorimetric monitoring heads.

Exception: There are no control variables of the heater controller assigned to the flow velocities but rather the frequency produced by the sensor at the appropriate velocity.

8 Errors

8.1 Test and diagnosis

The FC01-CC 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-CC 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.

8.1.1 Priority group I

Priority group I comprises the switch-on test routines (FC01-CC 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!

8.1.2 Priority group II

These test functions are continuously carried out during operation. The occurrence of errors No. 50, 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.

8.1.3 Priority group III

These test routines are also continuously carried out during operation.

Other than the above priority groups, errors No. 20, 30, 31, 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.

8.2 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. 50	No calibration data available	Carry out customer-specific calibration.
No. 10	Sensor not connected; or cable between FC01-CC 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

Errors	Cause	Rectification
No. 20	Medium temperature too low	
No. 30	Over limits of flow rate	
No. 31	Under limits of flow rate (V < (1st trim point - 10 %))	
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 version FC01-CC-U1T4.

9 Technical data

9.1 Ambient conditions

	rail-mounted	surface mounted	front panel mounted
Storage temperature:	-20 … +70 °C	-20 … +70 °C	-20 … +70 °C
Ambient temperature: *	+10 … +50 °C **	+10 … +50 °C	+10 … +50 °C
Degree of protection:	IP20	IP65	IP65

* Only if the modules are spaced by at least 10 mm.

** The max. ambient temperature of +40 °C applies to all systems fitted with current output C1.

9.2 Electrical characteristics

9.2.1 Power supply

AC supply

Pin selection:	Signal name	Pin XV
	ground	1
	line L	2
	neutral	3

DC supply

Pin selection:	Signal name	Pin XV
	shield	1
	$+U_V$	2
	$-U_V$	3

9.2.1.1 DC voltage supply

Supply voltage:	U_{VN} = DC 24 V *
Input voltage range: (ripple incl.)	U_V = DC 19 V to DC 32 V
Admissible ripple:	max. 20 % U_V
Rated current consumption:	I_{vnk} = 170 mA (calorimetric monitoring head) with zero flow
	I_{vnk} = 200 mA (calorimetric monitoring head) with max. flow (end of measuring range)
	I_{vnfr} = 110 mA (turbine-type sensor)

Power consumption may be up to 300 mA±10 % when analogue output C1 is fitted.

* DC 12 V possible if the FC01-CC is used **without** option C1 (analogue outputs).

Inrush current:	I_p = typ. 3 A (20 µs)
Switch-off current:	I_{kipp} = typ. 0.75 A
Rated power consumption:	P_n = 4.1 W (calorimetric monitoring head with zero flow, voltage outputs
	P_n = 4.8 W (calorimetric monitoring head) with max. flow (end of measuring range), voltage outputs
	P_n = 2.6 W (turbine-type sensor) voltage outputs
Insulation voltage:	supply input - central electronic unit ≥ DC 500 V

9.2.1.2 AC voltage supply

Supply voltage:	U_V = AC 24 $V_{(rms)}$ ± 10 %
Frequency:	f_V = 40 Hz to 100 Hz
Rated current consumption:	I_{vn1} = 170 mA to 200 mA (calorimetric monitoring head)
	I_{vn2} = 110 mA (turbine-type sensor)
Inrush current:	I_p = typ. 4 A (20 µs)
Switch-off current:	I_{kipp} = typ. 0.75 A $_{(rms)}$
Rated power consumption:	P_n = 4.1 VA
Current flow angle:	ψ = 50°
Insulation voltage:	supply input - central electronic unit ≥ DC 500 V

9.3 Analogue outputs

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

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.**

The output is reverse polarity protected.

