M_FC01_CC_0408_e

Circuit Protection & Control

Flow Controller FC01-CC
User handbook

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1 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

1.1.2 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.

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.**

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.

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.

2.1.2.2 Monitoring head CSF-01 with adjustable immersion depth

Application: heating and air-conditioning systems

Medium: air, inert gases, liquids

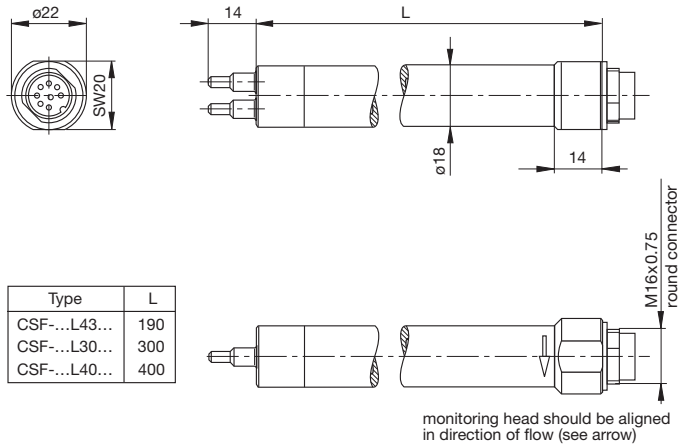
Style: smooth shank, 18 mm dia., immersion depth adjustable within the PG16 cable gland (accessory) or mounting in the stainless steel cutting ring gland

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)

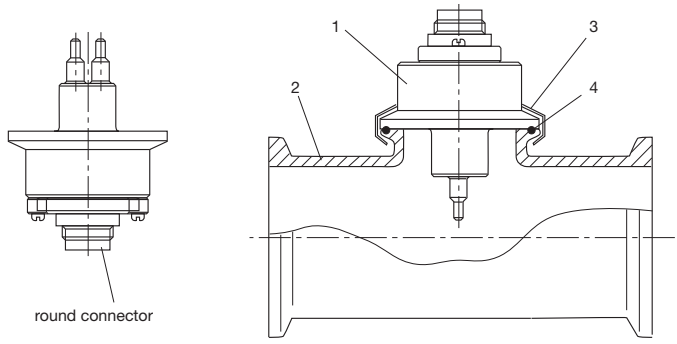


Type	L
CSF-…L43…	190
CSF-…L30…	300
CSF-…L40…	400

fig. 4

2.1.2.4 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)

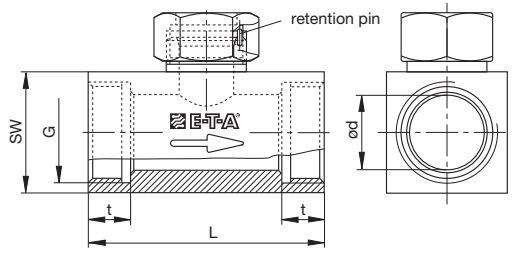
fig. 6

2.1.2.5.1 Sensor adapter TP-..

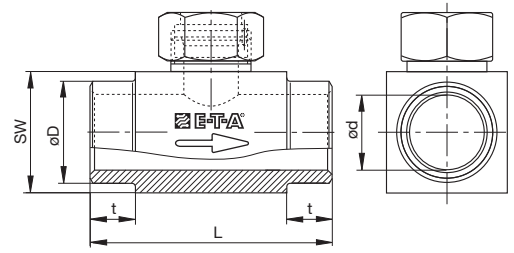
The sensor adapter TP-.. is available in 6 pipe diameters from 1/2" to 2".

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

2.1.3 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).

