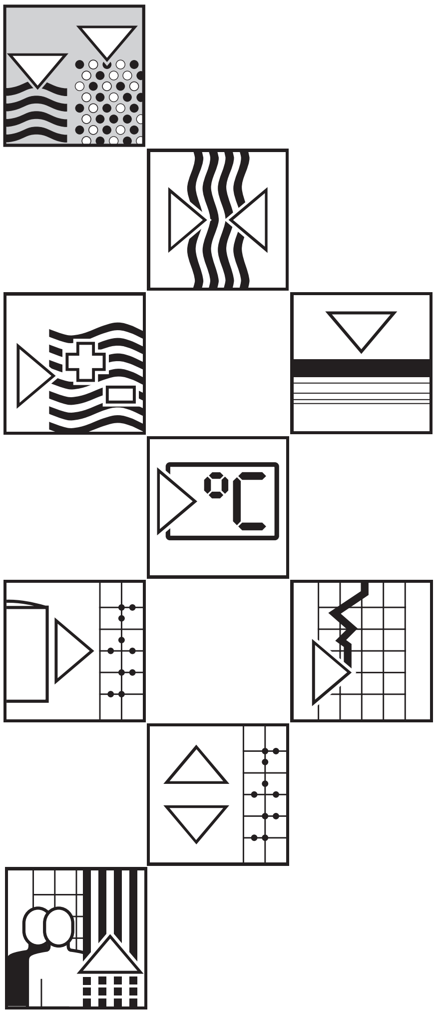
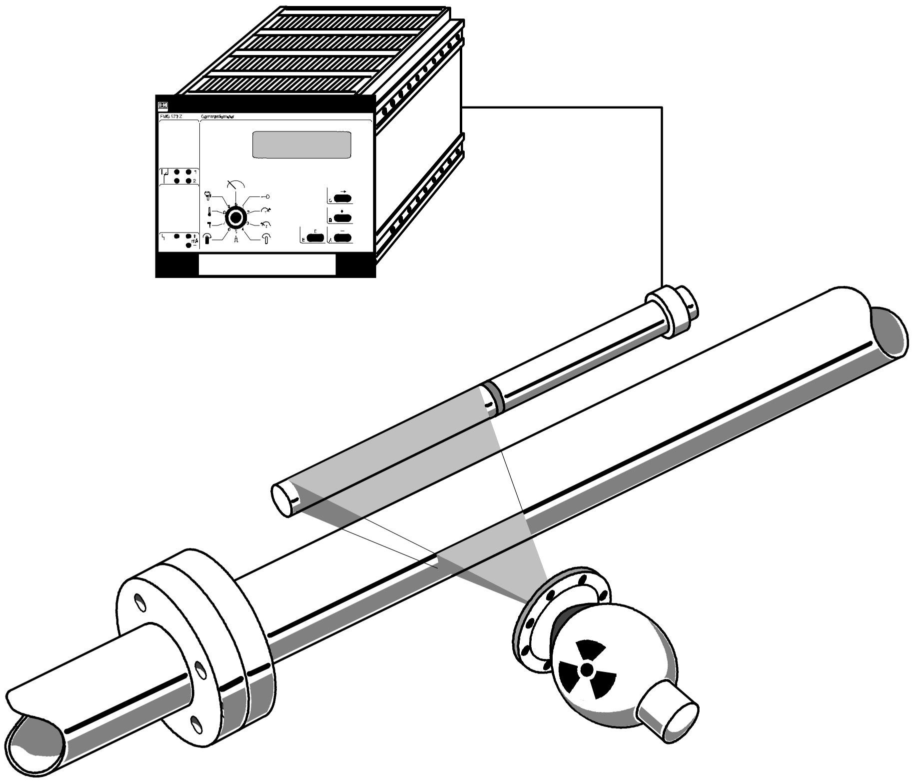
BA 107F/00/en/01.04
016139-1000
Software Version 1.4

Radiometric measuring system FMG 573 Z/S and DG 57 Density and Massflow Measurement

Operating Instructions





Endress+Hauser
The Power of Know How

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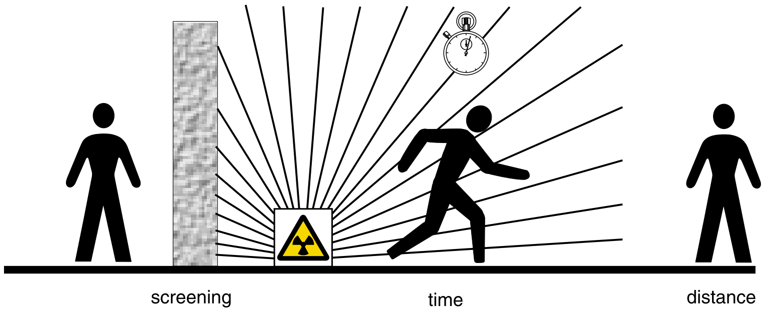
Basic regulations on radiation protection

Warning!
When handling radioactive sources, all unnecessary dosages should be avoided. All unavoidable dosages should be kept as low as possible. Three measures are used for this:



Distance
Keep the largest possible distance from the radiation source.
The local radiation dose rate decreases at the square-root of the distance from the radiation source.

Screening
Ensure the best possible screening between the radiation source and yourself as well as all others present.
Effective screening is provided by radiation protection containers (e.g. QG 2000) and all high-density materials (lead, iron, concrete).

Time
Stay as short as possible in the area exposed to radiation.

Empty pipe detection

If the pipe is empty due to operational reasons, dosages on the detector side can increase to dangerous levels, which may cause accelerated ageing of the detector unit and can in extreme cases lead to ists destruction or failure. Therefore an empty pipe detection should be installed, see p. 15.

Legal requirements for radiation protection

Handling radioactive emitters is legally controlled. The radioactive protection regulations of the country in which the plant is to be operated are to be strictly observed. For example, the radiation protection requirements dated 12.07.1989 are applicable to the Federal Republic of Germany. The following important points derived from this for radioactive measurement are:

Handling permit
A handling permit is required for operating a plant which uses gamma radiation. Application for the permit must be made to the Land government or the authority responsible (Land Offices for Environmental Protection, Trade Inspection Offices, etc.). The Endress + Hauser Sales Organisation will be pleased to help you obtain the permit.

Person responsible for radiation protection
The operator of the plant must nominate someone responsible for radiation protection who has the necessary specialist knowledge and who is responsible for observing all radiation protection regulations and procedures for radiation protection.
Endress+Hauser offers training courses in which the necessary specialist knowledge can be acquired.

Control area
Only persons exposed to radiation during the course of their job may sojourn in control areas (i.e. areas where the local dose rate exceeds a specific value) provided they are subjected to official personnel dose monitoring procedures. For example, in Germany the control area begins with a local dose rate of 7.5 µSv/h according to the radiation protection regulation in force. However, there may be a further reduction in this legal limit. The Endress+Hauser sales office will be pleased to provide further information of radiation protection and regulations in other countries.

1. Introduction

This manual is divided into three sections:

- general introduction and procedures valid for all chapters [Chapter 1 and 2]
- instructions for specific applications [Chapter 3 – 5]
- maintenance and trouble-shooting

Some information is duplicated in the application chapters. This is intentional, since the aim of the manual is to provide all the information required to solve a particular task together, rather than using cross-references to other parts.

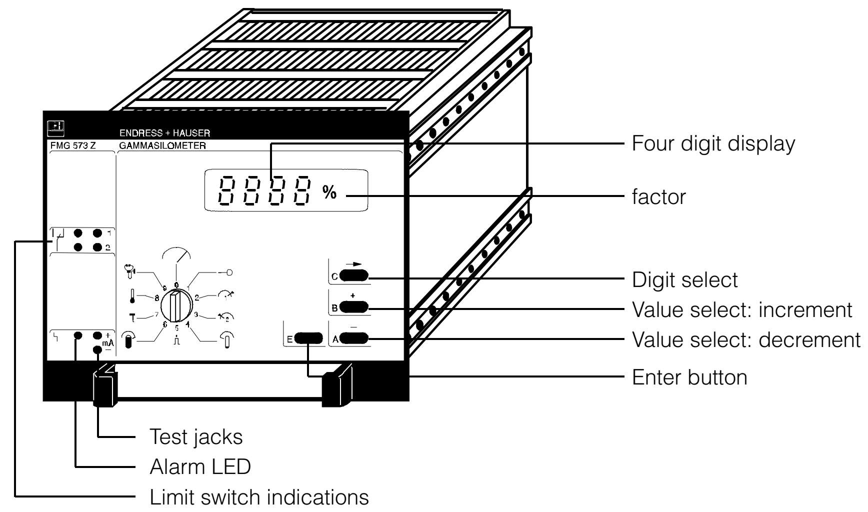


Fig. 1.1
Gammasilometer
Fig. 573 Z/S

Meaning of the symbols at the basic level

Measured value: Press the button indicated with an arrow→ to display the last 4 digits of a 5 digit measuring value. All four decimal points will flash,
e.g. **1.5352:** [1.535] → [5.3.5.2]

Key position: code input

Entry of set point 1: not, if relay 1 is used as a counter

Entry of set point 2: not, if relay 2 is used for a pre-set

Pulse rate N_{100} for ρ_{min} [N/100 ms]

Display of the actual pulse rate [N/100 ms]

Pulse rate N_0 for ρ_{max} [N/100 ms]

Time constant [s]: Default value is 60 s

Display of the medium temperature: only mode 20

Display of the error code / diagnosis

1.1. Radiation safety hints

This manual describes the handling of the source container for mounting and for set up under normal conditions.

All further activities like mounting, dismounting or exchange of the source must only be done by specially trained staff personnel or by radiation protection officials under strict observance of legal rules and regulations.

1.1.1 Radiometric measuring systems made by Endress+Hauser

Endress+Hauser radiometric density meters are designed, manufactured and shipped with special regard to German and international radiation safety regulations.

Original radiometric systems delivered by Endress+Hauser are normally equipped with double encapsulated sources Cs 137, exceptionally Co 60. Both comply with DIN 25426/ISO 2919, classification C 66646.

This is acknowledged to be the highest safety classification for industrial source containments.

For the source containers specific quality procedures are defined (ISO 9001), e.g. active measurements of each individual container to prove the specified shielding capability.

Radiometric density meters from Endress+Hauser utilize lowest source activities thanks to the most sensitive rod scintillation detector available.

However, in addition to international and local health protection rules, the following special hints must be observed.

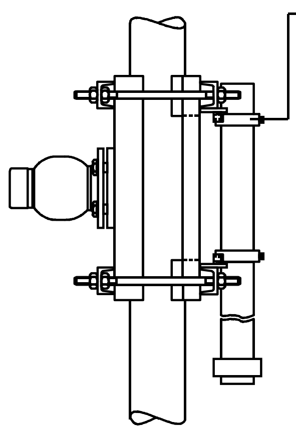
1.1.2 Control area at the detector side

The source activities are normally calculated based on the materials to be penetrated at lowest product density and on the factor $D \times \Delta\rho$.

D: Effective beam path through the medium [mm]

$\Delta\rho$: Density range $\rho_{max} - \rho_{min}$ [g/cm³]

For standard application requirements (time constant 60s, 2σ statistical variation) a source is selected to achieve a certain dose rate L at the detector with the pipe completely filled at the lowest density:



$D \times \Delta\rho$	L [mR/h] / [µSv/h]
30 ... 60	1.0 / 10
61 ... 80	0.8 / 8
81 ... 100	0.6 / 6
101 ... 130	0.4 / 4
131 ... 180	0.3 / 3
181 ... 360	0.2 / 2

Fig. 1.2
Calculation of source activity

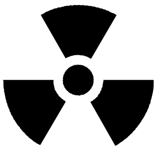
1.1.3 Control area at the source side

There will be no control area [7,5 μSv/h / 0,75 mrem/h] with using the following activities and the associated source containers:

QG 020: 925 MBq / 25 mCi [Cs 137]

QG 100: 9,25 GBq / 250 mCi [Cs 137]

When using Co 60 sources, the control area must be checked with a dose meter.



Important

- Independently of the above values, the actual dose rate must be measured individually, with a dose meter.
- The dose rate will increase dramatically at the detector side to dangerous levels if the pipe is not completely filled with product and the source is switched on. For possible measures, e.g. a warning signal or an automatic shut-off, please see chapter 1.6 / Empty pipe detection.
- The high dose rates produced by empty pipes cause accelerated ageing of the detector unit and can in extreme cases lead to its destruction or failure.

1.2. Applications

1.2.1 General remarks

The radiometric density measuring line is applied if alternative measuring methods fail to operate, e.g. coriolis meters, ultrasonic or optical systems.

Due to the absolutely contactless and non-intrusive nature of this technology, extreme process conditions, e.g. chemical incompatibility or abrasiveness, are ideal fields of application.

The radioactive measuring line is to be preferred for large pipe diameters, independent of the process conditions.

It is superior to conventional measuring systems which can only operate in by-pass arrangements.

1.2.2 Application examples at various industries

Offshore and refineries

- Control of drilling slurries on offshore platforms.
- Detection of different liquids, e.g. oils with different densities flowing in one pipe line.

Mining industry

- Measurement of slurries and pulp, the output signal is typically “% solids“
- monitoring settling processes
- flotation processes

Pulp and paper

- Quality control of different alkalis

1.3. Radiometric measuring principle

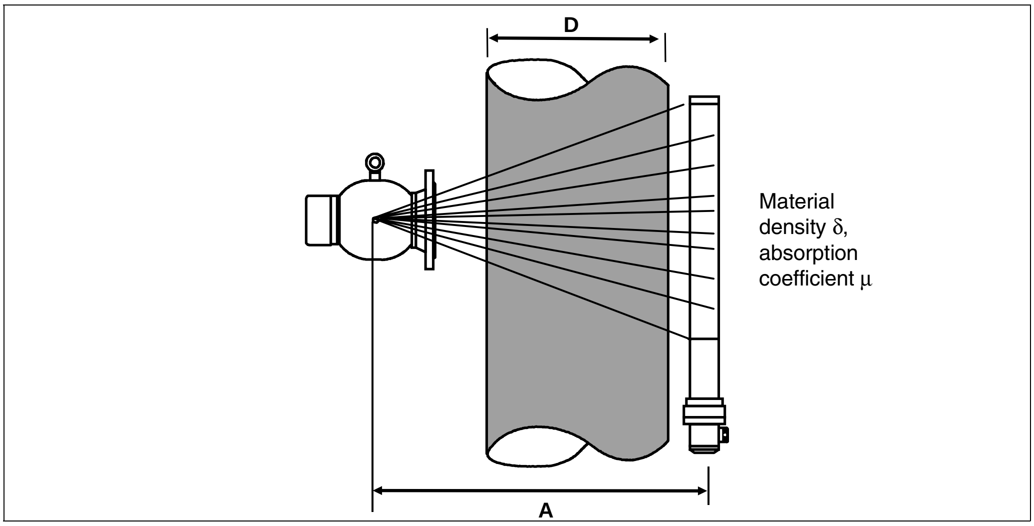


Fig. 1.3
Radiometric principle

1.3.1 Physical properties of gamma rays

Gamma radiation is absorbed when it penetrates matter. Basically, the attenuation [Fs] depends on the following parameters:

1.) Density [ρ] and thickness [D] of the material.

2.) A material and source dependent linear absorption coefficient [μ].

This is defined by the following formula:

$$\mathbf{Fs} = \mathbf{e}^{-\mu \times \rho \times D}$$

Similar to light or sound, the radiation decreases with the square of the distance [A]. For density applications, [μ], [D] and [A] are constants, and the radiation level depends on the density of the penetrated process material only. To achieve a density proportional signal, the received radiation level must be linearised exponentially.

The above mentioned physical facts are valid only for materials with an atomic mass number of less than 40 when using Cs 137 and less than 60 when using Co 60. Hydrogen is an exception as it absorbs twice as much as it's density would seem to allow.

For applications with dual component mixtures, e.g. sugar solutions, there is a defined relation between density and hydrogen content. Therefore the influence is eliminated by the on-line calibration.

1.3.2 Quality assessment

Besides quality specific facts, the key parameters that define the accuracy are:

- the statistical variation of the radioactive decay (A)
- the calibration (B)

(A) The statistical variation of the decay

The decay of a radioactive source is a stochastic phenomenon. This means, that the emission of γ-quanta varies randomly around an average value. The statistical calculation depends on the confidence level: 1σ, 2σ or 3σ

$\pm 1\sigma = \pm 1 \times \sqrt{N} \mathrel{\hat{=}} 68{,}28\ \%$ $\pm 2\sigma = \pm 2 \times \sqrt{N} \mathrel{\hat{=}} 95{,}45\ \%$
$\pm 3\sigma = \pm 3 \times \sqrt{N} \mathrel{\hat{=}} 99{,}74\ \%$

Normally the confidence level of 2σ is used.

The statistical variation is reduced by increasing the sampling time or the integration time [τ].

$$\pm\ 2\sigma = \pm\ \frac{2 \times \sqrt{N}}{\sqrt{\tau}}$$

The integration time set at the transmitter FMG 573 Z/S has a default value of 60 sec.