Insulation voltage:	analogue output - analogue output DC 500 V
	analogue output - central electronic unit DC 500 V

9.3.1 Voltage output V1 - 5 V FS

Signal voltage range:	U_S = 0 V (1 V) to 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)

9.3.2 Voltage output V2 - 10 V FS

Signal voltage range:	U_S = 0 V (2 V) to 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)

9.3.3 Current output C1 - 20 mA FS

Signal current range:	I_S = 0 mA (4 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 = 250Ω

9.4 Signal outputs

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

9.4.1 Relay outputs R2 (DC or AC)

Pin selection:	Signal name	Pin XAH
	Limit Switch 1 / shield	1
	Limit Switch 1 / N/O	2
	Limit Switch 1 / common	3
	LLimit 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:	3×10^5 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 $\cos \varphi = 0.5$:	2.4×10^5 cycles
Insulation voltage:	signal contact - central electronic unit DC 500 V
	signal contact - signal contact DC 500 V

9.4.2 Transistor outputs (DC)

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
Short circuit protection:	yes

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

Capacitive 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

9.5 Metrological data

9.5.1 FC01-CC with calorimetric monitoring head

Flow rate measurement:

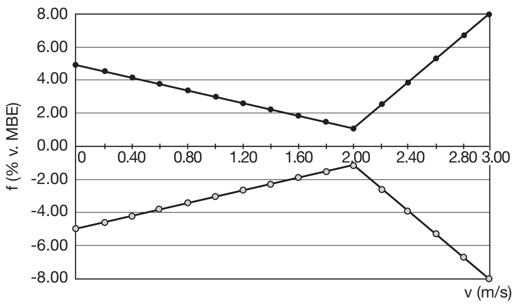
Measuring is possible up to the flow rates indicated in the display range. However, the indicated accuracy is no longer guaranteed. **The repeatability value remains valid.**

Medium:	water	air
Measuring range:	0.05 … 3 m/s	0.1 … 20 m/s
Display range:	0 … 4 m/s	0 … 100 m/s
Response delay:	2.5 s	3 s
Repeatability: (5 % MBE to 100 % MBE)	1 % MW **	1 % MW **
Accuracy special monitoring heads:	±1 % MBE *	±1 % MBE *
Accuracy standard monitoring heads:	(see failure diagram)	

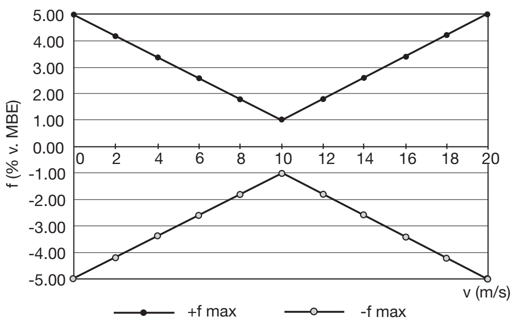
Temperature measurement:

Measuring range:	-40 … +130 °C	0 … +130 °C
Accuracy:	±1 % MB ***	±1.3 % MB ***

Failure diagram for water
(standard monitoring heads)



Failure diagram for air
(standard monitoring heads)



9.5.2 - Calorimetric monitoring heads for FC01-CC - Selector chart

Monitoring head	CST-01	CSF-01	CSF-02	CSF-03	CSP-01
Type of head	thread mounted	push-in	flange mounted	flange mounted	insertion head
Medium:					
air	x	x	x		x
water	x	x	x	x	x
other media [1]	x	x	x	x	x
Temperature range I (medium)	-40 … +130 °C	-40 … +130 °C	-40 … +130 °C	-40 … +130 °C	-40 … +130 °C
Temperature range II (connector)					
cable type 15	- 10 … +85 °C	- 10 … +85 °C	- 10 … +85 °C	- 10 … +85 °C	- 10 … +85 °C
cable type 18	- 40 …+ 85 °C	- 40 … +85 °C	- 40 … +85 °C	- 40 … +85 °C	- 60 … +200 °C
Temperature drift	0.05 %/K/MB	0.05 %/K/MB	0.05 %/K/MB	0.05 %/K/MB	0.05 %/K/MB
Pressure range	100 bar	100 bar	40 bar	40 bar	100 bar
Degree of protection (sensor/connector) [2]	IP67	IP67	IP67	IP67	IP67