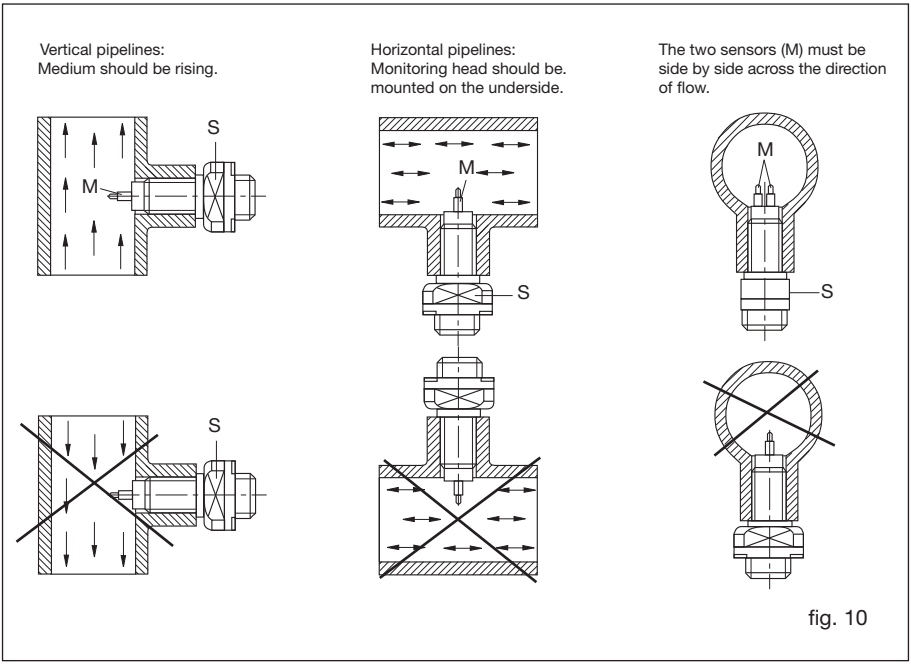


fig. 10

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.

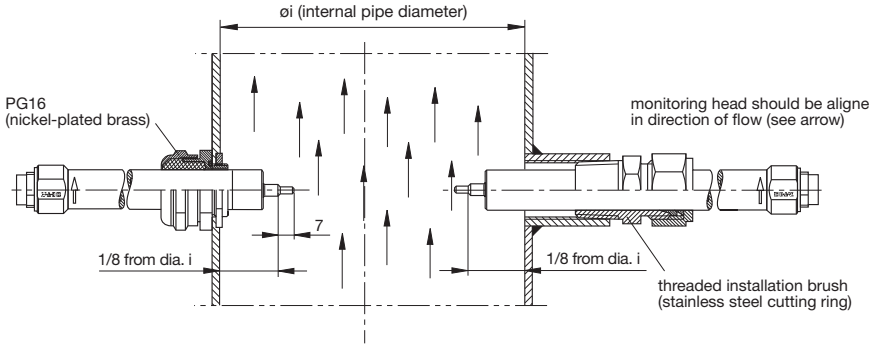


fig. 12

2.1.6 Electrical connection

Cable Do + Ka type xx
(depends on FC01-CC version and sensor type used - see figs. 24 and 25)