Example:

- Pulse rate at minimum density: 16500 pulses/s
- Integration time: 60 s
  Statistical variation: $\pm 2\,\sigma = \frac{2 \times \sqrt{16500}}{\sqrt{60}} = \pm\ 33{,}2\ ^{\text{pulses}}/_{\text{s}}$

that is equivalent at 16500 $^{\text{Imp}}/_{\text{s}}$: $\pm$ 0,20 %

Result:

The initial sizing of sources is made dependent on the requested accuracy and response time. To improve the accuracy (= lower statistical variation) with a given source strength, the integration time constant can be increased (up to 1000 sec.), causing, however, a slower response time of the measuring value.

(B) Calibration

The precision of the calibration procedure is most important for the linearity of the measurement. Details are exactly described in the application chapters 3 to 5.

The repeatability is dependent upon the device specific accuracies only.

Basic configuration for density measurement

Fig. 1.4 shows the basic configuration. The radiation produced by a radioactive source (2), usually Cs137, is collimated by the source container (1) as a narrow beam. The beam is directed through the pipe towards the detector (3). The detector measures a local dose and generates a pulse rate.

The change of the pulse rate relates to a change of the density:

$$N_{min} = \frac{N_{max}}{e^{-\mu \times D \times \Delta\rho}}$$

$\Delta\rho$	:	density range $\rho_{min} - \rho_{max}$
D	:	inner diameter of the pipe or length of the beam path through the product
μ	:	linear absorption coefficient
N_{max}	:	pulse rate at ρ_{min}
N_{min}	:	pulse rate at ρ_{max}

1.4. System components for density measurement

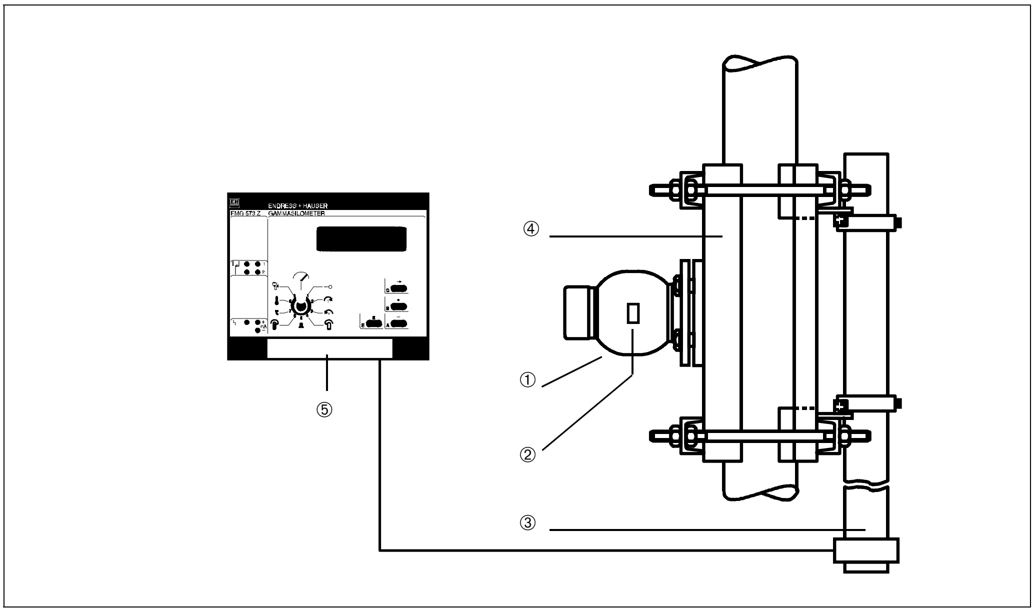


Fig. 1.4
Basic configuration for density measurement

Fig. 1.4 shows the basic set-up for density measurement. The components, which are described in detail in the following pages are as follows.

① Source container modified for density measurement
QG 020, DN100, 40 ° - part number 916060-9000
QG 100, DN100, 40 ° - part number 916061-9000
and additional modifications:

	Standard design	Pneumatic shut-off
Standard	013337-0001	and 213958-0000
EURO design	013337-0000	and 213958-0000
Sweden design	013337-0000	and 213958-0000

② Source: Cs 137 or Co 60; isotope and source activity depend on:

- pipe diameter
- thickness of the pipe walls, the material of the pipe and possibly of coatings
- density range
- required accuracy and response time

③ Detector DG 57 - density

④ Clamping device

- DN 80 ... DN 350: Part No. TSP 013336
- DN 350 ... DN 800: Part No. TSP 013252

⑤ Transmitter FMG 573Z/S

1.4.1 Source and source container

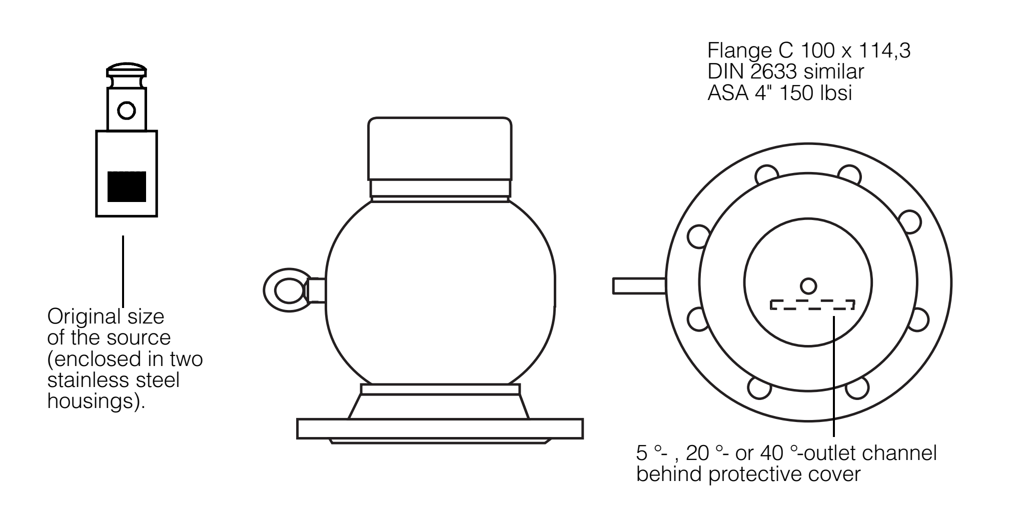


Fig. 1.5
QG 020/100
Source container

Principle of operation

The radio nuclide used as the γ-source is normally Cs 137 and exceptionally Co 60. The selection of the nuclide depends on the application. The main physical differences of the two types are:

1. Energy, determines the ability to penetrate material
   - Cs 137: 0,662 MeV
   - Co 60 : 1,173 MeV, or 1,337 MeV
2. Half life value, influences time of operation and the statistical variation:
   - Cs 137: 30 years
   - Co 60 : 5.3 years

The source is locked in a source container providing the necessary shielding. For different levels of shielding (by lead), two types, QG 020 (standard) and QG 100 (increased shielding) are used.

The radioactive source radiates in all directions. An output channel in the lead provides a defined radiation beam which is directed through the pipe to be measured only. Beam normally has an emission angle of 40 degrees with a 6 degree width. The source can be switched on or off either by manual operation or by remote control on the pneumatically or electrically actuated containers.

Full technical data is given in a leaflet, which accompanies the source container.

1.4.2 Detector DG 57 - density

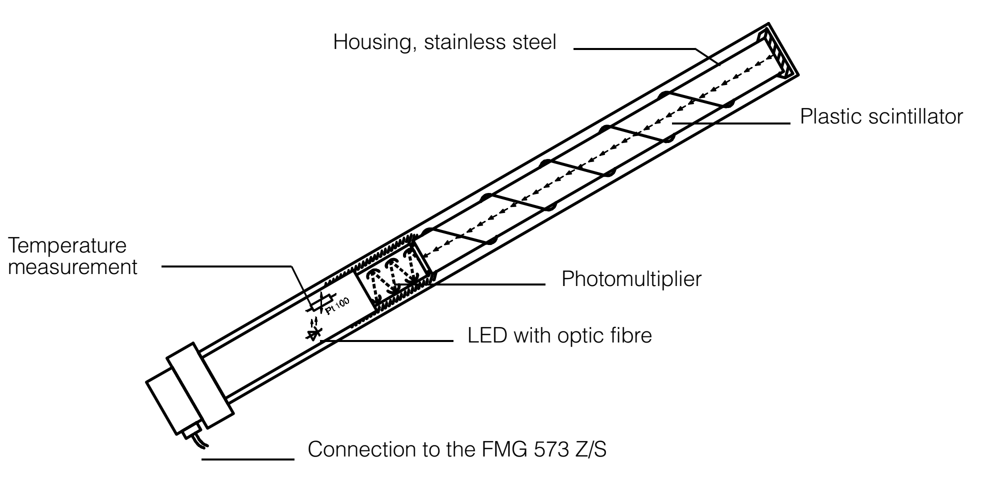


Fig. 1.6
DG 57 scintillation detector

Principle of operation

The main component of the DG 57 is a cylindrical rod made of transparent plastic scintillation material (400 mm or 100 mm, ø 48 mm). If a γ-quantum enters this material, most of the absorbed energy is converted into a small light flash (by photon effect). The number of flashes increases linearly with the intensity of gamma radiation and the exposed area.

A photomultiplier tube (PMT) is optically attached to the rod and detects these flashes. The signal processing circuit counts the light flashes using a sampling cycle of 500 ms and calculates the pulse rate (light flashes per second).

Prior to each sampling cycle, a light pulse generated by a LED is transmitted through the scintillator rod to the PMT (reference pulse). This reference value is transferred digitally together with the pulse rate and the actual temperature at the detector via a two-wire connection to the transmitter FMG 573 Z/S.

To achieve a maximum long-term stability in industrial environments, each DG 57 passes a special burn-in and calibration procedure. The sensor specific data are stored together with the operating program of the FMG 573 Z/S in two EPROMs. These data are used to compensate the primary sensor signals in order to provide a temperature-compensated and long-term stable pulse rate.

Technical data

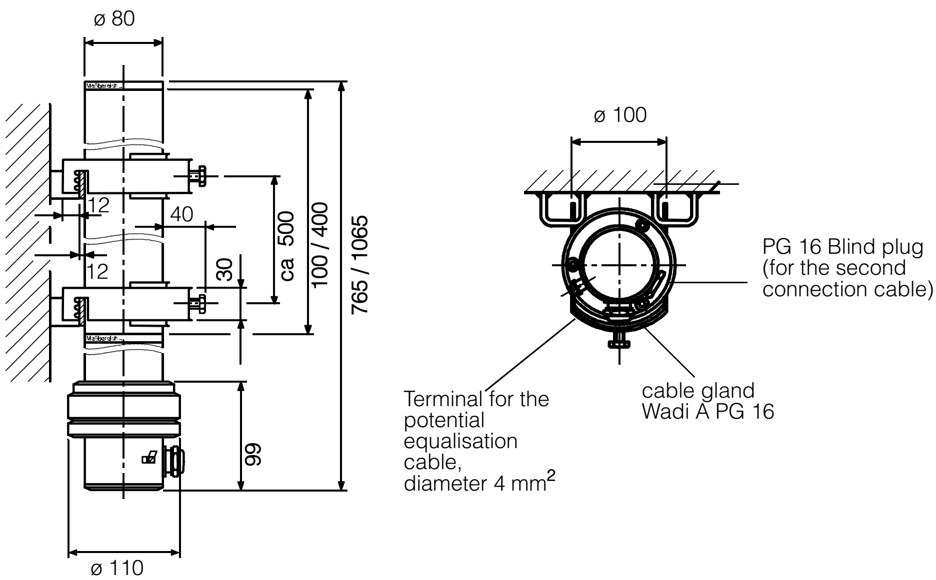


Fig. 1.7
Dimensions in mm
detector DG 57
(1"= 25,4 mm)

Type	DG 57 -D100 or DG 57-D400
Housing	Stainless steel 1.4301/SS 316TI
Cable glands	1x WADI A (water tight), PG 16 1x PG 16 blind plug
Weight 100 mm version 400 mm version	12.6 kg/18.0 kg (with water cooling jecket) 14.0 kg/19.6 kg (with water cooling jacket)
Protection class	IP 65, (equal to NEMA 4 or NEMA 4X)
Explosion protection	[EEx d ib] IIB or IIC* T6 *with specified safety barrier.
Output signal	Pulse code modulation, PCM, approx. 48 mA, with superimposed digital information of the pulse rate, the detector temperature and a reference signal
Temperature compensation	built-in
Operation temperature	-20 ... 50 °C, up to 120 °C with water cooling jacket From 40 °C upwards we recommend the use of a water cooling jacket. Water flow rate 40...200 l/h; max. water temp. 40 °C; water pressure 4 - 6 bar (We also recommend a flow control).
Electromagnetic compatibility	Emitted interference to EN 61326 ; Class B equipment Immunity to interference to EN 61326 ; Annex A (industry sector) and NAMUR EMC Recommendation (NE 21)

Water cooling jacket

The detector DG 57 is specified for operating temperatures up to 50 °C. For ambient temperatures higher than 40 °C a water cooling jacket is necessary.

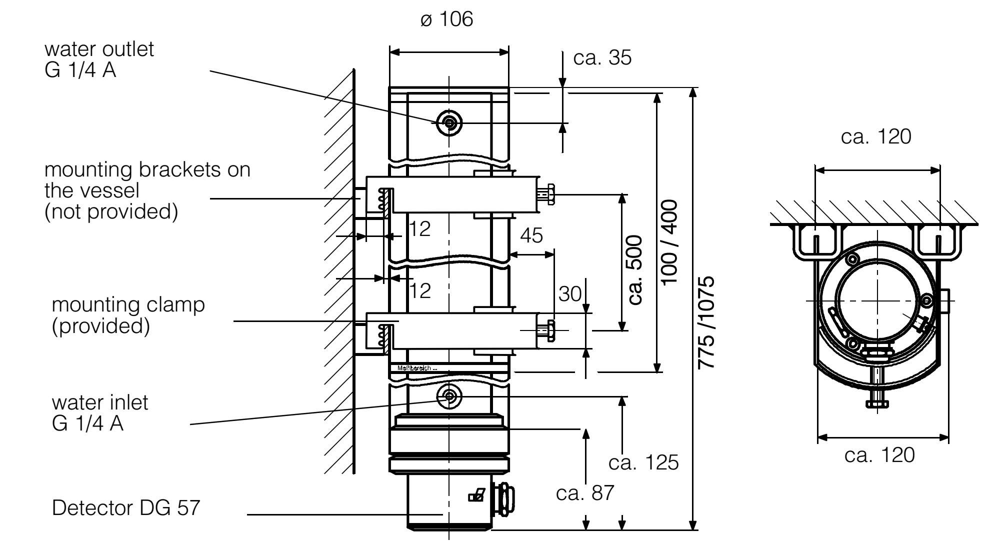


Fig. 1.8
Dimensions in mm
detector DG 57
with water jacket

Technical data

Weight 100 mm version 400 mm version	5.4 kg 5.6 kg
Water connection	2 x G1/4A, DIN/ISO 228
minimum flow rate at 20 °C water temperature	40 ... 100 l/h, depending on the operation conditions
Additional attenuation	equal to 5 mm of steel

1.4.3 Transmitter FMG 573 Z/S

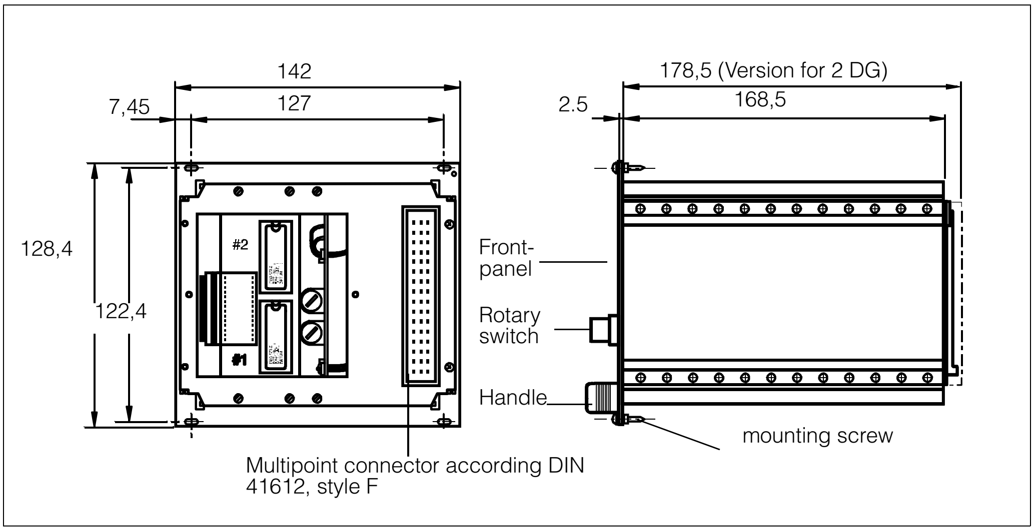


Fig. 1.9
Dimensions in mm
transmitter
FMG 573 Z/S

Principle of operation

The transmitter FMG 573 Z/S is a microprocessor controlled device in 19" Racksyst design, 28 pitch units wide. It provides one input for the rod scintillator DG 57 and a second input for temperature or flow measuring signals. Both are for the Endress+Hauser specific digital transmission signals (PCM, PFM) and allow the use of standard two wire cable (max. 25 Ohm per core).