MB measuring range
[1] e.g. oil
[2] with mating connector

9.5.3 FC01-CC with turbine-type sensor

Flow rate measurement:

Medium:	air	water
Measuring range:	1 … 20 m/s	0.1 … 5 m*
Accuracy:	±1 % MBE * ±3 % MW **	±1 % MBE * ±3 % MW **
Repeatability: (5 % MBE to 100 % MBE)	0.5 % MW **	0.5 % MW **

9.5.4 Turbine-type sensor for FC01-CC / Selector chart

Turbine-type sensor	TST-HM2	TST-AM1	TST-WM1
Medium:			
air	x	x	
water	x		x

9.5.5 Electronic control unit FC01-CC

Temperature drift:	0.1 %/K/MBE *
Heating up period until full accuracy is reached:	15 min.

* MBE - of final value
** MW - measured value
*** MB - measuring range

9.6 Sensor interface

9.6.1 Electrical data of the terminal for calorimetric monitoring heads

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_{load} = 0 … 2 kΩ Dielectric strength: ±15 V DC
XSK7 XSK8	SGND	Function: shield ground 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

* RTD = **R**esistive **T**emperature **D**evice

9.6.2 Electrical data of the terminal for turbine-type sensor

Terminal	Mnemonics	Data
XSF1	UBFR	Function: sensor supply voltage with integral amplifier Output voltage: U_a = 5 V DC ±4% Source resistance: R_{source} = 1.3 kΩ Dielectric strength: -7.5 V … +17.5 V DC
XSF2	FRIN	Function: terminal for sensor output signal Max. admissible signal level: - 0.5 V … + 5.5 V Min. required signal level: ± 20 mV Max. admissible signal frequency: f_{max} = 4 kHz Input resistance: > 200 kΩ Dielectric strength: -5 V … +10 V DC
XSF3	SGND	Function: shield-ground Terminal for turbine-type sensor cable shield
XSF4	DGND	Function: digital-ground Reference potential for turbine-type sensor voltage supply and output signal

10 Accessories

No.	Accessory	Ordering configuration
1	Surface mounted housing	FC01-FH-CC
2	Front mounted housing	FC01-ST-CC
3	Connecting cable for calorimetric monitoring head	
	cable type LifYCY 4 x 2 x 0.2 mm^2	Do+Ka
	- type 15 / -10 °C …+80 °C highly flexible/paired	
	- type 18 / -60 °C … +200 °C non-halogenuous/highly flexible/paired	
4	Connecting cable for turbine-type sensor	
	cable type LifYCY 2 x 3 x 0.35 mm^2	Do+Ka type 16-
5	Calorimetric monitoring heads	CST / CSF / CSP
6	Turbine-type sensors	TST
7	Sensor adapter (screw-in or welding type)	TP
8	Ball valve	BV
9	Locking set 01 (for monitoring head CSF-01)	0Z122Z000204

Examples

1.1 Example 1: Calorimetric monitoring head - Medium water - New curve

Tasc definition

The FC01-CC with calorimetric monitoring head shall be used to control a water cooling cycle.

The flow velocity to be controlled and measured lies between 0.00 m/s and 1.80 m/s at a constant medium temperature of approx. +82 °C.

A flow meter with turbine-type sensor to be used as a reference instrument is available on loan.

Approach

As the accuracy does not need to be very high (±5%), it is supposed that 10 trim points are required to provide a satisfactory solution. To obtain a higher accuracy, the number of trim points can be increased to 20.

The distribution of the 10 trim points should be linear over the entire measuring range.

Implementation

Select the calorimetric sensor in submenu **SENSOR SELECT** before making the custom designed calibration.

Enter 1023 (marked on sensor) as C value to define the sensor-specific tolerances. The T value is a code for the temperature sensitivity of the sensor and needn't be taken into account for this application. The preset value of 50 is transferred.

After entering and confirming the sensor-specific data, press ▲ UP and ▼ DOWN = ▲ + ▼ in order to branch into submenu **CUSTOMER TRIM**.

The settings required for the custom-designed calibration start after the 3-digit code - **ACCESS CODE** - (see para. 5.3.1) - has been entered.