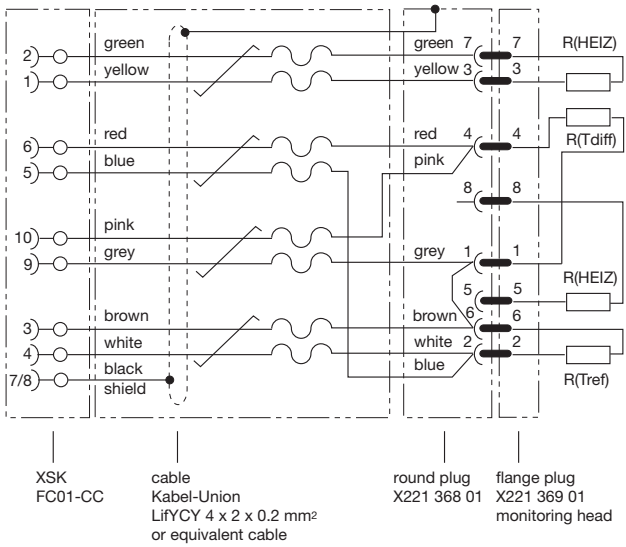


fig. 14

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

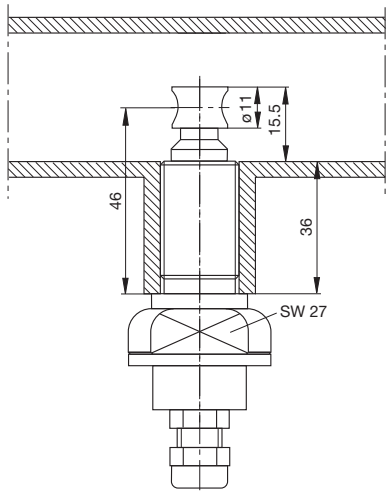


fig. 16

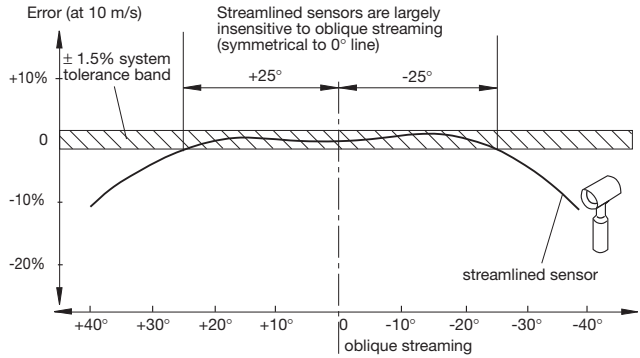


fig. 18

2.2.3 Electrical connection

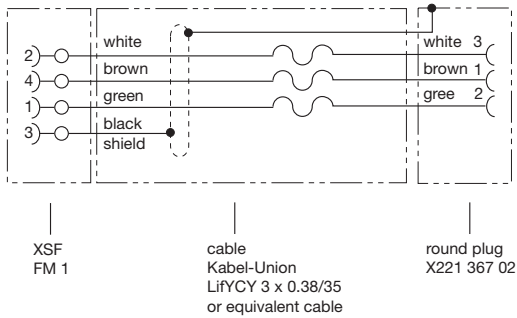


fig. 19

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.

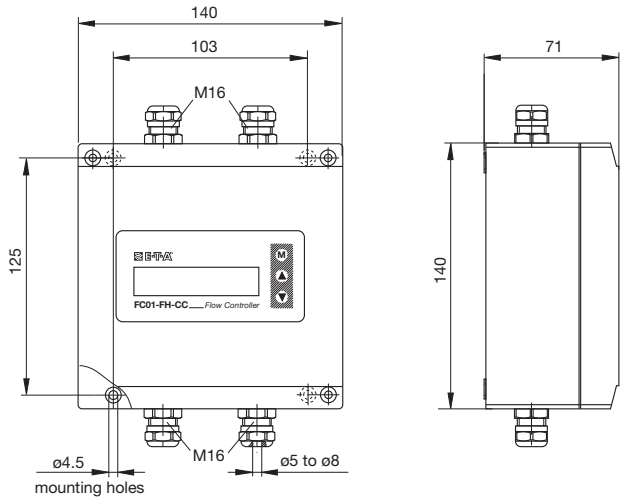


fig. 21

2.3.2 Electrical connection

Valid for all plug-in screw terminal strips:

Cable size:	0.14 mm² to 1.5 mm², single or stranded conductor
Stripping length:	6.5 mm
Clamping screw:	M2 (nickel-plated brass)
Contact material:	pre-tinned tin bronze

XV - Power supply

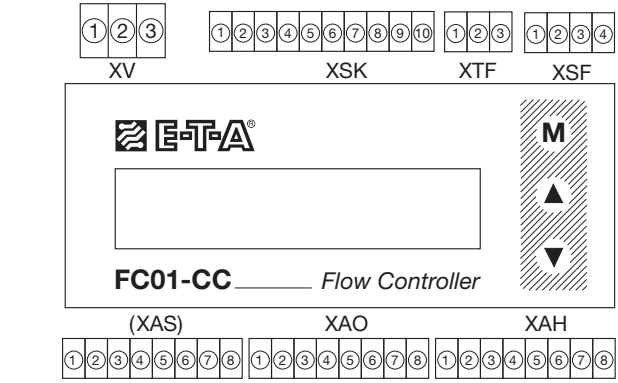
Connection by 3 pole connector; max. 1.5 mm²; 3 x 0.75 mm² cable recommended

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

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

2.3.2.2 Circuit diagram FC01-CC

Version: 24 V, transistor outputs (NPN)