The output signals are:

- 0/4....20 mA and 0/2....10 V
- 2 relay for set points or for counting or pre set contacts
- 1 alarm relay for indication of system errors

The operating software consists of five major blocks.

1.) Conversion of the primary sensor signals into a temperature-compensated and stable pulse rate.

2.) Linearisation to convert the pulse rate into a density proportional signal.

3.) Special modes for:

- density measurement only
- selection of up to four calibration curves
- temperature compensation
- mass flow calculation.

4.) Supporting software for the calibration procedure and for the scaling of the analogue output and the display

5.) Self checking with safety functions and a closed control loop for the detector.

Technical data

Housing	19" Racksyst cassette, 28 pitch wide
Plug connector	27 pin according DIN 41612, style F
Protection	IP 20 (front panel), IP 00 (connectors)
Weight	2,2 kg
Operating temperature	– 20 °C...+ 60 °C (– 4 ... 140 °F)
Storage temperature	– 40 °C...+ 75 °C (– 40 ... 167 °F)
Power supply	24/110/115/127/220/230/240 Volts AC + 15 %/– 10 %; 50 ... 60 Hz; 23 VA, 20 ... 28 Volt DC; 15 W
RF immunity	3 V/m (144 + 430 MHz)
Data back up	CMOS RAM, battery backed up for at least 8 years
Electromagnetic copatibility	Emitted interference to EN 61326 ; Class A equipment Immunity to interference to EN 61326 Use a screened cable to connect the sensor to the switching unit. Installation hints for screened cables and general information on EMC test requirements for E+H instruments can be found in Technical Information TI 241.

Inputs and outputs

Input 1	PCM from DG 57; 13,3 V/48 mA, FMG 573 Z: Ex-free, FMG 573 S + safety barrier: [EEx ib] IIB/IIC
Input 2	PFM from TMT 2530 Z or from TSP 8267 (Analog-PFM-converter), FMG 573 Z – for safe applications FMG 573 S + safety barrier: Range [EEx ib] II B/C
Analogue outputs	1 x 0/4...20 mA; Ri max. 500 Ω 1 x 0/2...10 V; Ri min. 10 kΩ. Current- and voltage outputs cannot be defined independently. Selecting 0/4 mA automatically sets 0/2 V. – with AC - power supply: DC -isolated – with DC - power supply: connected to the negative pole Test jacks at the front panel for the current output
Output in case of alarm	– 10 % – +110 % – maintain the last measuring value – continue to measure
Time constant	1 ... 1000 s

Relay outputs	2 potential-free changeover contacts for set points or for a counter or a pre set counter 1 potential free changeover contact for an alarm signal
Contact rating	AC load: – max. 4 A/250 V – max. 500 VA; cos φ > 0,7 DC load: – max. 100 W at 48 V or – max. 50 W at 250 V

1.5. Empty pipe detection

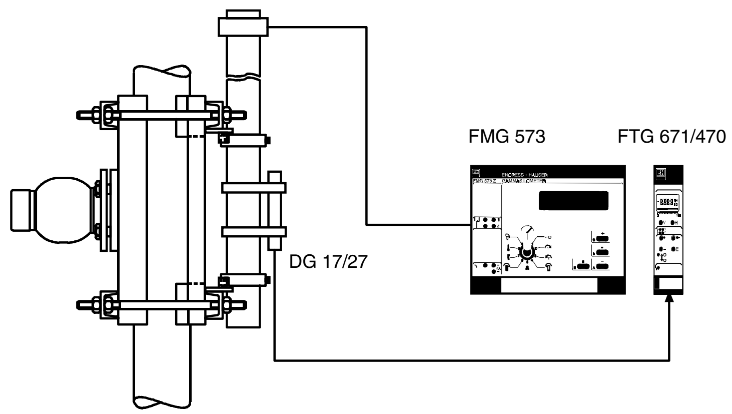


Fig. 1.10
Density measurement with radiation monitoring through FTG 671/470

Mounting of a DG 17/27 on the DG 57 for empty pipe detection

If the pipe is empty due to operational reasons, radiation levels on the detector side can increase to dangerous levels.

The safest method to avoid such a situation is to install a second radiometric system to monitor the current radiation level. In the event of high radiation, it is possible to install an alarm and/or the source container can be switched off automatically e.g. by means of a pneumatic actuator.

Important

- The high dose rates produced by empty pipes cause accelerated ageing of the detector unit and can in extreme cases lead to its destruction or failure.

1.6. Options

1.6.1 Angled irradiation

Clamping devices for pipes 80 ... 200 mm [3 ... 8 inch] outer diameter, for doubling the measuring distance. Part number. MTS-013550

1.6.2 Density measurement in vessels

For density measurements performed in vessels, the special mounting MTS-13131 "Trenn A"-density is to be mounted.

The source is located in a lead shielding in a protection pipe. There must also be a protective pipe in the vessel to house the source shielding device. It must not bend, as this will result in measurement errors.

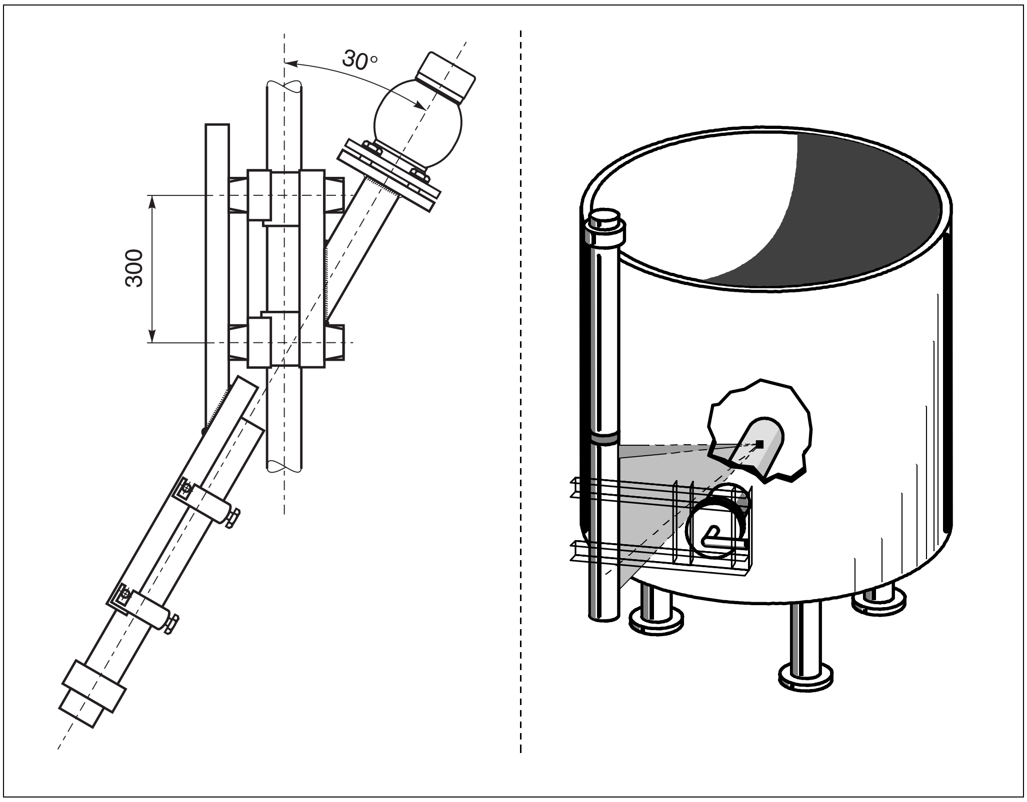


Fig. 1.11
Clamping device for diagonal beam paths right: special source for interface measurement

2. Preparations

2.1. Set up of the transmitter FMG 573 Z/S

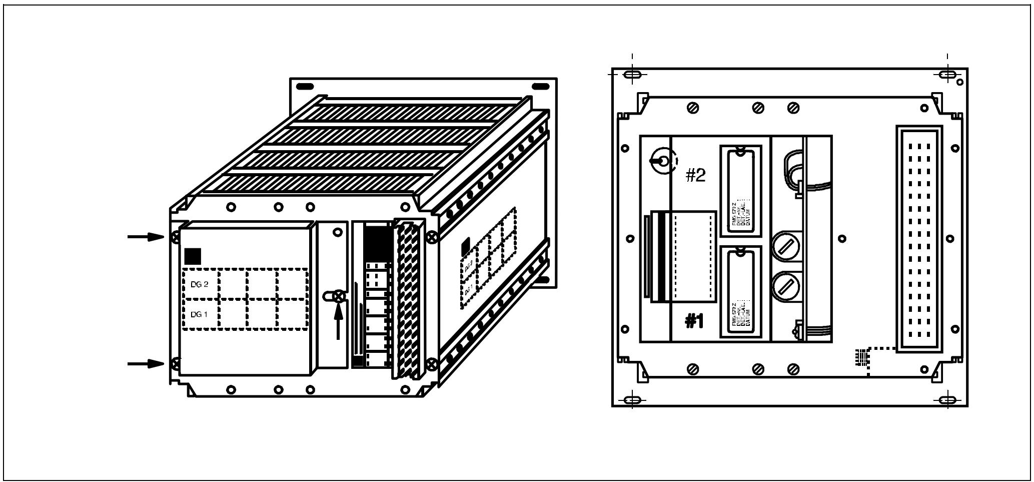


Fig. 2.1
Accessing the EPROM sockets

General remarks

Each FMG 573 Z/S, if delivered with a detector DG 57, is equipped with the corresponding EPROMs containing the detector specific data and the software program for the density application.

Exceptionally a refitting of the EPROMs might be necessary, e.g. by a replacement delivery: If the detector is delivered separately, the required EPROMs will be inside the head of the detector.

1. Stand the FMG 573 Z/S on its front panel.

Caution: Do not stand it on the rotary switch, support it to prevent damage.

2. Remove the rear cover plate as shown on the drawing, - a separate printed circuit board with two EPROM sockets is now accessible.
3. Insert the EPROMs into their matching sockets number 1 or 2:
   The corresponding number is printed on the label of the EPROMs. Both Eproms must have the same software version.

Hint:

Check, that the code marks of the EPROMs conform with the picture above. They must be directed to the top of the transmitter.

Wrong positioning of the EPROMs with power on will destroy them!

Please verify that the number printed on the EPROMs , e.g. Cs 4375 D, corresponds to the serial number of the DG 57 to be connected.

The same transmitter FMG 573 Z/S (two channel version) can be used for density and level applications. Depending on the detector DG 57, density or level version, the appropriate software is delivered.

2.2. Operation of the FMG 573 Z/S

2.2.1 Introduction

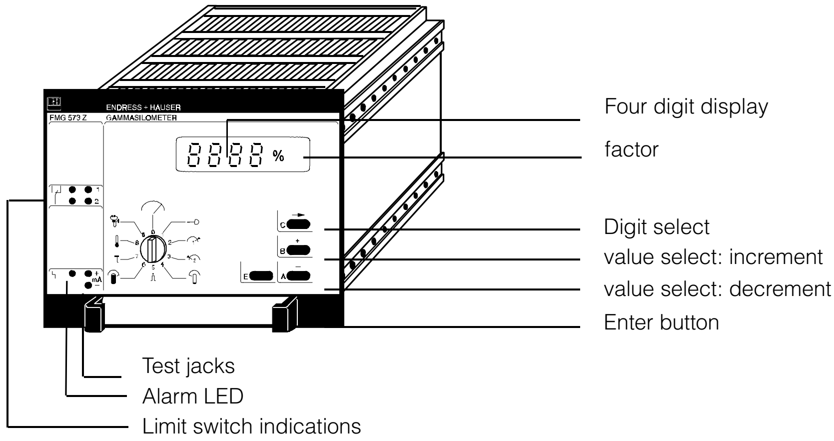


Fig. 2.2
FMG 573 Z/S
operating elements

Meaning of the symbols of the basic level

Measued value: press ➞: button - to display the last four digits of a 5 digit number (all decimal points flash), e.g. **1.5352:** [1.535] ➞ [5.3.5.2]

Key input: code entry (selection of the levels):

Input of set point 1: not if relay 1 is used as a counter

Input of set point 2: not if relay 2 is used as a preset counter

Pulse rate N_{100} for ρ_{min} [N/100 ms]

Display of the actual pulse rate [N/100 ms]

Pulse rate N_0 for ρ_{max} [N/100 ms]

Integration constant [s]: Default value is 60 s

Display of the medium temperature: only mode 20

Display of the error code / diagnosis

The FMG 573 Z/S software is organised for different levels of operation:

1. The basic level
2. Different programming levels.

1.) In the basic level the actual measured value is displayed and major settings can be checked. This is done by turning the rotary switch.

2.) The programming levels are for calibration and for service:
By entering a code (0045, 0145, ... 1045) in switch position 1, eleven programming levels are accessible. The programming levels are either general, e.g. calibration, or application specific, e.g. mass flow parameters. Depending on the code entered, each switch position is allocated a new meaning:

Example - level 0145

Code-entry: 0145

Relay mode: Min./Max.-safety of the setpoint limit switch 1 or counter

Min./Max. safety of the setpoint limit switch 2

Entry of the source type: Cs 137 or Co 60

Analogue output: 0 or 4 ... 20 mA

Analogue output in case of error:
01: 0 %; 02: – 10 %;
11: 100 % of the last measuring value;
12: 110 %, 20: Hold

Minimum PFM frequency of input 2

Maximum PFM frequency of input 2

Last error code. When the entry button is pressed, this value is deleted.

An overview of all levels and positions (matrix fields) is shown at the end of each application related chapter.

2.2.2 Code entry

1.) Turn the rotary switch to position 1

2.) Use the cursor ➞ to select the digit to be altered:
the selected digit flashes.

3.) Choose the desired number with + 'increment' or – 'decrement', e.g. [0600]

4.) Repeat the step 2.) and 3.) until the number is displayed completely
[0640 ... 0645]

5.) Confirm with „E". The confirmed code is now displayed permanently,
e.g.. [0645]

6.) Turn the rotary switch clockwise to the desired switch position (2 ... 9) to display or to change parameters.

7.) As soon as the switch position (O) is set or passed, the program exits the selected level and returns to the basic level.

Notes

* If a wrong code is entered, the display will show [0] after pressing „E"
* When passing „0" by using + or – there is an over- or underflow on the not selected left or right digit, e.g.. [0800] - - [0790].

2.2.3 Data entry

1.) Enter the programming level in switch position (1).

2.) Turn the rotary switch to the required position No. (2 ... 9).

3.) Use the cursor ➞ to select the digit to be entered: the selected digit flashes and if you want to chance e.g. (1.01) into (3.03).

4.) Select the required number, e.g.. (3.01) by + 'increment'
(or – 'decrement', for a different value).

5.) Repeat step 3.) and 4.) until the number is displayed completely.

6.) Press the E-button: the entered number is now displayed permanently, e.g. (3.03).

2.3. Density measurement in pipes

2.3.1 General remarks

The place where the density measurement is installed and the process conditions very much influence the quality of the measurement:

* air bubbles cause a lower indication of the real product density as the system measures the sum of product and air.
* build up, deposits, corrosion and abrasion change the inner diameter of the pipe and therefore influence the measurement.
* turbulences after quarter bends, T- or U-shaped pipes can result in a non-homogeneous mixture of liquids or slurries.

Choice of the location

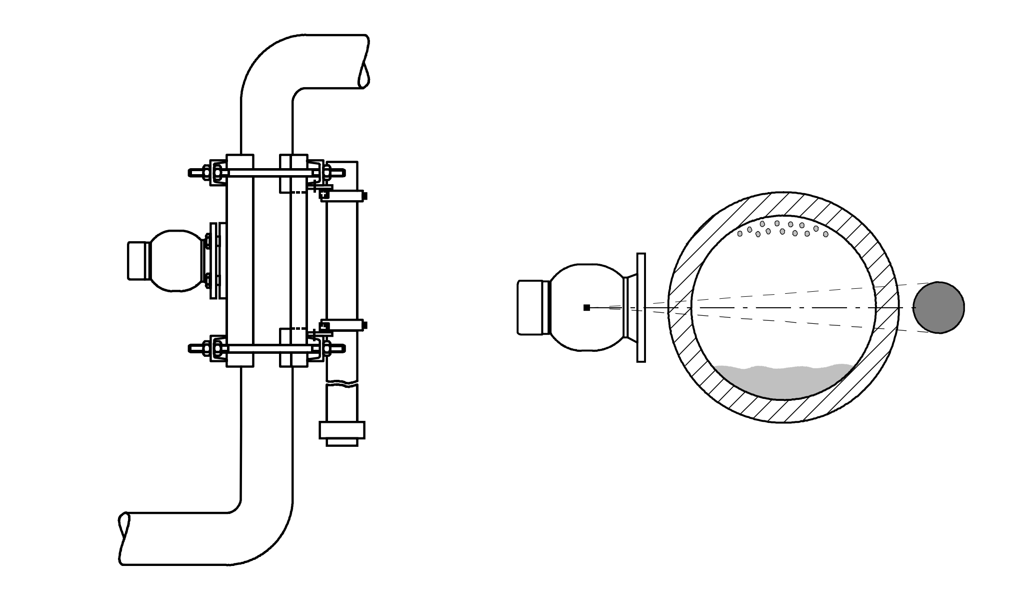


Fig. 2.3
choice of location

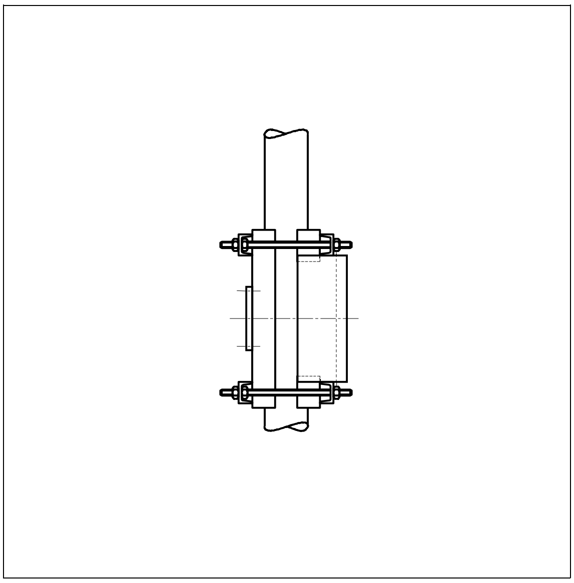
The most constant conditions will be achieved when:

- mounting on bottom fed, vertical pipes
- Where only horizontal pipes are accessible, the radiation beam should penetrate the pipe horizontally: this reduces the influence of air bubbles and deposits.