As an already filed custom-designed curve has to be completely overwritten, the inquiry about the **CHARACTERISTICS** of the curve shall be answered by **new**. In that case, the trim points selected are pre-assigned to data (see para. 7.2.5).

Enter 10 as the **NUMBER OF TRIM POINTS** by pressing ▲ UP and ▼ DOWN = ▲ + ▼ .

The temperature difference setpoint - **TEMPERATURE DIFFERENCE** - is shown in the table of para. 7.2.1 where a temperature difference of 10 °C is indicated for water in this flow velocity range.

As in this example a new custom-designed curve is to be determined, it is necessary to assign the max. flow velocity (1.80 m/s) to trim point 10. The remaining trim points (9 … 1) are automatically and linearly assigned as follow:

After trim point 10 has been set at 1.80 m/s and the flow velocity has actually been controlled accordingly, automatic calibration is started by simultaneously pressing ▲ UP and ▼ DOWN = ▲ + ▼ .

Trim point	V [m/s]					
10	1.80					
9	**1.60**					
8	**1.40**					
7	**1.20**					
6	**1.00**					
5	**0.80**					
4	**0.60**					
3	**0.40**					
2	**0.20**					
1	**0.00**					

The following **Y** value was determined for flow velocity 1.80 m/s after completion of the heating-up period and the calibration.

Trim point	V [m/s]	Y				
10	1.80	**35400**				
9	1.60					
8	1.40					
7	1.20					
6	1.00					
5	0.80					
4	0.60					
3	0.40					
2	0.20					
1	0.00					

This value represents the heating power required to measure the velocity of 1.80 m/s.

After this value has been transferred, trim points 9 … 1 should be processed the same way.

The Y values shown in the following table were measured for trim points 9 … 1.

The medium temperature at which the calibration was made (here: **TRIM IS READY! TEMP = 82.8 °C**) is indicated on the display after the last trim point.

The CUSTOMER TRIM procedure is now completed!

Trim point	V [m/s]	Y				
10	1.80	35400				
9	1.60	**35267**				
8	1.40	**35158**				
7	1.20	**35063**				
6	1.00	**34890**				
5	0.80	**34668**				
4	0.60	**34347**				
3	0.40	**33846**				
2	0.20	**32957**				
1	0.00	**24635**				

Before quitting the submenu, the calibration data shall be permanently stored by pressing M MODE.

Verification of the solution

In order to verify the curve determined, again set the flow velocity at the various trim points and compare it to the values indicated by the FC01-CC during the measuring operation.

Test values are:

Trim point	V [m/s]	Y	V [m/s] Test data	Deviation [%MBE *]	
10	1.80	35400	**1.94**	**-7.78**	
9	1.60	35267	**1.67**	**-3.89**	
8	1.40	35158	**1.38**	**1.11**	
7	1.20	35063	**1.18**	**1.11**	
6	1.00	34890	**0.99**	**0.56**	
5	0.80	34668	**0.80**	**0.00**	
4	0.60	34347	**0.61**	**-0.56**	
3	0.40	33846	**0.42**	**-1.11**	
2	0.20	32957	**0.21**	**-0.56**	
1	0.00	24635	**0.01**	**-0.56**	

The verification of the trim points indicates that trim point 10 is outside the tolerance required.

One of the reasons may be that the flow velocity varied when point 10 was set.

To increase the accuracy at a velocity of 1.80 m/s, that trim point should be redetermined

* MBE - Upper measuring range value

Correction of the characteristic curve

To correct a custom designed curve branch into submenu **CUSTOMER TRIM** the same way as when determining the curve.

The inquire about the **CHARACTERISTIC** shall be answered by **old** as the curve filed is largely maintained, with only point 10 being corrected.

All other data (trim point, temperature difference) remain unchanged and are transferred by pressing M MODE.

The set flow velocity (1.80 m/s) is confirmed at trim point 10 and the automatic calibration as described under **Implementation** is started.