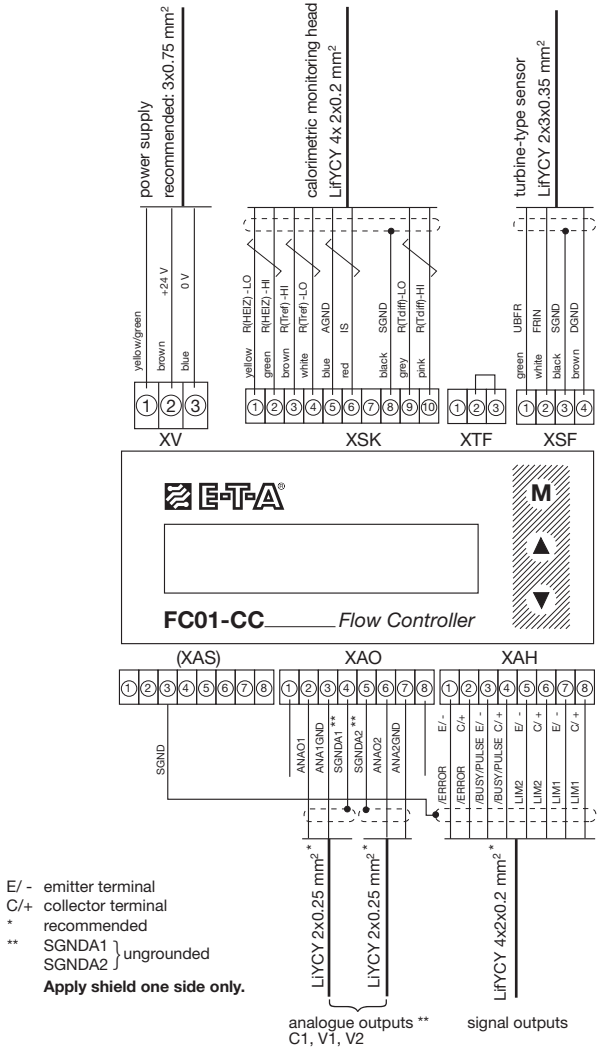


fig. 25

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)

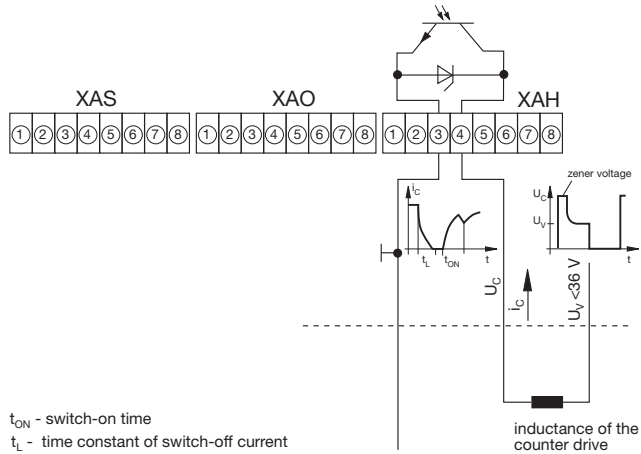


fig. 27

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.

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!

4.2.1 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!