Notes

1. Ensure that the pipe can carry the weight of the whole arrangement: QG 020 + DG 57 + clamping device (82 to 112 kg)
   (for QG 100 additional approximately. 50 kg more)
2. The detector temperature must not exceed 50 °C (122 °F)
3. If mounted outdoors, the detector must be protected against direct exposuure to the sun and low temperatures (by insulation or heating) . Ingress protection is to IP 65.

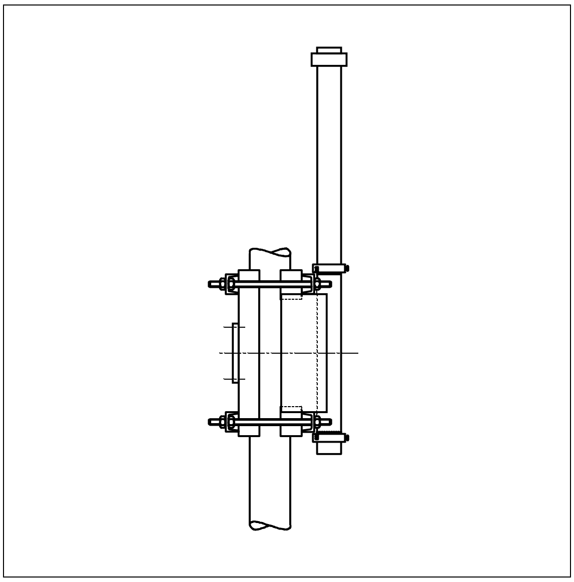
2.3.2 Mounting



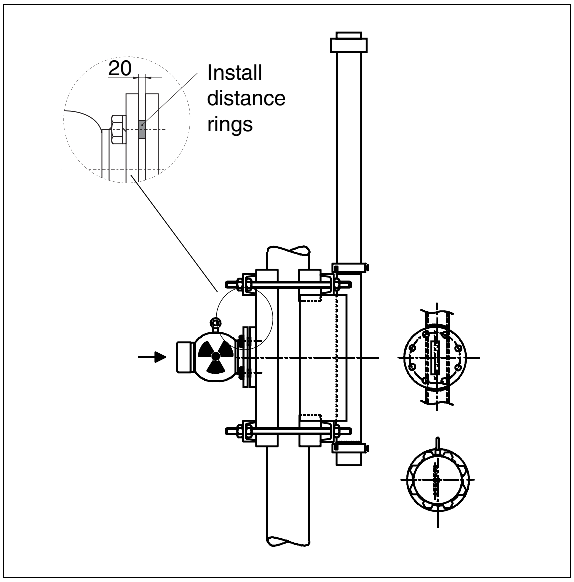
Attention

The source container may be switched on only with medium in the pipe. Observe the radiometric safety regulations!

- Mount the clamping device on the pipe without the detector and the source container.



- Attach the detector: the marks of the active area must correspond with the fixing supports of the clamping device.
- Preferred position of the detector head is at the top.



- Mount the source container
- The transport ring corresponds to the collimating slot: make sure that it matches with the slot of the clamping device.

Hint:

Note the asymmetric position of the collimating slot of the source container.

2.3.3 Source container QG020/QG100 (Density version 13337)

The source container used for density applications has an additional fixing screw (5 mm hexagon socket screw) to prevent any movement of the source holder. This avoids movement of the source due to vibrations.

Keep the O-ring, which seals the protective cap, lubricated with silicone grease (long-term lubricant)!

A) Removal of the protective cap

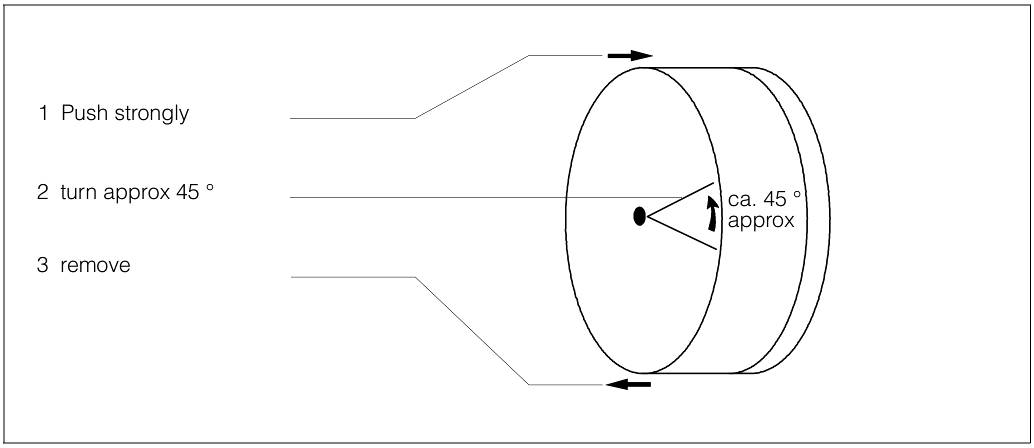


Fig. 2.4
Remove cap

B) To switch off

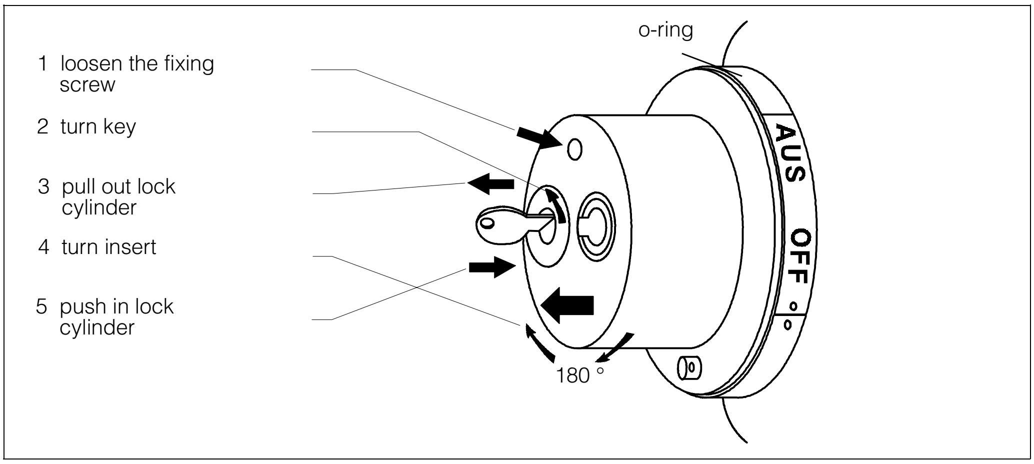


Fig. 2.5
Switch off

C) To switch on

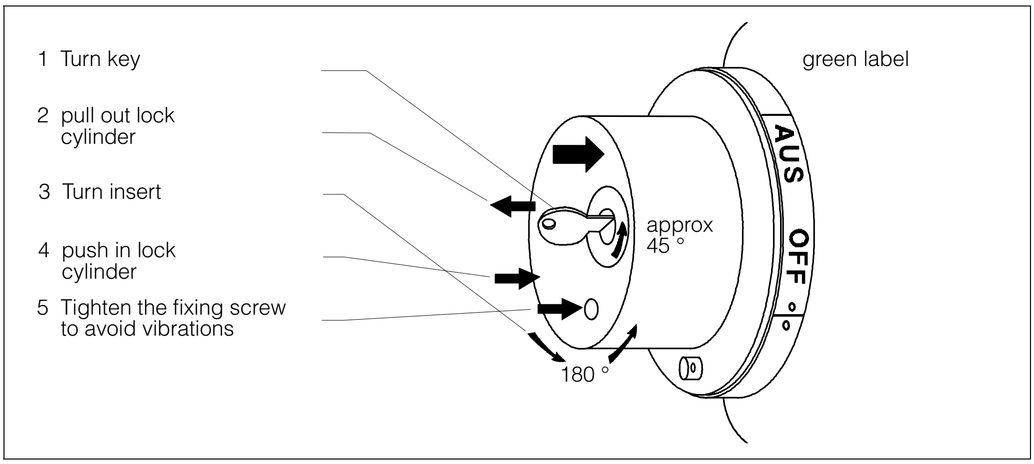


Fig. 2.6
Switch on

3. Density measurement

3.1. Introduction

3.1.1 Overview of the measurement configuration

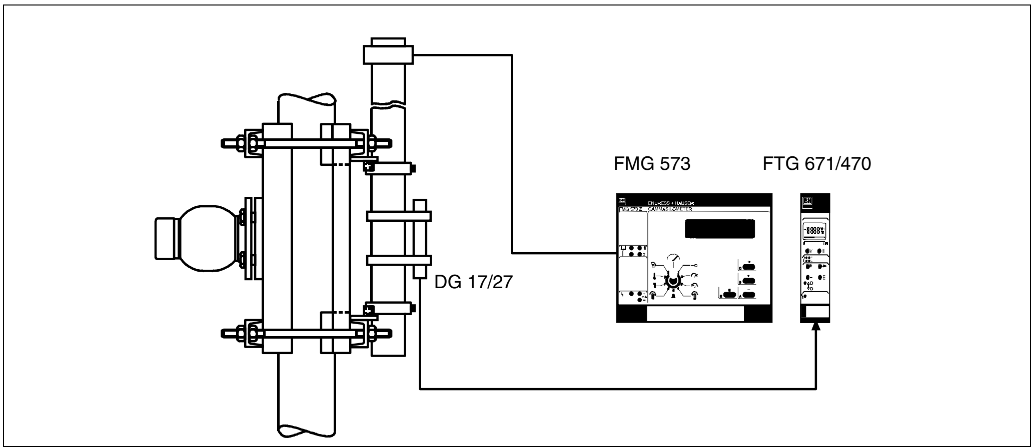


Fig. 3.1 Arrangement for density measurement

3.1.2 Quick set-up reference

	Chapter	Page
1. Electrical connections:	3.2	24
2. Programming of the FMG 573 Z/S:	3.4	27
3. 2-point calibration	3.5	32
4. Selection of the output signal		
• Density [weight/volume]	3.8.1	34
• % Concentration	3.8.2	34
• % Solids [Weight]	3.8.3	36
• Dry solids		
* % Volume	3.8.4	38
* Weight/Volume	3.8.5	40
5. Set points of the limit switches	3.9	42

3.2. Electrical connection

Important hint

Please observe, in addition to the following sections of this manual, our planning instructions and the radiation protection regulations. Also for applications in explosion hazardous areas, the test certificates as well as the local explosion protection laws.

3.2.1 Installation of the transmitter FMG 573 Z/S

The FMG 573 Z/S is a 28 HP wide transmitter in 19" technology. It is installed either in a Racksyst field housing (IP 65) or in a 19" Racksyst rack. The connector in the rack or in the field housing must comply to DIN 41612, type F.

The transmitter FMG 573 Z/S must be installed outside the explosion hazardous area.

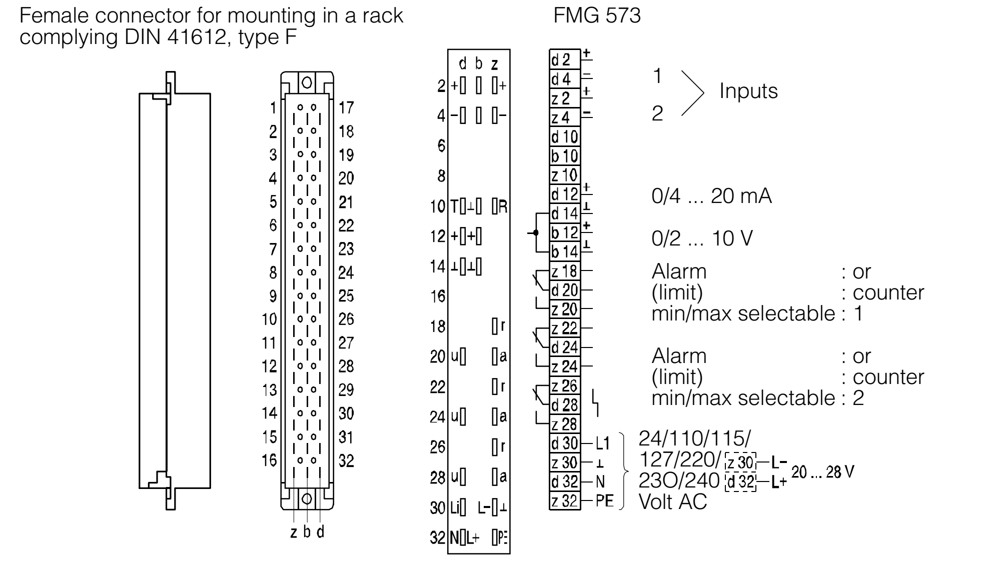


Fig. 3.2
Pin assignment and coding pins

Typical error codes

E401 No signal from the DG 57 – check the wiring and its polarity.

E901 Pulse rate is out of the measuring range – normal indication, when the measuring line is not yet fully calibrated.

3.2.2 Wiring in non-explosion hazardous areas (FMG573Z)

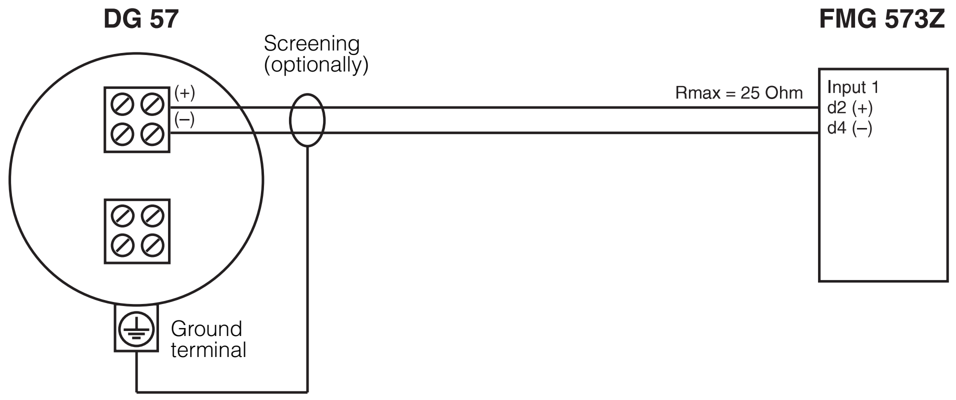


Fig. 3.3
Wiring in non-explosive hazardous areas

3.2.3 Wiring in explosion hazardous areas (FMG573S + Zener barrier)

Explosion hazardous areas specification IIB/IIC/T6

- Observe the instructions of the safety barrier and the PTB certificates
- The intrinsically safe circuit of the safety barrier is connected to the potential equalisation line or plant grounding system. Therefore the complete sensor wiring must be connected with the potential equalisation line.
- Check the maximum allowed inductance and capacitance values of the wiring as stated in the PTB and safety barrier certificates.

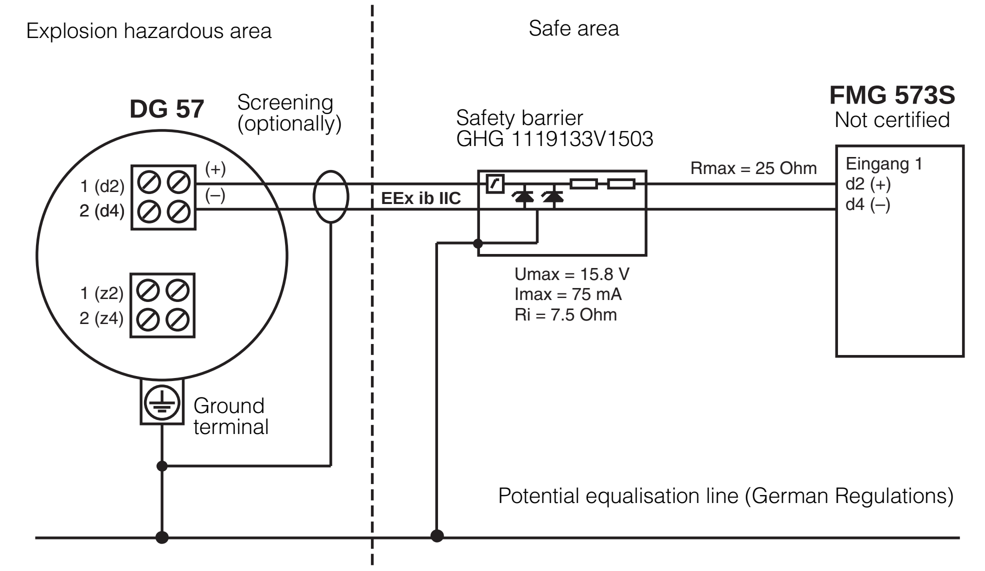


Fig. 3.5
Wiring in explosive hazardous areas EEx ib IIB/IIC

3.3. Calibration

3.3.1 General remarks

The radiometric density measuring line requires a calibration with product. Usually this is done by using the process fluid. The actual density must be determined by a laboratory analysis.