The **Y** value for a flow velocity of 1.80 m/s is shown in the following table:

Trim point	V [m/s]	Y				
10	1.80	**35346**				

The correct value is transferred!

All other calibration data remain unchanged and shall be confirmed by pressing M until the end of the calibration menu is reached.

Another verification of the characteristic curve will show the following test values:

Trim point	V [m/s]	Y	V [m/s]Test data	Deviation [%MBE]	
10	1.80	35346	**1.85**	**-2.78**	
9	1.60	35267	**1.67**	**-3.89**	
8	1.40	35158	**1.38**	**1.11**	
7	1.20	35063	**1.18**	**1.11**	
6	1.00	34890	**0.99**	**0.56**	
5	0.80	34668	**0.80**	**0.00**	
4	0.60	34347	**0.61**	**-0.56**	
3	0.40	33846	**0.42**	**-1.11**	
2	0.20	32957	**0.21**	**-0.56**	
1	0.00	24635	**0.01**	**-0.56**	

The example shows that after being corrected, trim point 10 is within the required tolerance of ±5 %.

Expansion of the characteristic curve

By following the instructions of para. 7.2.7, an existing curve can also be expanded upward.

In application example 1, the flow velocity range shall be increased by 0.30 m/s. This means that two additional trim points are required: at 1.95 m/s and at 2.10 m/s.

To do this, branch into submenu CUSTOMER TRIM and enter **old** because the existing curve shall not be deleted but rather be expanded.

Increase the number of trim points from 10 to 12. Do not change the temperature difference, leave it at 10 °C!

Then assign flow velocity 2.20 m/s to trim point 12 (for ease of usage it had already been pre-assigned with 1.82 m/s) and start the automatic calibration. After determination of the **Y** value for point 12, trim point 11 is assigned to a velocity of 1.95 m/s (it had already been pre-assigned to 1.81 m/s) and the automatic calibration is started.

All other data remain unchanged and shell be confirmed by pressing Ⓜ until the end of the CUSTOMER TRIM menu is reached.

Trim point	V [m/s]	Y				
12	**2.10**	**35441**				
11	**1.95**	**35396**				
10	1.80	35346				
9	1.60	35267				
8	1.40	35158				
7	1.20	35063				
6	1.00	34890				
5	0.80	34668				
4	0.60	34347				
3	0.40	33846				
2	0.20	32957				
1	0.00	24635				

Manual entry of a characteristic curve

It is also possible to enter a custom designed curve by means of the keyboard.

This may be reasonable when several FC01-CC flow meters are used under identical conditions (medium, installation etc.).

To duplicate the expanded curve of example 1 on a second FC01-CC, select a calorimetric sensor in submenu **SENSOR SELECT** and set its C value.

For other entries proceed as described for example 1 (Implementation).

CHARACTERISTIC	→	new
NUMBER OF TRIM POINTS	→	12
TEMPERATURE DIFFERENCE	→	10

Take the data for the curve from the table (page 88) and set them on the FC01-CC.

Flow velocity 2.10 m/s shall be assigned to trim point 12. Other than with the automatic calibration the applicable Y value of 35441 shall be entered by means of the keyboard. 1.95 m/s and 35396 is set for point 11 etc.

The procedure is repeated until the entire curve has been determined.

After the data for point 1 have been entered and confirmed, the display indicates **TRIM IS READY! TEMP = 25.0 °C**.

Other than with the automatic calibration, the calibration temperature at which the curve has been determined will be flashing on the display and must be set at 82.8 °C by hand (example 1 - Implementation).

The calibration data are now completely entered.

Before quitting the submenu, press M to permanently store the calibration data.

11.2 Example 2: Turbine-type sensor - Medium: air - New curve - Curve following the manufacturer's curve - Theoretical curve

Task definition

The FC01-CC shall be used to control the air flow in a reaction chamber.

The flow velocity in the supply pipe where the turbine is located is twice as high as in the reaction chamber.

The reaction velocity is 10 m/s max. and 6 m/s min. This range is particularly important for the production and will be controlled and supervised for processing. The accuracy should be 2 % MBE (upper measuring range value).