4.2.1.1.2 Turbine-type sensor TST

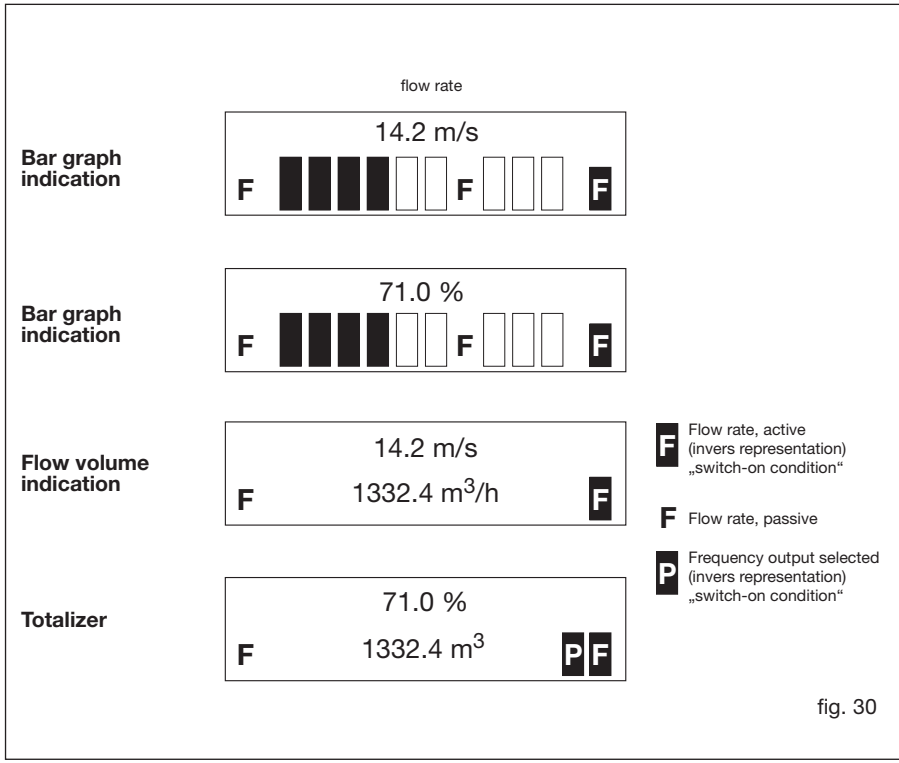
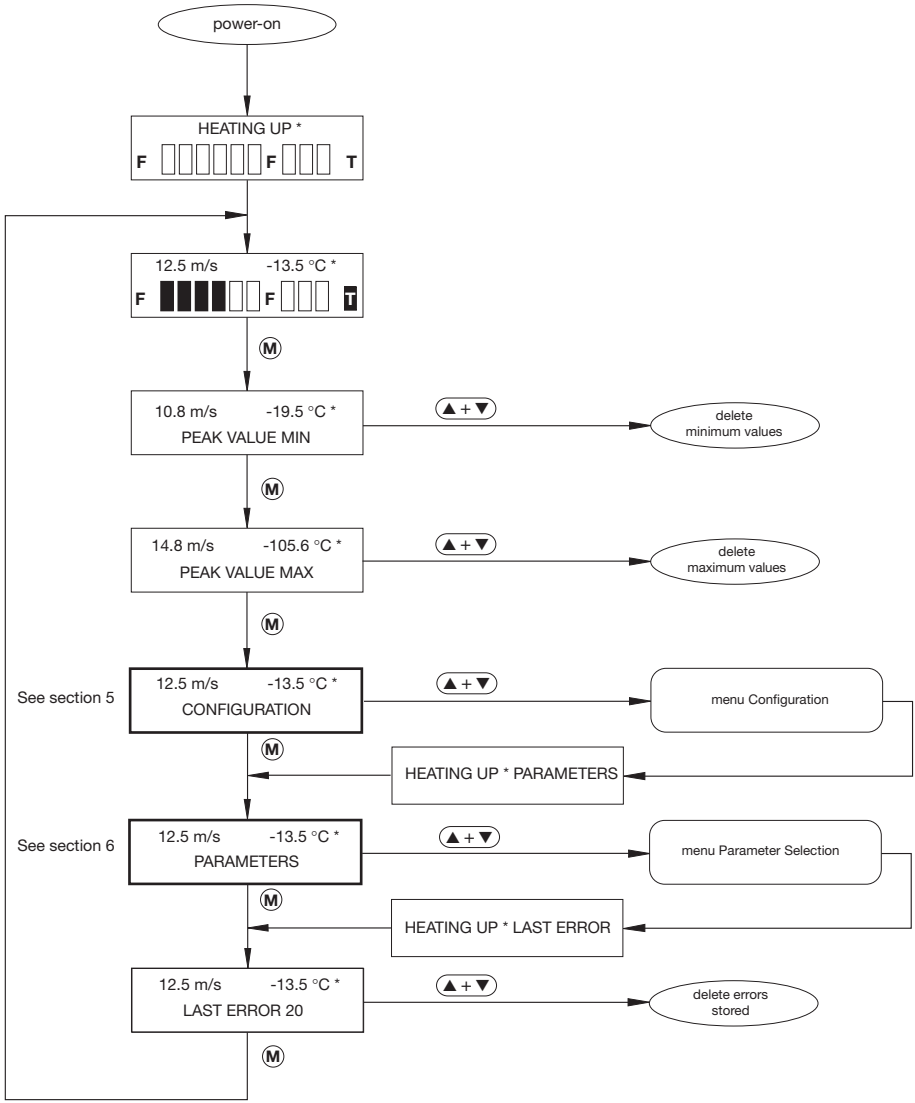


fig. 30

4.2.1.4 Main menu



* not available with turbine-type sensor

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 ≤ $\Delta\vartheta$ ≥ 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

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

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.

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.