- The calibration value is always entered in [g/cm^3].
- As with any system that requires a calibration, the accuracy is directly influenced by the quality of the laboratory analysis!
- Check that the product temperature is the same at that measured during the laboratory analysis.

After calibration a calibration plate can be manufactured, which can then be used to check the the calibration or recalibrate the system at a later date.

3.3.2 One point or two point calibration

The two point calibration should be performed to achieve a highly reliable measurement:. In this case, the FMG 573 Z/S automatically calculates the linear absorption coefficient (μ) from the calibration data.

- For reliable measurements, the difference between the two calibration points should be at least one third of the measuring range.

If this is difficult to achieve with the original process product, water can be used for one calibration point.

If initially only one density value can be calibrated, the one point calibration can be used for a quick start up. The one point calibration provides a sufficient accuracy around the calibration point. For control purposes this might be sufficient. Nevertheless the gradient of the calibration curve might be too steep or too flat.

- For the one point calibration, the linear absorbtion coefficient must be entered. Contact Endress+Hauser for the correct value for your application.

To achieve a high accuracy, later during operation, the calibration can be completed by performing the two point calibration.

3.3.3 Calibration sets

Up to three different calibration sets can be programmed. This is useful if different products are to be measured in the same pipe.

- Example: slurries with different carrier liquids and constant density of the solids - the output signal is 'Dry solids' [Weight/Volume]. Depending on which calibration set is selected, the following characteristics are used:

1.) Two point calibration

- Density range ρ_{min} and ρ_{max}
- Calibration densities (ρ_1, ρ_2) and the corresponding pulse rates (N_1, N_2)

2.) One point calibration

- Density range ρ_{min} and ρ_{max}
- Linear absorbtion coefficient [μ]
- Calibration density and the corresponding pulse rate (ρ_1, N_1)

3.4. Programming the FMG 573 Z/S

The transmitter is delivered with certain software default settings. The initial set-up is performed to check and change default parameters before starting with the calibration.

Software reset

In order that you do not have to check all default settings, we recommend a **software reset prior to the first set up.** With this you ensure, that accidential or unauthorised entries are reset to the default values.

Caution:
If calibration was already performed and values are entered in the FMG 573, these values will be lost after a software reset.

3.4.1 Software-Reset

Rotary-switch	Display	Entry	Meaning
1	0	2607	Entry of the programming level (Service)
9	0	2607	By pressing „E“ the software reset is initiated. The default values are activated. E 204 will be displayed and the alarm relay switches. After a short period the error code E 901 appears (normal indication when the calibration is not yet completed).

3.4.2 Initial set up

Rotary-switch	Display	Entry	Meaning
1	0	3500	Entry of the programming level (Sensor data)
6	XXXX		The displayed detector no. must match the detector no. of the connected DG 57!
1	0	0145	Entry of the programming level
4	1	 0 1	Select the isotope: this influences the decay compensation Co 60 Cs 137 (default)
5	0	 0 1	Selection of the analogue output 0 mA ... 20 mA/0 V ... 10 V (default) 4 mA ... 20 mA/2 V ... 10 V
6	12	 01 02 11 12 20 30	Behaviour of the analogue output on alarm: Start of the measuring range, e.g. 4 mA/2 V (The example depends of the prior selection) – 10% of the analogue measuring range, e.g. 2.4 mA/1.2 V 20 mA/10 V +110 % of the analogue measuring range, e.g. 21.6 mA/10.8 V (default) hold the last measuring value if possible: continue to measure
1	0145	0345	Entry of the next programming level
2	10	10	Check the operating mode ‘density only‘ (default)
1 or 0			Proceed with the calibration or end

Typical error codes

E901 Pulse rate is out of the measuring range:
normal indication, when the measuring line is not yet fully calibrated.

3.4.3 Use of the calibration sets

Rotary-switch	**Display**	**Entry**	**Meaning**
1	0	 0545 0445	Entry of the programming level Two point calibration One point calibration
9	XX	YZ	Meaning of the entry YZ Entry set 1 ... 4 blank: Activation of the selected set for modification 1: Confirmation of the selected set; Any changes now become valid. 2: Delete (!) the selected set
9	XX	12	Example Unlock calibration set 2 for recalibration
0			End

3.4.4 To lock the access to the calibration data

This feature is used to prevent unauthorised or accidental alterations and is activated after all settings have been made.

Rotary-switch	**Display**	**Entry**	**Meaning**
1	0	0345	Entry of the programming level
3	X	9999 2 1	To lock the calibration values Activation of the ’Two point calibration’ Activation of the ‘One point calibration‘
0			End

3.4.5 Change of the integration time

Value, which when increased reduces the influence of the statistical variation. The default value is 60 s.

Please refer to section 1.4.2 for the physical influences.

Rotary-switch	**Display**	**Entry**	**Meaning**
1	0	0045	Entry of the programming level
7	60	XX	Entry of the new integration time 1 ... 1000s
0			End

3.5. Two point calibration

Note

- The complete measuring line (DG 57, FMG 573 Z/S) must have been in operation for at least 6 hours with the radiation switched on and with product in the pipe.
- When the pipe is empty, switch off the radiation (leave system in operation)
- The integration time must be set to 60 s (default value)
- Make sure that the source holder is always fixed when in operation (refer to Chapter 2.3.3). Note all entered values as well as the date, the calibration values and the pulse rates.

Rotary-switch	Display	Entry	Meaning
1	0	0345	Entry of the programming level
2	X	10	Density measurement
3	X	2	Check if the calibration mode 'Two point calibration' is selected (default value)
5	200.0	XXX.X	Entry of the inner pipe diameter or the real length of the radiation path through the product.
1	0345	0545	Entry of the programming level
9	XX	1	Selection of the calibration set 1
2	1.000	X.XXX	Entry of the beginning of the density measuring range in [g/cm^3]; – If the output signal should be dry solids [Weight/Volume], enter the density of the carrier liquid [g/cm^3].
3	2.000	X.XXX	Entry of the end of the density measuring range in [g/cm^3]
Fill pipe with calibration fluid of density ρ_1 (lower density value): wait at least 5 min.			
5	1	1	Selection of lower calibration point: ρ_1 = low density
6	XXXX(X)	ENTER	Current pulse rate [N/100 ms]. Press ENTER to store
7	XXXX		Check stored pulse rate [N/100 ms]
8	0.0000	XXXX(X)	Enter density of calibration liquid [g/cm^3].
Fill pipe with calibration fluid of density ρ_2 (upper density value): wait at least 5 min.			
5	1	2	Selection of upper calibration point: ρ_2 = low density
6	XXXX(X)	ENTER	Current pulse rate [N/100 ms] Press ENTER to store
7	XXXX		Check stored pulse rate [N/100 ms]
8	0.0000	XXXX(X)	Enter density of calibration liquid [g/cm^3].
9	1	11	Active calibration set no. 1
0			End

Typical error codes

E820 ρ_{min} **>** ρ_{max}. Enter the correct values in switch position No. 2 and No. 3 (0545)
or The calibration densities ρ_1 and/or ρ_2 are out of the entered measuring range defined by ρ_{min} and ρmax.

E821 The calibrated density ρ_1/ρ_2 or the pulse rate N1/N2 is = 0, or the calibration density ρ_1 is bigger then ρ_2 - enter the correct values in switch position No. 5, No. 7 and No. 8

E901 The pulse rate is out of the measuring range: check if ρ_{min} and ρ_{max} are entered correctly or the pipe is empty or only partly filled.

3.5.1 Production of a calibration plate

A steel calibration plate (for thickness contact E+H) is placed in the beam between the source container and pipe. This simulates a density increase in the fluid flowing through the pipe. The equivalent density value is noted and stamped on the plate.

Rotary-switch	Display	Entry	Meaning
If possible, fill the pipe with calibration fluid with the low density value (ρ_1) Switch off radiation, insert steel plate, switch on radiation and wait at least five minutes			
0	X.XXXX		Note displayed density value to 4th decimal point (press ⇒ to display to this resolution)
1	0	0345	Entry of programming level
3	XXXX	1	Selection of one point calibation
1	X.XXXX	0445	Entry of programming level
9	XX	1	Selection of the calibration set no. 1
6	XXXX(X)	ENTER	Current pulse rate [N/100ms] **Press ENTER to store**
7	XXXX		Check stored pulse rate [N/100 ms]
8	0.0000	X.XXX(X)	Entry of the noted density [g/cm^3]
9	1	11	Activate the calibration set No. 1
0			End
Switch off radiation, remove steel plate, switch on radiation and wait at least five minutes			

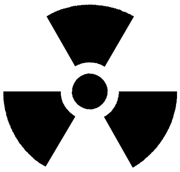
3.5.2 Automatic recalibration using calibration plate

A periodic recalibration of the system is recommended in oder to compensate any measuring errors which may occur due to wear of or build-up in the pipe. The measuring conditions of the initial plate calibration must be reproduced. The system must have been operating for at least an hour before calibration.

Rotary-switch	Display	Entry	Meaning
Fill the pipe with the calibration fluid used to produce the calibration plate			
1	X.XXXX	0945	Entry of programming level
6	X.XXXX	1	Entry of calibration mode: 1 = automatic*
1	X.XXXX	0445	Entry of programming level
8	X.XXXX		Check that calibration plate value is displayed – if not, enter as follows
9	XX	1	Selection of the calibration set no. 1
8	0.0000	X.XXX(X)	Entry of the density on plate [g/cm^3]
9	1	11	Activation of the calibration set no. 1
Switch off radiation, insert steel plate, switch on radiation and wait at least five minutes			
Short-circuit connections z10 and b10 for at least one second The recalibration starts automatically and lasts about 10 minutes, during which time the error message E 902 is displayed			
Switch off radiation, remove steel plate, switch on radiation and wait at leaastfive minutes			

*For procedure with manual start of the recalibration see Section 6.1.1.

3.6. One point calibration



Note:

- The complete measuring line must be in operation for at least 6 hours with the source container switched on and with product in the pipe.
- When the pipe is empty, switch off the radiation (leave system in operation)
- The integration time must be set to 60 s (default value)
- Make sure that the source holder is always fixed when in operation (refer to Chapter 2.3.3). Write down all entered values as well the date, the calibration values and the pulse rates.

Rotary switch	Display	Entry	Meaning
1	0	0345	Entry of the programming level
3	2	1	Selection of the one point calibration mode
5	200.0	XXX.X	Entry of the inner pipe diameter or the length of the real radiation path through the process fluid [mm]. **Note:** Enter this value precisely. It directly influences the calculation of the absorption.
1	0	0445	Entry of the programming level
9	1	1	Selection of the calibration set 1
2	1.000	X.XXX	– Entry of the beginning of the density measuring range [g/cm^3]. – If the output signal is dry solids (weight/volume), enter the density of the carrier liquid [g/cm^3].
3	2.000	X.XXX	Entry of the end of the measuring range [g/cm^3]
4	6.154	XXXX	Entry of the linear absorption coefficient [μ]
6	XXXX(X)		Actual pulse rate [N/100 ms] **Procedure** 1. Fill the pipe with the calibration fluid. 2. Wait at least 5 minutes , before you read out the pulse rate. 3. As soon the pulse rate is constant, store it by pressing the Enter button.
7	XXXX		Display of the stored pulse rate [N/100 ms]
8	1.500	X.XXX(X)	Entry of the density value of the applied calibration fluid [g/cm^3]
9	1	11	Activation of the calibration set no. 1
0			End

3.7. Upgrade of a one-point to a two-point calibration

Rotary switch	Display	Entry	Meaning
1	0	0345	Entry of the programming level
3	1	2	Selection of the two point calibration mode
1	0345	0545	Entry of the programming level
9	11	1	Modification of the calibration set no.1
5	1	 31 32 1 2	1. Transfer of the calibration data (density and pulse rate) from the one point-calibration: * The one point calibration value gets used as ρ_1: lower calibration density * The one point calibration value gets used as ρ_2: higher calibration density Press the Enter button to confirm the entered value 2. Calibration of the second calibration point Entry: ρ_1 = lower calibration density (if 32 was selected before) ρ_2 = higher calibration density (if 31 was selected before)
6	XXXX(X)		Actual pulse rate [N/100 ms] **Procedure** 1. Fill the pipe with the calibration fluid 2. Wait at least for 5 minutes, before you read out the pulse rate 3. As soon as the pulse rate is constant, store it by pressing the Enter button.
7	XXXX		Display of the stored pulse rate [N/100 ms]
8	X.XXX(X)	X.XXX(X)	Entry of the density value of the calibration fluid [g/cm^3]
9	1	11	Activation of the calibration set no.1
0		11	End

Typical error codes

E801 $\rho_{min} > \rho_{max}$. Enter the correct values in switch position 2 and 3 (0445 or 0545)

E810 The calibration density of the one point calibration is out of the range defined by ρ_{min} and ρ_{max}.

E901 The pulse rate is out of the display capacity: Check, if ρ_{min} and ρ_{max} are entered correctly or the pipe is empty or only partly filled.

3.8. Selection of the output signal

For all internal calculations of the FMG 573 Z/S, values are used with the unit [g/cm^3]. Depending on the application, the industry and of the country, other engineering units can be used.

3.8.1 For liquids and solutions: Conversion of [g/cm^3] into other units [weight/volume]

Rotary switch	Display	Entry	Meaning
1	0	0845	Entry of the programming level
2	1	1	Selection of the conversion unit
3	1.01	X.XX	Selection of the density measuring unit: Weight Volume 1 = g 01 = cm^3 2 = kg 02 = dm^3, l 3 = t 03 = m^3 4 = oz 04 = in^3 5 = lb 05 = ft^3 6 = sh cwt 06 = yd^3 7 = cwt 07 = fl.oz/GB 8 = sh tn 08 = fl.oz/US 9 = tn 09 = gal/GB 10 = gal/US
1	0845	0345	Entry of the programming level
8	X.XXX(X)		Display the start of the measuring range of the analogue output; based on ρmin [g/cm^3], as defined before, during the calibration procedure and converted into the prior selected engineering unit.
9	X.XXX(X)		Display of the end of the measuring range of the analogue output; based on ρmax [g/cm^3] as defined before and converted into the selected engineering unit.
0			End

Typical error codes

E900 The displayed number is larger then 9999: Check, if the selected engineering unit fits into the display capability.

3.8.2 Liquids and solutions: % concentration

The FMG features a non-linear conversion of density into % concentration This is done by entering a conversion table with up to 18 points. The operating program interpolates linearly between each point.

Example

Ethanol + water at 20 °C
Required measuring range: 10 ... 30 %

Data taken from tables:

%	0	10	20	30	40	50
Density	0.9987	0.9818	0.9687	0.9540	0.9351	0.9139

(Round off the values to 4 digits behind the decimal point)

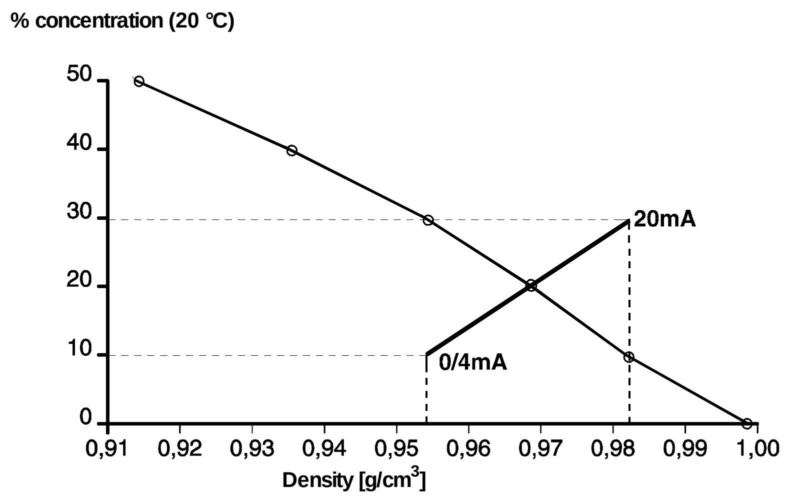


Fig. 3.6
Density-concentration conversion

Rotary switch	Display	Entry	Meaning
1	0	0845	Entry of the programming level
2	1	3	Entry of the conversion mode % „concentration“
7	1	1	Check/entry of the first value of the conversion table
8	0.00 %	10	Entry of % concentration; the first table value is the start of the measuring range of the analogue output.
9	0.000	0.9818	Entry of the corresponding density value [g/cm^3]
7	1	2	Entry of table value no.‘2‘
8	0	20	Entry of the next value % concentration
9	0.00 %	0.9687	Entry of the corresponding density value [g/cm^3]
7	2	3	Enter of table value no.‘3‘
8	0.00 %	30	Entry of the last value % concentration, the last table value is the end of the measuring range of the analogue output
9	0.000	0.9540	Entry of the corresponding density value [g/cm^3]
0			End

Typical error codes

E710 The table values % concentration must strictly increase or decrease. Check the table and correct it. If necessary delete the table. To delete it, the value 33 must be entered in switch position 7. Then the table must be entered again.