The flow range below this range does not require a special accuracy. Flow velocities below 2 m/s needn't be measured. Accelerations amount to approx. 0.5 m/s^2.

The sensor to be used is turbine-type sensor TST02HM2.

Typical turbine characteristic curve as specified by manufacturer (TST02HM2)

V - flow velocity [m/s]

F - signal frequency [Hz]

V [m/s]	F [Hz]					
1	51.2					
2	197.3					
4	542.6					
6	905					
8	1258					
10	1609					
12	1966					
14	2342					
16	2676					
18	3048					
20	3368					

Approach

Velocity $\mathbf{V}_r$ in the reaction chamber is assigned to the frequencies supplied by the turbine in the supply pipe as a result of the flow velocity prevailing there $\mathbf{V}_f$.

As the turbine has no significant non-linearities in the relevant velocity range and the error at 2 m/s trim point steps remains below 1%, the characteristic curve can already be run with 8 trim points.

Please see the following table for pre-assignments.

V_f [m/s]	F [Hz]	SP	V_r [m/s]			
20	3368	**8**	**10**			
18	3048	**7**	**9**			
16	2676	**6**	**8**			
14	2342	**5**	**7**			
12	1966	**4**	**6**			
10	1609	**3**	**5**			
8	1258					
6	905					
4	543	**2**	**2**			
2	197					
1	51					
0	0	**1**	**0**			

V_f - flow velocity at the turbine
F - output frequency of the turbine
SP - trim points
V_r - velocity prevailing in the reaction chamber and to be displayed

Display range available: 0 to 11 m/s

Number of trim points: 8

Implementation

All entries necessary to implement the above approach shall be made in menu **CONFIGURATION**. Select the turbine-type (**TYPE TURBINE**) in submenu **SENSOR SELECT**.

After selecting the sensor type, simultaneously press ▲ UP and ▼ DOWN = ▲ + ▼ to branch into submenu **CUSTOMER TRIM** where the curve is filed.

Enter the 3-digit code - **ACCESS CODE** - (see para. 5.3.1) to access the actual CUSTOMER TRIM program.

As a new curve shall be entered, the inquiry about the **CHARACTERISTICS** of the curve shall be answered by **new**.

Press ▲ UP and ▼ DOWN = ▲ + ▼ to set the **NUMBER OF TRIM POINTS =** (SP = 8 as defined under Approach) on the display. The menu will then automatically jump to the trim point mode.

The first line of the display will show **TRIM POINT 8**.

Characteristic curves shall always be entered down from the top, with the highest velocity assigned to the highest trim point. All other points and velocities shall be assigned in a downward sequence.

.....m/s will now be flashing in the second line, which means that the velocity of 10 m/s assigned to trim point 8 can be entered.

Upon the configuration of the value set **Y = ...** will be flashing in the second line of the display. The applicable frequency, **3368** shall be entered in Hertz.

Upon confirmation of the entry, the display will leave the flashing mode and indicate the set quantities as assigned.

As only a theoretical curve is entered and no curve shall be recorded, press M to jump via menu inquiry **DATA OK?** to the next trim point.

The loop will be run through until the last trim point has been entered.

END? STORE DATA? will be asked after completion.

The curve entered is permanently stored by pressing M.

You are now in the main branch of the configuration menu where all further determinations for system operation can be made the same way as with the standard FC01.

Verification of solution

The solution can be verified by means of a reference meter.

11.3 Example 3: Turbine-type sensor - Medium: air - New curve - Curve according to reference meter

Task definition

Exhaust air of an air-conditioning system shall be measured. There is only one place to install the flow meter, although the distances as required in para 2.2.2.1 cannot be observed there. A deformation of the flow profile and incorrect measurements must therefore be expected. It is however possible to run the relevant area via the air supply rate and to measure the average air output velocity by using a measuring instrument.

The application does not require a special accuracy. However, the max. error should not exceed 7.5 % MB (measuring range).