- 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)

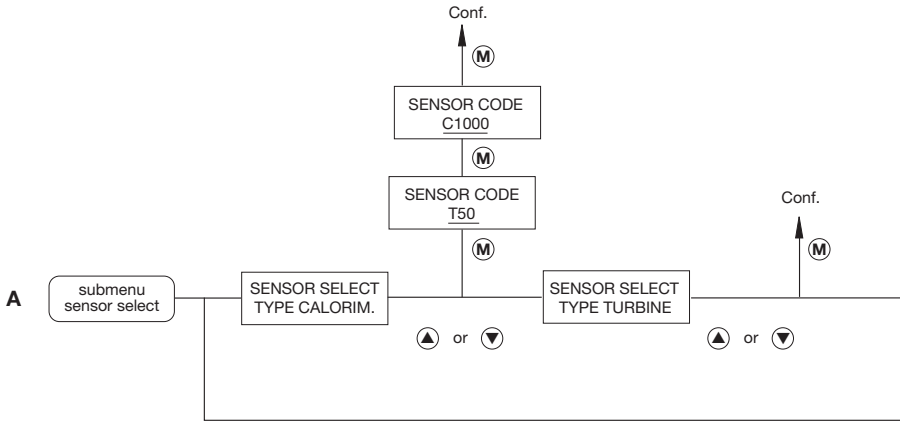
LS2 ON = 0.00

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.

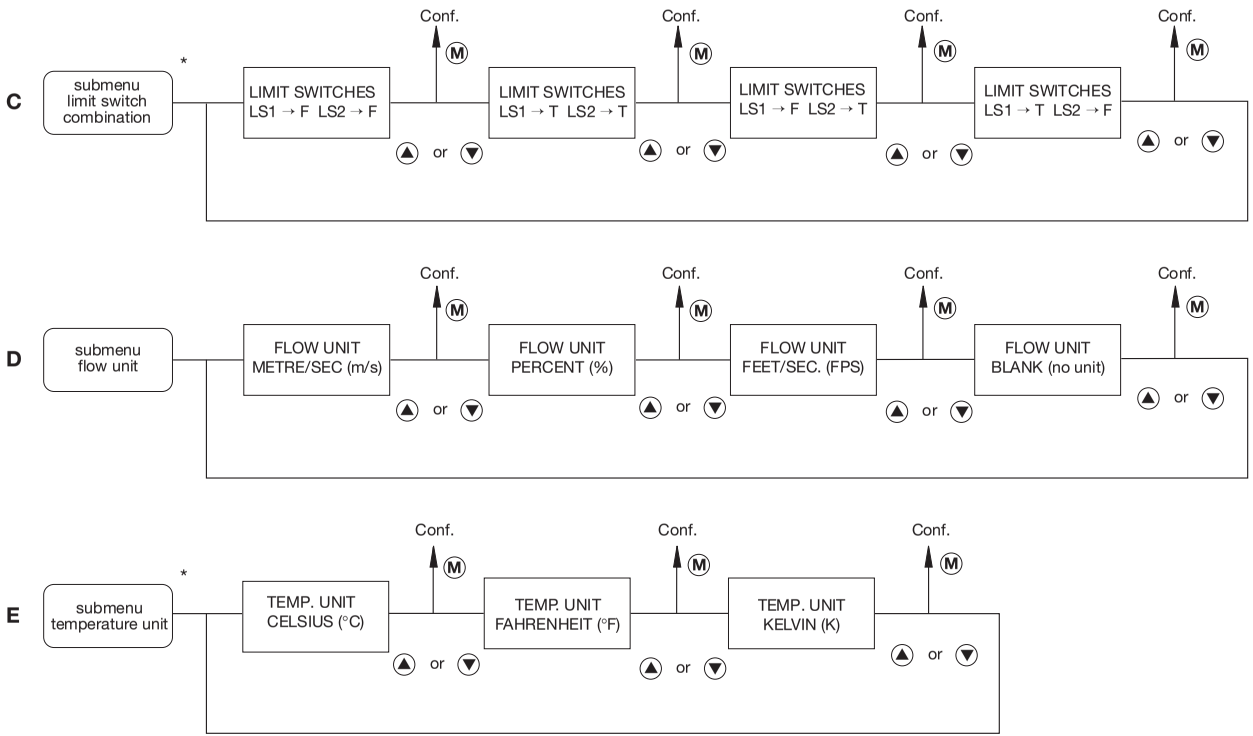
An overview of the configuration menu and a summary of the measuring ranges and menus available for the sensor type selected are shown on the following pages.