E711 The table values for density must strictly increase or decrease. Check the table and correct it. If necessary delete the table. To delete it, the value 33 must be entered in switch position 7. Then the table must be entered again.

3.8.3 Measurement in slurries: Solid matter content [% weight]

For the conversion from density into solid matter content (% weight) a table with up to 18 points can be entered. The operating programme interpolates linearly between two values. The conversion formula is:

$$\%\ \text{solids} = \frac{1 - \dfrac{\rho_{carrier}}{\rho}}{1 - \dfrac{\rho_{carrier}}{\rho_{solids}}} \times 100\ \%$$

$$\rho = \frac{\rho_{carrier}}{1 - \dfrac{\%\ \text{solids}}{100\ \%} \times \left(1 - \dfrac{\rho_{carrier}}{\rho_{solids}}\right)}$$

Depending on the required accuracy and resolution, a table must be drawn up:

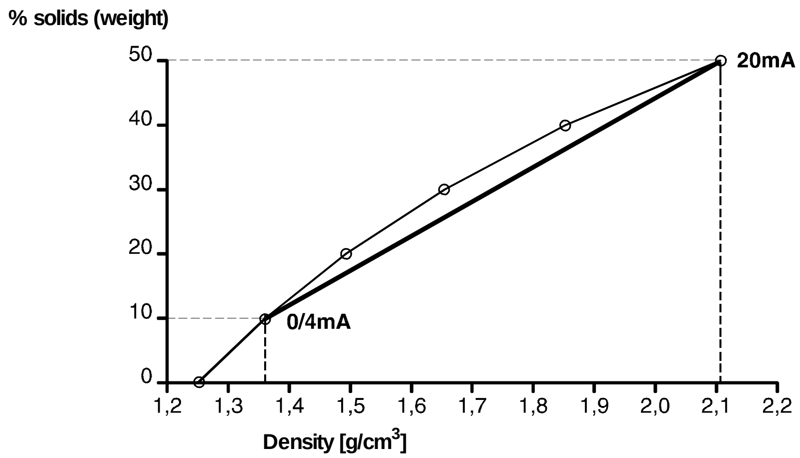


Fig. 3.7
Density-solids content (weight %) conversion

Example

$\rho_{\text{Carrier liquid}}$: 1,250 g/cm^3
ρ_{Solids}: 6,700 g/cm^3
Measuring range: 10 ... 50 %

Table no.:	1	2	3	4	5
% Solids:	10	20	30	40	50
Calculated density 'ρ' :	1.3607	1.4929	1.6535	1.8529	2.1069

Rotary switch	Display	Entry	Meaning
1	0	0845	Entry of the programming level
2	1	3	Entry of the conversion mode % "concentration"
7	1	1	Check/entry of table position ‘1‘
8	0.00	10	Entry of % solids content; The first table value is the start of the analogue measuring range
9	0.000	1.3607	Entry of the prior calculated corresponding density value [g/cm^3]
7	1	2	Entry of table value no.2
8	0.00 %	20	Entry of the next table value % solids content
9	0.000	1.4929	Entry of the corresponding density value [g/cm^3] etc.
etc.			
7	4	5	Entry of table value no. 5
8	0.00 %	50	Entry of the last value for %solids content of the table, the last value is the end of the measuring range of the analogue output.
9	0.000	2.1069	Entry of the corresponding density value [g/cm^3]
0			End

Typical error codes

E710 The values for % solids content must strictly increase or decrease.
Check the table and correct it. If necessary delete it.
To delete it, the value 33 must be entered in switch position 7.
Then the table must be entered again.

E711 The values for the density must strictly increase or decrease:
Check the table and correct it.If necessary delete it. To delete it, the value 33 must be entered in switch position 7. Then the table must be entered again.

3.8.4 Measuring of slurries: solids content [% Volume]

The conversion of density into solids content [% Volume] is linear.
Both minimum- and maximum values, calculated beforehand, must be entered.

The formula applied is:

$$\text{Solids content [\%Volume]} = \frac{\rho - \rho_{carrier}}{\rho_{solids} - \rho_{carrier}} \times 100\ \%$$

$$\rho = \frac{\text{Solids (\% Volume)} \times (\rho_{solids} - \rho_{carrier})}{100\ \%} + \rho_{carrier}$$

Example

ρ Carrier fluid: 1,000 [g/cm³]
ρ Solids: 3,200 [g/cm³]
Required measuring range: 10...30 %

Procedure

1.) Calculation of the corresponding density for 10 %:

$$\rho = 10\ \% \times \frac{(3{,}200 - 1{,}000)}{100\ \%} + 1{,}000 = 1{,}220\ g/cm^3$$

2.) Calculation of the corresponding density for 30 %:

$$\rho = 30\ \% \times \frac{(3{,}200 - 1{,}000)}{100\ \%} + 1{,}000 = 1{,}660\ g/cm^3$$

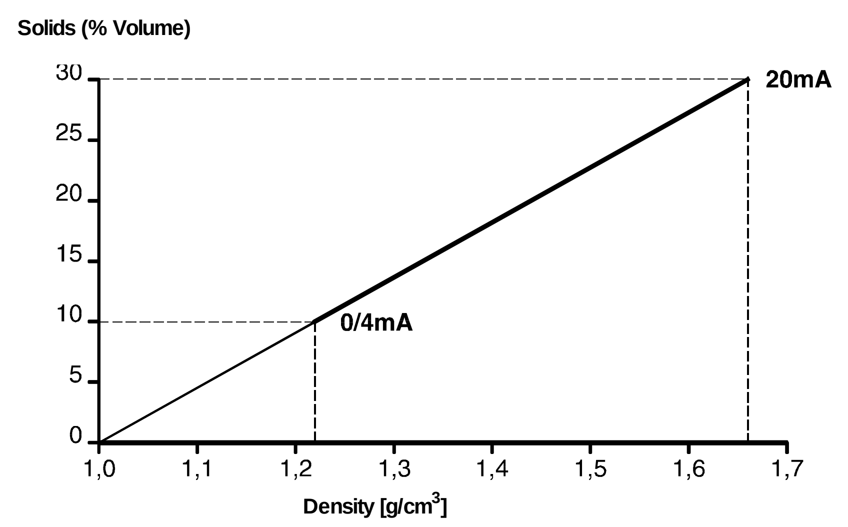


Fig. 3.8
Density-solid contents (volume %) conversion

Rotary switch	Display	Entry	Meaning
1	0	0845	Entry of the programming level
2	1	3	Selection of the conversion mode % ”Concentration“
7	1	1	Check or enter the first table value
8	0.00 %	10	Entry of % solids content; the first table value is the beginning of the measuring range of the analogue output
9	0.000	1.220	Entry of the prior calculated corresponding density value [g/cm^3]
7	1	2	Entry of table value no.2
8	0.00 %	30	Entry of the second value % solids content
9	0.000	1.660	Entry of the corresponding density value [g/cm^3]
0			End

Typical error codes

E710 The values of % solid content must strictly increase or decrease
Check the table and correct it. If necessary delete the table.
To delete it, the value 33 must be entered in switch position 7.
Then the complete table must be entered again.

E711 The density values must strictly increase or decrease.
Check the table and correct it. If necessary delete the table.
To delete it, the value 33 must be entered in switch position 7.
Then the complete table must be entered again.

3.8.5 Measurement of slurries: Solids [weight/volume]

The conversion of density to solids content is done automatically.
Calculated by the following formula:

$$\text{Solids [weight/volume]} = \frac{\rho - \rho_{carrier}}{1 - \frac{\rho_{carrier}}{\rho_{solids}}}$$

The display always starts with '0' (Weight/Volume).
To enter the end of the measuring range, the corresponding density value must be calculated.

$$\rho = \text{solids}\ [\text{weight}/\text{volume}] \times \left(1 - \frac{\rho_{carrier}}{\rho_{solids}}\right) + \rho_{carrier}$$

This value is entered as ρmax during the calibration.

Example

ρCarrier:		1,250 [g/cm^3]
ρSolid:	6,800 [g/cm^3]	
Measuring range:		0 ... 1600 g/l

Procedure

1.) Conversion of [g/l] into [g/cm^3]: 1600g/l = 1,6g/cm^3

2.) Calculation of the corresponding density value for 1,6 g/cm^3 [Weight/Volume]

$$\rho = 1{,}6\ \text{g/cm}^3 \times \left(1 - \frac{1{,}250\ \text{g/cm}^3}{6{,}800\ \text{g/cm}^3}\right) + 1{,}250\ \text{g/cm}^3 = 2{,}556\ \text{g/cm}^3$$

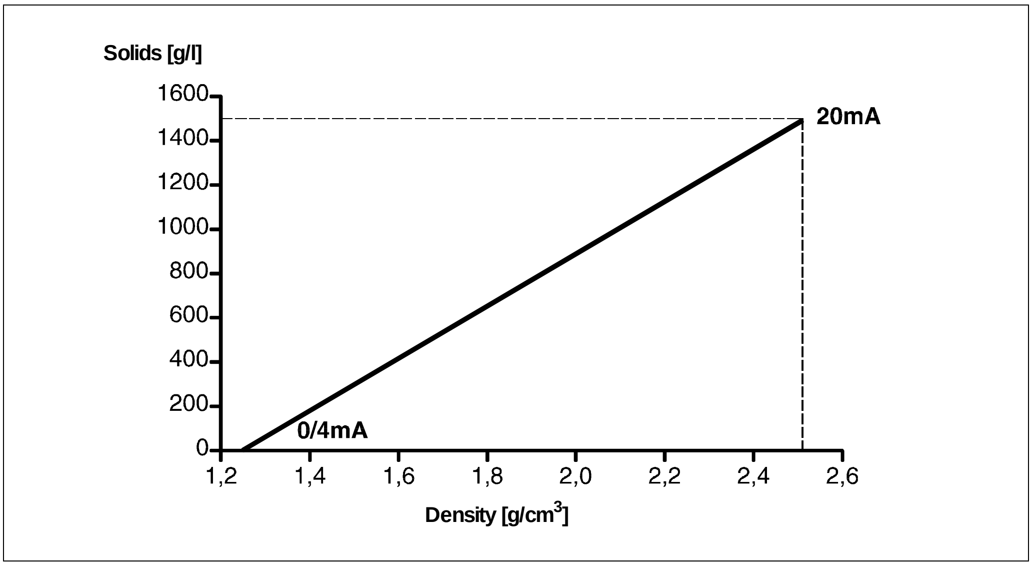


Fig. 3.9
Density-solids content (wt/va) conversion

Rotary switch	Display	Entry	Meaning
1	0	0845	Entry of the programming level
2	1	2	Selection of the conversion mode ’2’
3	1.01 	 1.02	Entry of the (weight/volume)-unit: X.XX 1 = g 01 = cm^3 2 = kg 02 = dm^3, l 3 = t 03 = m^3 4 = oz 04 = in^3 5 = lb 05 = ft^3 6 = sh.cwt 06 = yd^3 7 = cwt 07 = fl.oz/GB 8 = sh tn 08 = fl.oz/US 9 = tn 09 = gal/GB 10 = gal/US Example: [g/l]
5	1.500	6.800	Entry of the density of the solids contents [g/cm^3].
1	0845	0345	Entry of the programming level
3	X	 1 2	Check which calibration mode is selected: 1 = one point calibration 2 = two point calibration
1	0345	XXXX 0445 0545	Depending on the prior check: enter the matching programming level of the calibration mode 0445: One point calibration 0545: Two point calibration
9	11	1	Calibration set no.1 gets modified
2	X.XXX	 1.250	Enter the density of the carrier liquid [g/cm^3]. This value can only be modified in the one point or the two point calibration mode), e.g. 1.250
3	XXXX	2.556	Entry of the calculated density at the highest solids content, e.g. 2.556
9	1	11	Activate calibration set no.1
1	0445 0545	0345	Entry of the programming level
9	1600		Check the display of the end of the measuring range of the analogue output
0			End

Typical error codes

E900 Displayed number is bigger than 9999: Check if the selected engineering unit fits into the display range.

3.9. Set points/relays

3.9.1 Introduction

The FMG 573 Z/S features two independent relays, which can be used as switch points in the density mode.

The switching of each relay is defined by three parameters:

1.) Set point:
0 ... 100 % related to the measuring range of the analogue output

2.) Hysteresis:
0 ... 100 %; for a two point control with one relay, this value defines the on/off cyle.

3.) Fail-safe mode: Min.- or Max.-safety;
This determines the use of the relay:
- Min. for low value alarm
- Max. for high value alarm

The setting also defines whether the hysteresis is added or deducted from the set point.

Default values

	Set point	Hysteresis	Fail-safe mode
Relay 1:	10 %	3 %	Min.
Relay 2:	90 %	3 %	Max.

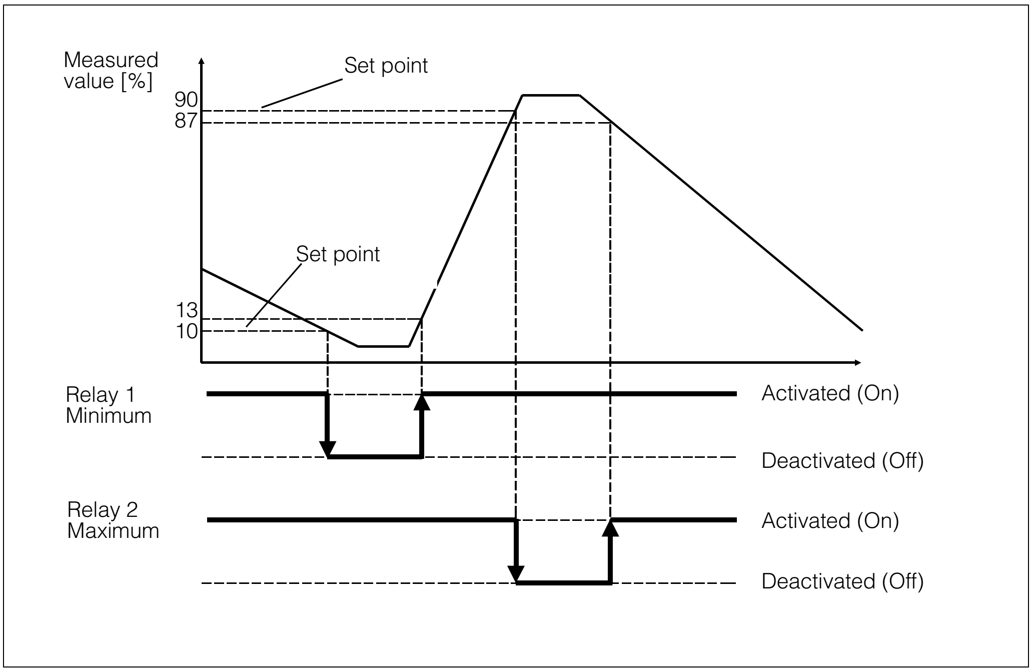


Fig. 3.10
Minimum and Maximum fail-safe mode

Rotary switch	Display	Entry	Meaning
1	0	0045	Entry of the programming level
2	10,0 %	XX	Entry of the set point [%] of relay 1
3	90,0 %	XX	Entry of the set point [%] of relay 2
1	0045	0245	Entry of the programming level
2	3,0 %	XX	Entry of the hysteresis [%] of relay 1
3	3,0 %	XX	Entry of the hysteresis [%] of relay 2
1	0245	0145	Entry of the programming level
2	1.0	 1.0 1.1	Entry of the fail-safe mode of relay 1 Minimum (default) Maximum
3	1.1	 1.0 1.1	Entry of the fail-safe mode of relay 2 Minimum Maximum (default)
0	XXXX		End