The air output velocity expected is comprised between 5 m/s and 12 m/s, with peak velocities possibly rising to 15 m/s. Although in that upper range an accuracy is not defined, it should be ensured that these velocities are indicated at the analogue output of the FC01-CC. The flow velocity falling below 2 m/s should be signalled in a passive way by means of a relay.

Accelerations amount to approx. 0.1 m/s^2.

The air is filtered from dust and the relative humidity may be up to 60 %.

Approach

Run in steps through the velocity range of the system assigning the resultant turbine frequencies to the velocities indicated by the reference meter. (Accuracy of the reference meter: ±1.5 % MBE (upper measuring range value), MB (measuring range) =1 … 30 m/s).

Typical turbine characteristic curve as specified by manufacture (TST02HM2)

V - flow velocity [m/s]

F - signal frequency [Hz]

V [m/s]	F [Hz]					
1	51.2					
2	197.3					
4	542.6					
6	905					
8	1258					
10	1609					
12	1966					
14	2342					
16	2676					
18	3048					
20	3368					

The distribution range of the trim points is made following the different demands on the curve in different ranges.

Range 1: monitoring range for V < 2 m/s

Range 2: measuring range with defined accuracy 5 to 12 m/s

Range 3: peak velocity range with undefined accuracy.

Range 1 can be covered with one trim point at approx. 2 m/s as the FC01-CC extends the measuring range beyond the lower trim point by 10 % of the measuring range.

In range 2, trim points are spaced by approx. 1 m/s.

Range 3 is covered with two additional trim points.

The 12 trim points resulting shall be assigned to the reference velocity as shown in the table below:

The accuracy when verifying the velocities is ±1 % MBE (upper measuring range).

SP No.	V_{ref} [m/s]					
1	2					
2	4					
3	5					
4	6					
5	7					
6	8					
7	9					
8	10					
9	11					
10	12					
11	13					
12	15					

Implementation

After installing the turbine and the reference sensor, prepare for recording the characteristic curve on the FC01-CC.

Branch to submenu **CONFIGURATION** in the main menu.

As a turbine-type sensor shall be used, select **TYPE TURBINE** in submenu **SENSOR SELECT**.

Branch in submenu **CUSTOMER TRIM** by simultaneously pressing ▲ UP and ▼ DOWN = ▲ + ▼.

In the first menu option you are asked if you wish to use this submenu. Press M for **yes**.

In order to access the actual calibration menu, enter the 3-digit code - menu option **ACCESS CODE** (see para. 5.3.1).

You now have access to the CUSTOMER TRIM program.

The next inquiry - **CHARACTERISTICS** - shall be answered by **new** pressing ▲ UP or ▼ DOWN.

Set the number of trim points (SP = 12 according to Approach) on the display by pressing ▲ UP and ▼ DOWN = ▲ + ▼.

The system is then run up to its max. velocity of 15 m/s.

The velocity should be established between 14.9 and 15.1 m/s. (Observe input periods of the pipe and the reference meter.)

The display indicates **TRIM POINT 12** to which a velocity of 15 m/s shall be assigned.

..... m/s is flashing in the second display line, calling for you to enter the reference velocity value prevailing in the system. This value should now be constant and lie between 14.9 and 15.1 m/s.

To determine the pertinent turbine frequency, proceed to submenu **TRIM ACTIVE**.

The FC01-CC now determines the turbine signal frequency to be assigned to the flow velocity and will indicate for example:

TRIM POINT 12

15.05 m/s 2786

You may see from the turbine curve that the flow velocity at its point of installation is higher than the actual average flow velocity. This error is compensated for by confirming the values of TRIM POINT 12.

Switch off the flashing mode of the Y quantity by pressing M. During the flashing mode, the applicable figure can be changed by pressing ▲ UP and ▼ DOWN = ▲ + ▼.

The V and Y figures can now be filed by pressing switch M.

Via **DATA OK! M = NEXT** you can return to the calibration loop. The display will indicate the next lower trim point.

The flow velocity in the system is set between 12.9 and 13.1 m/s following the table. (Observe input periods of the pipe and the reference meter.)