5.15 Configuration submenus



Conf.→ return to configuration menu

Configuration submenus (cont'd)



* not available with turbine-type sensor

Conf.→ return to configuration menu

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

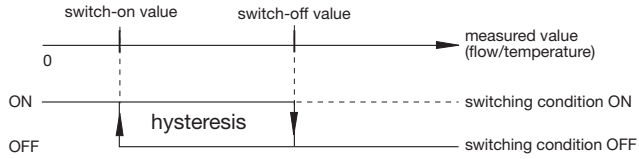


fig. 33

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.

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

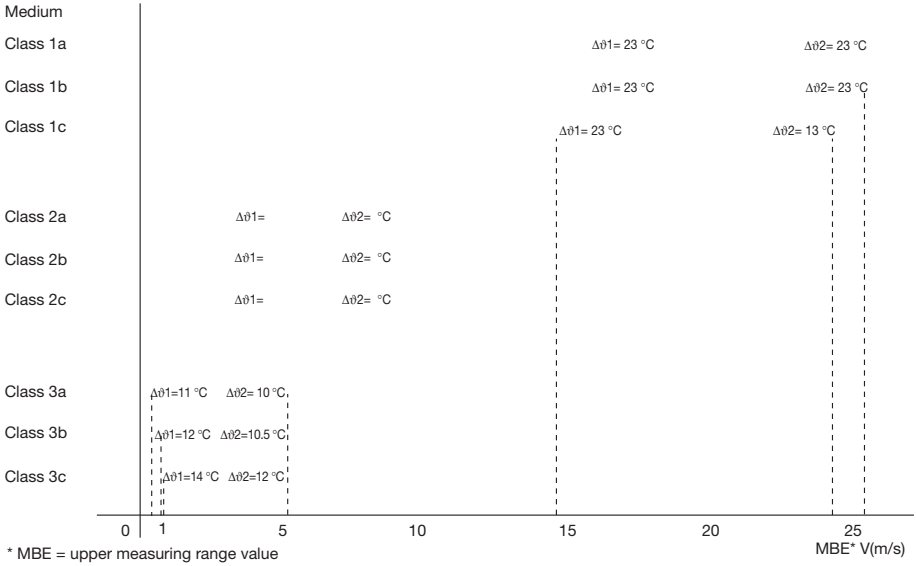
Class 3: water and similar media, oils and other homogenous liquids, and liquid mixtures

Note:

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

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

7.2.4 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.

The T value is calculated by:

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

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.

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.

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 ($V < (1^{st}$ 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.

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

9.3 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.**

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 φ = 0.5:	2.4×10^5 cycles
Insulation voltage:	signal contact - central electronic unit DC 500 V
	signal contact - signal contact DC 500 V

9.5 Metrological data

9.5.1 FC01-CC with calorimetric monitoring head

Flow rate measurement:

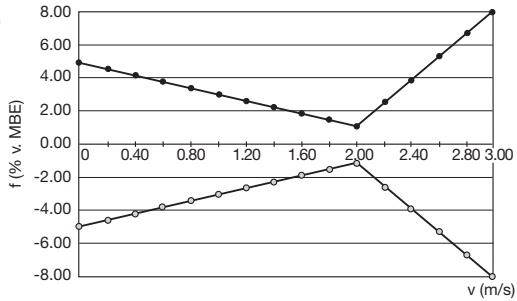
Measuring is possible up to the flow rates indicated in the display range. However, the indicated accuracy is no longer guaranteed. **The repeatability value remains valid.**

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)	

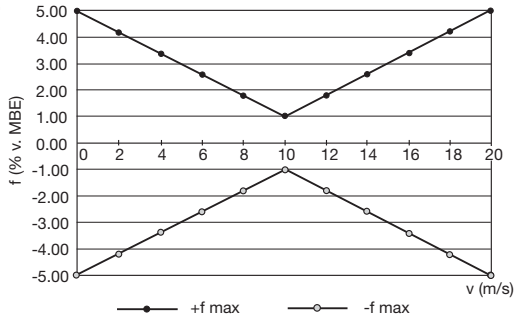
Temperature measurement:

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)



9.5.3 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

9.6.2 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

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!

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 Ⓜ 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 Ⓜ 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 %.

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 Ⓜ to permanently store the calibration data.

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.

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 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

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.

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T

X

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)