3.10. Programming matrix for density measurement

0	**Operating level**	**Basic settings**	**• Relay-functions**	**• Operation mode • calibration mode**	**1 point calibration**	**2 point calibration**	**• Conversion of the engineer-ring unit • Entry % concentration**	**Re-calibration**	
1	Code 0045	Code 0145	Code 0245	Code 0345	Code 0445	Code 0545	Code 0845	Code 0945	Code 1145 see Chapter 6
2	Setpoint relay 1 [%] **I0.0%**	Relay 1: safety mode 1.0 minimum 1.1 maximum safety **I.0**	Relay 1: hysteresis [%] **3.0%**	Mode 10: Density measurement **I0**	Start of the densitiy measurement range ρ_{min} [g/cm^3] **I.000**	Start of the density measurement range ρ_{min} [g/cm^3] **I.000**	Selection of the engineering unit 1: g/cm^3 2: solids content 3: % concen-tration **I**		
3	Setpoint relay 2 [%] **90.0%**	Relay 2: safety mode 1.0 minimum 1.1 maximum safety **I.I**	Relay 2: hysteresis [%] **3.0%**	Calibration mode 1: 1-point calibration 2: 2-point calibration **2**	End of the density measuring range ρ_{max} [g/cm^3] **2.000**	End of the density measuring range ρ_{max} [g/cm^3] **2.000**	Selection of the density unit Mass Volume 1 = g 01 = cm^3 2 = kg 02 = dm^3 3 = t 03 = m^3 4 = oz 04 = in^3 5 = lb 05 = ft^3	Mass Volume 6 = sh.cwt 06 =yd^3 7 = cwt 07 =f l. oz (GB) 8 = sh tn 08 =fl. oz (US) 9 = tn 09 = gal (GB) 10 = gal (US) Example: [g/cm^3]	**I.0I**
4	Pulserate for calibrating ρ_{min} [N/100 ms] **5000**	Isotope 0: Co 60 1: Cs 137 **I**	**9999**	Lock-/unlock code 045/4+6 1111: Unlock 9999: Lock **9999**	Linear absorption coefficient µ (calculated from 2-point calibration) **6.I54**	K-factor **I.000**	Density of the carrier fluid ρ [g/cm^3] **1.000**		
5	Actual pulse rate [N/100 ms] integrated **xxxx**	Current output 0: 0 ... 20 mA 1: 4 ... 20 mA **0**	**3**	Length of the radiation beam through the process fluid [mm] **200**	Absorption coeffiecient K x 1000 **I.000**	Selection of the calibration point 1: ρ_{low}/2: ρ_{high} From the 2 point calibration 31: $\rho_{cal} = \rho_{low}$ 32: $\rho_{cal} = \rho_{high}$ **I**	Density of the solid ρ [g/cm^3] **I.500**	Current measured value	
6	Pulse rate for calibrating ρ_{max} [N/100 ms] **4000**	Analogue output: during alarm 02: -10 % 12: 110 % 20: Hold 01: 0 % 11: 100 % 30: Continue **I2**		**0**	Actual pulse rate [N/100 ms] integrated, press >E< to calibrate **xxxx**	Actual pulse rate [N/100 ms] integrated, press >E< to calibrate **xxxx**	Actual measuring value, engin. unit as selected in level 0845 **xxxx**	Entry recalibration mode 0: manual 1: automatic	
7	Integration constant 0 ... 1000 s **60**	**200**	**I000**	Actual measuring value, engi-neering unit as selected in 0845 **xxxx**	Calibration pulse rate [N/100 ms] **xxxx**	Calibration pulse rate [N/100 ms] **xxxx**	Conversion table for % concentra-tion. Entry of table 1 ... 18 33: delete **I**	τ for recalibration	
8	**--**	**I200**	Simulation of the output signal –10 % ... 110 % **xx%**	Start of the measuring range of the analogue out-put, engineer-ing unit as selected in 0845 **xxxx**	Entry of the calibration density [g/cm^3] **I.500**	Entry of the calibration density [g/cm^3] **I.500**	Entry of the % concentra-tion value **0,00%**	Error code E 902 during recalibration 0: alarm off 1: alarm on (default)	
9	Error analysis: Display of the actual error code **E-**	Last error code, delete with >E< **Exxx**	Days of operation delete with >E< **xxxx**	End of the measuring range of the analogue out-put, engineer-ing unit as selected in 0845 **xxxx**	Selection of the calibration set X.1-X.3 set no. 1.X: Activate 2.X: Delete **I0**	Selection of the calibration set X.1-X.3 Set no. 1.X: Activate 2.X: Delete **I**	Entry of the corresponding density value [g/cm^3] **0**	———	

4. Mass flow

4.1. Introduction

4.1.1 Overview of the measurement configurations

FMG 573 Z/S	Mode 31	Mode 32
Input 1:	DG 57	DG 57
Input 2:	TSP 8267	TSP 8267
Relay 1:	Set point 1 or as a totaliser	Set point 1 or as a totaliser
Relay 2:	Set point 2 as a totalising or as a preset counter	Set point 2 as totalising or as a preset counter
Output:	Solids content (Mass flow content)	Mass flow (total)

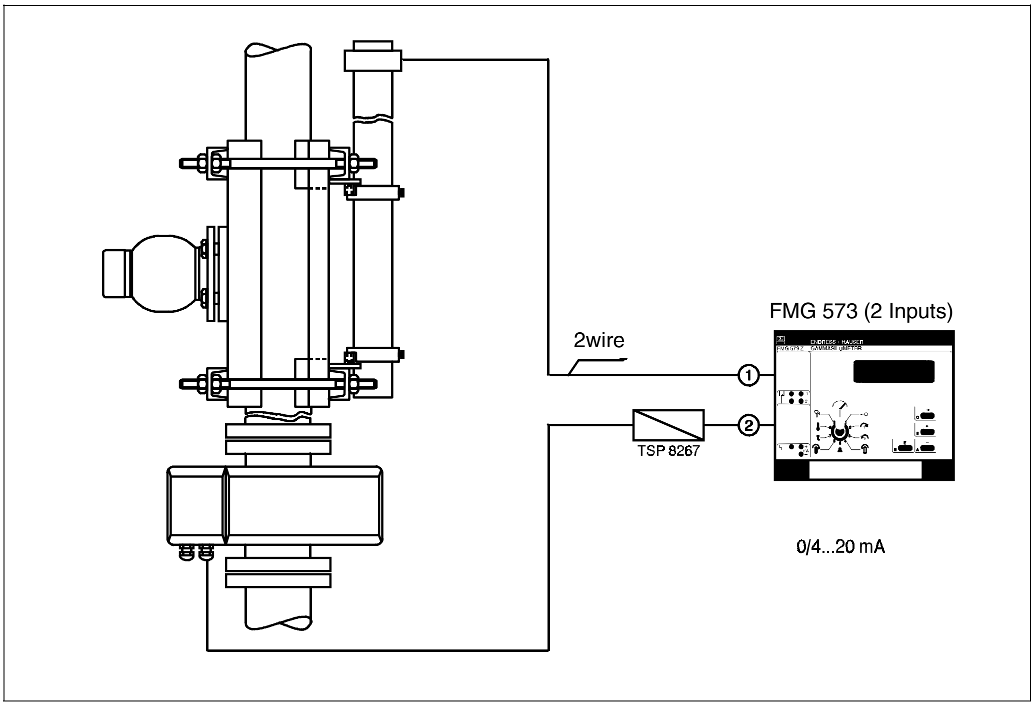


Fig. 4.1
Arrangement for mass flow measurement

4.1.2 Quick set up reference

4.2. Electrical connections

Important hint

Please observe, in addition to the following chapters of this manual, our planning instructions and the radiation protection laws relevant for your application;
Also, for applications in explosion hazardous areas observe the test certificates and observe the local explosion protection laws.

4.2.1 Installation of the transmitter FMG 573 Z/S

The FMG 573 Z/S is a 28 HP unit in 19“ technology. It can be mounted either in a RACKSYST rack or in a field housing (IP 65).

The female connector at the rack or at the field housing must comply with DIN 41612/style F. (For details, please observe the picture below).

The transmitter FMG 573 Z/S must be installed outside the explosion hazardous area.

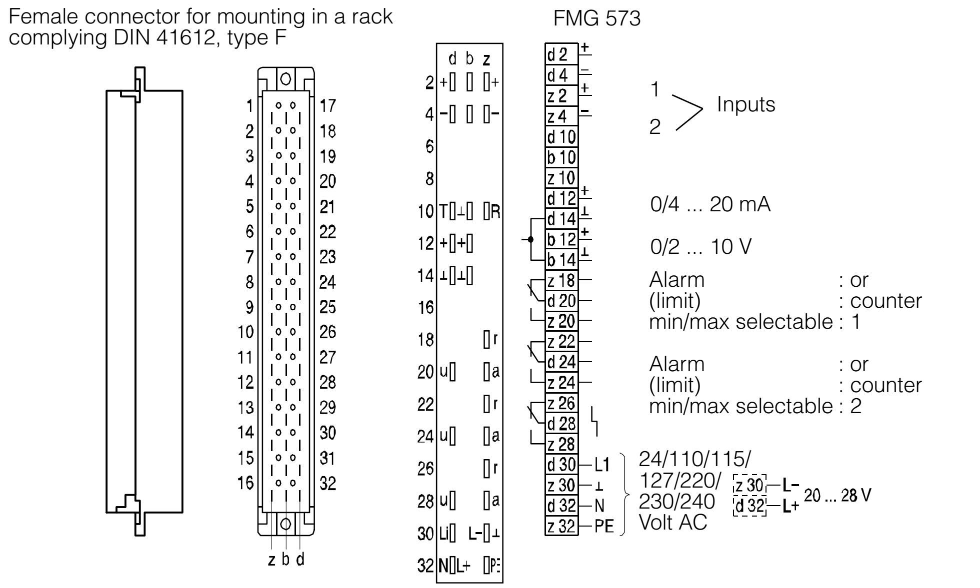


Fig. 4.2
Pin assignment and coding pins

Typical error codes

E401 No signal from the DG 57: Check the wiring and it’s polarity.

E402 No signal from the TSP 8267: Check the wiring and it’s polarity.

E901 The pulse rate is out of range. Normal indication during the first set up, when the unit is not yet fully calibrated.

4.2.2 Mounting of the PFM converter TSP 8267

This unit (4 pitch units,19“ technology) converts standart analogue signals (0/4 ... 20 mA or 0/2...10 V) into a special PFM signal used by Endress+Hauser with a frequency range of 200 ... 1200 Hz. It is installed next to the FMG 573 Z/S to convert the separate flow signal provided by an electromagnetic flow meter.

Note

The analogue inputs are not intrinsically safe. Necessary explosion protection devices must be installed in the flow meter or in the wiring

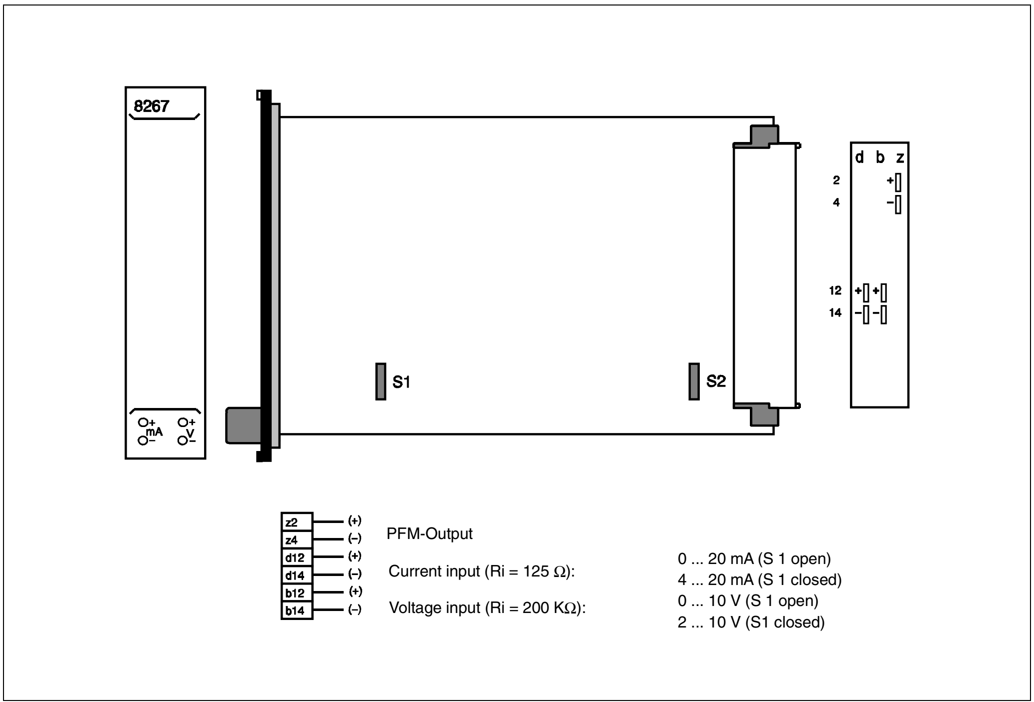


Fig. 4.3
TSP 8267
19" Racksyst card

4.2.3 Wiring for non-explosion hazardous applications

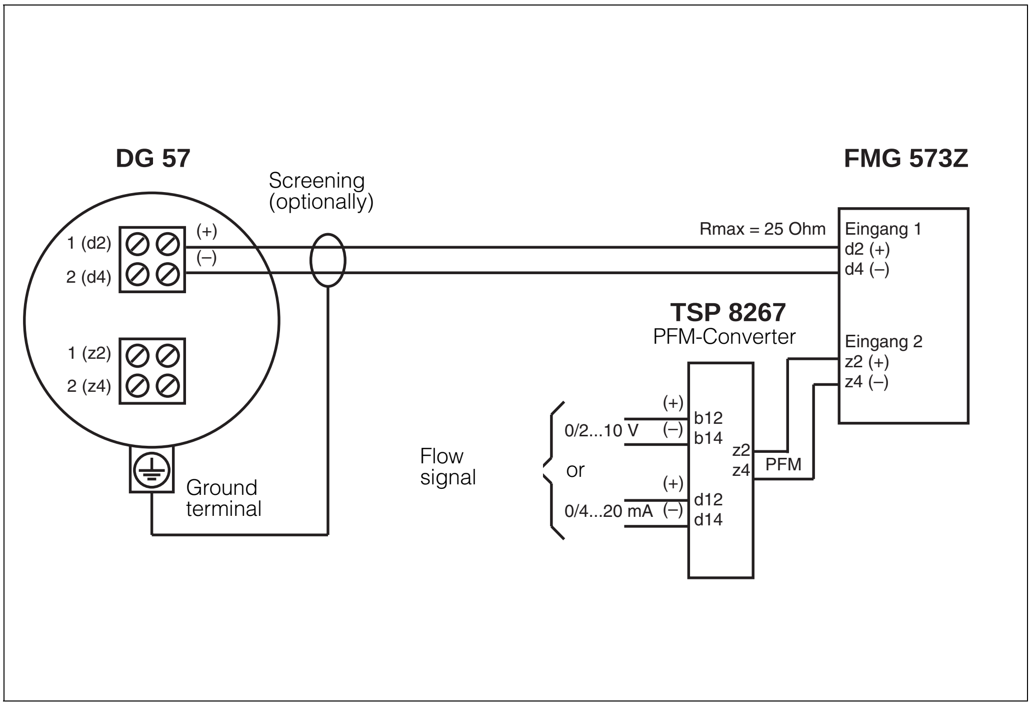


Fig. 4.4
Wiring in non-explosive hazardous areas

4.2.4 Explosion hazardous applications

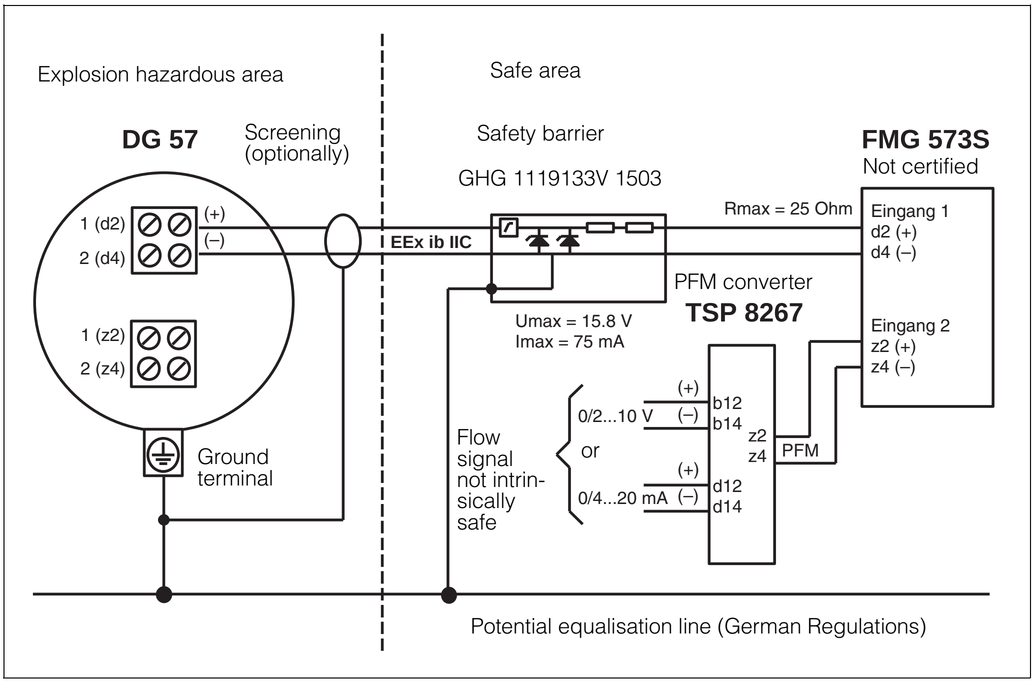


Fig. 4.5
Wiring in explosive hazardous areas EEx ib IIB/IIC

Wiring for areas according to IIB/T6 and IIC/T6

- Observe the instructions of the safety barrier and the PTB-certificates
- The intrinsically safe circuit of the safety barrier is connected to earth ground via the potential equalizing line or plant grounding system. Therefore the whole sensor wiring and the detector housing must be connected to the potential equalizing line.
- Check the maximum allowed capacitance and inductance values of the wiring according to the PTB-certificates

4.3. Calibration

4.3.1 General remarks

The radiometric mass flow measuring system requires a calibration during the process with medium applied. This is normally done by applying the process fluid as under process conditions. The actual density must be determined by a laboratory analysis and be entered separately.