TRIM POINT 11

13.7 m/s . . . .

The flashing mode indicates that the pre-assigned value (V) can be varied. (Pre-assignment is made automatically to reduce the setting times.) Read the entire value (between 12.9 and 13.1 m/s) indicated by the reference meter and transfer it by means of then ▲ UP and ▼ DOWN = ▲ + ▼ switches in the FC01-CC.

The TRIM ACTIVE cycle is started and the frequency value determined is stored.

Repeat the procedure until trim point 1 is reached.

Quit the **CUSTOMER TRIM** submenu by

END! STORE DATA?

M = YES

This is to ensure the curve data are stored in a non-volatile memory and are available for normal measuring operation.

You are now in the main branch of the configuration menu. Proceed as with the standard FC01.

Verification

Verification

Run the FC01-CC parallel to the reference meter in the main menu measuring mode.

The measured values of the two instruments must now be identical, with an error tolerance of ±5 % MBE (upper measuring range value).

11.4 Example 4: Distribution of trim points

Task definition

The FC01-CC with calorimetric monitoring head shall be used to measure air flowing at a max. velocity of 25 m/s.

The lower measuring range value is approx. 0 m/s. A calibrated calorimetric metering pipe is used as a reference. The pertinent measuring instrument indicates the flow velocity in m/s.

The measuring range of the reference instrument is specified between 1 m/s and 40 m/s; the measuring error shall be 1 % of the value measured.

The resultant total error shall be < 3 % of the upper measuring range value.

Approach / Implementation

With a disturbance-free flow profile, the trim points can be calculated by the following formula:

$$\mathbf{AB = MA + (MB \times (1 - e^{-(((SP-1) \times g)/SG)}))}$$

$$g = 2.5 \times (SP - 1)/SG$$

AB -	trim value [m/s]	
MA -	lower measuring range value [m/s]	= 0 m/s
ME -	upper measuring range value [m/s]	= 25 m/s
MB -	measuring range [m/s]	
	MB = ME - MA = 25 m/s	
SP -	trim point no.	
SG -	total number of trim points	= 16
g -	distribution coefficient	

Determine the trim points using the above formulas.

V_{lin} shows the alternative linear trim point selection.

Verification

Projecting the suggested trim points on to the standard curve used by E-T-A will result in max. error being 0.5 % MBE.

This is clearly below the required ±3 % MBE (0.75 m/s).

With a linear trim point distribution, max. error would be 2.4 %. This would also be a satisfactory solution, with the advantage that you needn’t calculate the trim points.

SP No.	g	V [m/s]		V_{lin} [m/s]
16		**25.00**	set at upper measuring range value	**25.00**
15	2.19	**21.31**		**23.33**
14	2.03	**20.20**		**21.66**
13	1.88	**18.87**		**20.00**
12	1.72	**17.33**		**18.33**
11	1.56	**15.58**		**16.66**
10	1.41	**13.67**		**15.00**
9	1.25	**11.62**		**13.33**
8	1.09	**9.51**		**11.66**
7	0.94	**8.41**		**10.00**
6	0.78	**5.42**		**8.33**
5	0.63	**3.62**		**6.66**
4	0.47	**2.10**		**5.00**
3	0.31	**0.96**		**3.33**
2	0.16	**0.24**		**1.66**
1		**0.00**	set at zero	**0.00**

Index

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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 FREQUENCY 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. 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. 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)

Table 1

Project:				Responsible:		Date:
Monitoring head type:			C =	T =		
TRIM POINT	V_{ref} [m/s]	V_{fm1} [m/s]	Y_{T1} [digit]	Y_{T1} [Hz]	Y_{T2} [digit]	T1 = ... °C T2 = ... °C $T = 50 + (Y_{T2} - Y_{T1})/(T2-T1)$
20						
19						
18						
17						
16						
15						
14						
13						
12						
11						
10						
9						
8						
7						
6						
5						
4						
3						
2						
1						

Appendix 2 - Menu structure of the FC01-CC (operator dialogue)