- The calibration value is always entered in the unit [g/cm^3].
- As with any system that requires an in-line calibration, the possible accuracy depends directly on the quality of the laboratory analysis.
- Check that during the laboratory analysis the medium temperature is the same as the process temperature.

After calibration a calibration plate can be manufactured, which can then be used to check the calibration or recalibrate the system at a later date.

4.3.2 One point- or two point calibration

To achieve a highly reliable measurement, the two point calibration should be used. In this case, the FMG 573 Z/S calculates automatically the linear absorption coefficient (μ) from the calibration data.

- For reliable measurements, the difference between the two calibration values should be at least one third of the measuring range.

If this is difficult to achieve with the process fluid, water can be used for one calibration value.

Use a one point calibration for a quick start up, if only one density value can be calibrated initially.

- In this case, the correct linear absorbtion coefficient must be entered manually. Contact Endress+Hauser for the correct value of the linear absorption coefficient appliable for your application

The one point calibration provides a sufficient accuracy around the calibration value. This might be sufficient for controls but the slope of the calibration curve might be too steep or too shallow.

Later, during operation, the calibration can be upgraded with a second calibration point to achieve the best accuracy.

4.3.3 Calibration sets

Up to three different calibration sets can be programmed. This can be useful, if different products are to be measured in the same pipe.

- Example: Slurries with different carrier liquids and the same solids density - the output signal is ’solids content’ [mass/volume]. Depending of the calibration mode, each of the four sets consists of the following parameter:

1.) Two point calibration

- Density measuring range ρ_{min} and ρ_{max}
- Calibration densities (ρ_1, ρ_2) and the corresponding pulse rates (N_1, N_2)

2.) One point calibration

- Density measuring range ρ_{min} and ρ_{max}
- Linear absorption coefficient [μ]
- Calibration density and the corresponding pulse rate (ρ_1, N_1)

4.4. Programming the FMG 573 Z/S

The transmitter FMG 573 Z/S is delivered with certain default settings. The initial set up is done to check and possibly change the default parameters before starting the calibration procedure.

Software reset
In order that you do not have to check all the default settings, we recommend a sofware reset prior to the first set up. This ensures that accidental or unauthorised entries are reset to the original default values.

Caution:
If calibration was already performed and values had been entered into the FMG 573, these values will be lost by a software reset.

4.4.1 Software reset

Rotary switch	Display	Entry	Meaning
1	0	2607	Entry of the programming level
9	0	2607	With pressing ”E“ the software reset is performed. Default values are activated. E 204 is displayed and the alarm relay will switch. After a short while, the error code E 901 appears (normal indication, if the calibration is not yet fully completed)

4.4.2 Initial set up

Rotary switch	Display	Entry	Meaning
1	0	3500	Entry of the programming level (sensor data)
6	XXXX		The displayed sensor number must match with the sensor number of the DG 57 connected!
1	3500	0145	Entry of the programming level
4	1	 0 1	Selection of the isotope: this influences the decay compensation Co 60 Cs 137 (default)
5	0	 0 1	Selection of the analogue output 0 mA ... 20 mA/0 V ... 10 V (default) 4 mA...20 mA/2 V ... 10 V
6	12	 01 02 11 12 20 30	Selection of the analogue output during ‘alarm‘ Start of the display range, e.g. 4 mA/2 V (the values depend on the prior selection) – 10 % of the display range, e.g. 2,4 mA/1,2 V 20 mA/10 V 110 % of the display range, e.g. 21,6 mA/10,8 V (default) Hold the last value Continue, if possible
1	0145	0345	Entry of the next programming level
2	10	 31 32	Entry of the operation mode Solids content Mass flow
1 or 0			Proceeding with the calibration or end

Typical error codes

E901 The pulse rate is out of the measuring range.
Normal indication if the calibration is not yet completed.

4.4.3 Use of the calibration sets

Rotary switch	Display	Entry	Meaning
1	0	 0545 0445	Entry of the programming level Two point calibration One point calibration
9	XX	YZ	Meaning of the entry YZ Entry set 1 ... 4 blank: Unlocking of the selected set for modification 1: Activating of the selected set; Any modifications become valid now. 2: Delete (!) the selected set
9	XX	12	Example: Unlocking of the calibration set 2 for recalibration.
0			End

4.4.4 Displaying the actual density

Rotary switch	Display	Entry	Meaning
1	0	1045	Entry of the programming level
9	XXXX(X)		Actual density [g/cm^3]
0			End

4.4.5 Locking the access to the calibration data

Locking the access shall prevent changes of the calibration data by accidental or unauthorised alterations.

Rotary switch	Display	Entry	Meaning
1	0	0345	Entry of the programming level
3	X	9999 2 1	To lock the entry Activating the two point calibration Activating the one point calibration
0			End

4.4.6 Change of the output damping:

By increasing this parameter, the influence of the statistical variation is reduced.
The default value is 60s. Please observe the Chapter 1.4.2 for the physical influences.

Rotary switch	Display	Entry	Meaning
1	0	0045	Entry of the programming level
7	60	XX	Entry of the new output damping (1 ... 1000 s).
0			End

4.5. Two point calibration

Note

- The complete measuring line (DG 57, FMG 573 Z/S) must have been in operation for at least 6 hours with the radiation switched on and with product in the pipe.
- When the pipe is empty, switch off the radiation (leave system in operation)
- The integration time must be set to 60 s (default value)
- Make sure that the source holder is always fixed when in operation (refer to Chapter 2.3.3). Note all entered values as well as the date, the calibration values and the pulse rates.

Rotary-switch	Display	Entry	Meaning
1	0	0345	Entry of the programming level
2	X	10	Density measurement
3	X	2	Check if the calibration mode 'Two point calibration' is selected (default value)
5	200.0	XXX.X	Entry of the inner pipe diameter or the real length of the radiation path through the product.
1	0345	0545	Entry of the programming level
9	XX	1	Selection of the calibration set 1
2	1.000	X.XXX	Entry of the beginning of the density measuring range in [g/cm^3]; – If the output signal should be dry solids [Weight/Volume], enter the density of the carrier liquid [g/cm^3].
3	2.000	X.XXX	Entry of the end of the density measuring range in [g/cm^3]
Fill pipe with calibration fluid of density ρ_1 (lower density value): wait at least 5 min.			
5	1	1	Selection of lower calibration point: density ρ_1
6	XXXX(X)	ENTER	Current pulse rate [N/100 ms]. Press ENTER to store
7	XXXX		Check stored pulse rate [N/100 ms]
8	0.0000	XXXX(X)	Enter density of calibration liquid [g/cm^3].
Fill pipe with calibration fluid of density ρ_2 (upper density value): wait at least 5 min.			
5	1	2	Selection of upper calibration point: density ρ_2
6	XXXX(X)	ENTER	Current pulse rate [N/100 ms] Press ENTER to store
7	XXXX		Check stored pulse rate [N/100 ms]
8	0.0000	XXXX(X)	Enter density of calibration liquid [g/cm^3].
9	1	11	Active calibration set no. 1
0			End

Typical error codes

E820 ρ_{min} **>** ρ_{max} – enter the correct values in switch position No. 2 and No. 3
or The calibration densities ρ_1 and/or ρ_2 are out of the entered measuring range, which is defined by ρ_1 and ρ_2.

E821 The calibrated density value ρ_1/ρ_2 or the pulse rate N1/N2 is = 0, or the calibration density ρ_1 is bigger then ρ_2 – correct the values in switch position No. 5, No. 7 and No. 8

E901 The pulse rate is out of the defined measuring range: Check, if ρ_{min} and ρ_{max} are entered correctly or the pipe is empty or only partly filled.

4.5.1 Production of a calibration plate

A steel calibration plate (for thickness contact E+H) is placed in the beam between the source container and pipe. This simulates a density increase in the fluid flowing through the pipe. The equivalent density value is noted and stamped on the plate.

Rotary-switch	Display	Entry	Meaning
If possible, fill the pipe with calibration fluid with the low density value (ρ_1) Switch off radiation, insert steel plate, switch on radiation and wait at least five minutes			
0	X.XXXX		Note displayed density value to 4th decimal point (press ⇒ to display to this resolution)
1	0	0345	Entry of programming level
3	XXXX	1	Selection of one point calibation
1	X.XXXX	0445	Entry of programming level
9	XX	1	Selection of the calibration set no. 1
6	XXXX(X)	ENTER	Current pulse rate [N/100ms] Press ENTER to store
7	XXXX		Check stored pulse rate [N/100 ms]
8	0.0000	X.XXX(X)	Entry of the noted density [g/cm^3]
9	1	11	Activate the calibration set No. 1
0			End
Switch off radiation, remove steel plate, switch on radiation and wait at least five minutes			

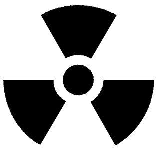
4.5.2 Automatic recalibration using calibration plate

A periodic recalibration of the system is recommended in oder to compensate any measuring errors which may occur due to wear of or build-up in the pipe. The measuring conditions of the initial plate calibration must be reproduced. The system must have been operating for at least an hour before calibration.

Rotary-switch	Display	Entry	Meaning
Fill the pipe with the calibration fluid used to produce the calibration plate			
1	X.XXXX	0945	Entry of programming level
6	X.XXXX	1	Entry of calibration mode: 1 = automatic*
1	X.XXXX	0445	Entry of programming level
8	X.XXXX		Check that calibration plate value is displayed – if not, enter as follows
9	XX	1	Selection of the calibration set no. 1
8	0.0000	X.XXX(X)	Entry of the density on plate [g/cm^3]
9	1	11	Activate the calibration set no. 1
Switch off radiation, insert steel plate, switch on radiation and wait at least five minutes			
Short-circuit connections z10 and b10 for at least one second The recalibration starts automatically and lasts about 10 minutes, during which time the error message E 902 is displayed			
Switch off radiation, remove steel plate, switch on radiation and wait at least five minutes			

*For procedure with manual start of the recalibration see Section 6.1.1.

4.6. One point calibration



Note

- The complete measuring line (DG 57, FMG 573 Z/S) must have been in operation for at least 6 hours with the source container switched on and with product in the pipe.
- When the pipe is empty, switch off the radiation (leave system in operation)
- The integration time must be set to 60 s (default value)
- Make sure that the source holder is always fixed when in operation (refer to Chapter 2.3.3). Note all entered values as well as the date, the calibration values and the pulse rates.

Rotary switch	Display	Entry	Meaning
1	0	0345	Entry of the programming level
3	2	1	Selection of the one point calibration mode
5	200.0	XXX.X	Entry of the inner pipe diameter or the real length of the radiation path [mm] through the process fluid. **Note:** This value must be entered exactly. It directly influences the calculation of the absorbtion.
1	0	0445	Entry of the programming level
9	1	1	Selection of the calibration set no.1
2	1.000	X.XXX	– Entry of the beginning of the density measuring range [g/cm^3]. – If the analogue signal shall be solids content (mass/volume), entry of the density of the carrier liquid [g/cm^3].
3	2.000	X.XXX	Entry of the end of the density measuring range [g/cm^3]
4	6.154	XXXX	Entry of the linear absorbtion coefficient [μ]
6	XXXX(X)		Actual pulse rate [N/100 ms] **Procedure** 1. Fill the pipe with the calibration fluid. 2. Wait for at least 5 minutes, before you read out the pulse rate. 3. As soon as the pulse rate remains reasonably constant, store it by pressing the Enter button.
7	XXXX		Display of the stored pulse rate [N/100 ms]
8	1.500	X.XXX(X)	Entry of the density value of the applied calibration fluid [g/cm^3]
9	1	11	Activation of the calibration set no. 1
0			End

4.7. Upgrade of a one-point to a two-point calibration

Rotary switch	Display	Entry	Meaning
1	0	0345	Entry of the programming level
3	1	2	Selection of the two point calibration mode
1	0345	0545	Entry of the programming level
9	11	1	Modification of the calibration set no.1
5	1	 31 32 1 2	1. Transformation of the calibration data (density and pulse rate) from the one point calibration: * The value of the one point calibration will be used as ρ_1: lower calibration density * The value of the one point calibration will be used as ρ_2: higher calibration density. Confirm by pressing the Enter button 2. Selection of the second calibration value depending on the prior entry ρ_1 = lower calibration density (if 32 was selected) ρ_2 = higher calibration density (if 31 was selected)
6	XXXX(X)		Actual pulse rate [N/100 ms] **Procedure** 1. Fill the pipe with the calibration fluid 2. Wait for at least 5 minutes before you read out the pulse rate 3. As soon as the pulse rate remains reasonably constant, store it by pressing the Enter button.
7	XXXX		Display of the stored pulse rate [N/100 ms]
8	X.XXX(X)	X.XXX(X)	Entry of the density value of the applied calibration fluid [g/cm^3]
9	1	11	Activating the calibration set no.1
0		11	End

Typical error codes

E801 $\rho_{min} > \rho_{max}$ – Enter the correct values in switch position 2 and 3. (0445 or 0545)

E810 The calibration density of the one point calibration is out of the range defined by ρ_{min} and ρ_{max}.

E901 Pulse rate is out of the display range: Check, if ρ_{min} and ρ_{max} are entered correctly or the pipe is empty or only partly filled.

4.8. Entry of the flow rate

The flow rate signal (0/4 ... 20 mA or 0/2 ... 10 V) of the magnetic flowmeter is converted into a PFM frequency signal of 200 ... 1200 Hz (by the converter TSP 8267). The corresponding flow rate for 20 mA/10 V must be entered into the FMG 573 Z/S.

Caution: This value must be entered with the units cm^3/s, usually a conversion from the original unit is required.

The measuring value of the flow rate must be divided into:

- the mantissa (1 ... 9999) in level 1045/switch position 3
- the exponent (– 9 ... + 9) in level 1045/switch position 4

The maximum flow rate is to be entered as described below:

[Level 1045/switch position 3] * [Level 1045/switch position 4].

Example:

Maximum flow rate is 15 m^3/h.

1.) $15\ m^3/h \times \frac{1000000\ [cm^3/m^3]}{3600\ [s/h]} = 4167\ cm^3/s$

2.) Values to be entered: mantissa = 4167, exponent = 0

Rotary switch	Display	Entry	Meaning
1	0	1045	Entry of the programming level
2	3.3	3.3	Entry of the original unit of the flow signal: X.X 01 = cm^3 1 = seconds [s] 02 = dm^3 2 = minutes [min] 03 = m^3 3 = hours [h] 04 = in^3 4 = days [d] 05 = ft^3 06 = $yard^3$ (GB) 07 = fluid ounce (GB) 08 = fluid ounce (US) 09 = Gallon (GB) 10 = Gallon (US) **Example: m^3/h**
3	9999	4167	Entry of the mantissa of the maximum flow rate [cm^3/s] **Example:** 4167×10^0 [cm^3/s]
4	1	0	Entry of the exponent of the maximum flow rate [cm^3/s] **Example:** 4167×10^0 [cm^3/s]
5	XXXX		Actual flow rate: Display with the original unit • Technical units are displayed in switch position 2 Example: [m^3/h]
0			End

4.9. Selection of the analogue output signal

4.9.1 Code 31 / solids content

The FMG 573 Z/S uses the units for calculation of the solids content [g/cm³] and [cm³/s].For slurries with a defined density of the carrier liquid and a defined solids density, the formula below is applied:

Flow rate [cm³/s] x density of the solids [g/cm³] = solids content [g/s]

where as the

$$\text{solids density } [g/cm^3] = \frac{\rho - \rho_{carrier}}{1 - \frac{\rho_{carrier}}{\rho_{solids}}}$$

Depending on the application, the industry branch or the country, the internal measuring unit [g/s] can be converted into the common international units, e.g. [t/h].

Selection of the measuring range

The maximum value of the analogue output [20 mA/10 V] is internally calculated with the following formula:

Maximum flow rate [cm³/s] x maximum solids density [g/cm³] = maximum solids content [g/s]

To select the measuring range, „ρ_{max}“, which defines the value of the maximum solids content, must be calculated.

Example
- Measuring value: 0 ... 12 t/h = 0/4 ... 20 mA
- Maximum flow rate: 20 m³/h
- $\rho_{carrier}$: 1.25 g/cm³
- ρ_{solids}: 6.80 g/cm³

Procedure

1.) Conversion of the required measuring value from [t/h] into the unit [g/s]:

$$12\,[t/h] \times \frac{1000000\,[g/t]}{3600\,[s/h]} = 3333\,[g/s]$$

2.) Conversion of the maximum flow rate [m³/h] into the unit [cm³/s]

$$20\,[m^3/h] \times \frac{1000000\,[cm^3/m^3]}{3600\,[s/h]} = 5556\,[cm^3/s]$$

3.) Calculate:

$$\text{Maximum solids content} = \frac{\text{Maximum mass flow}}{\text{Maximum flow rate}} = \frac{3333\,[g/s]}{5556\,[cm^3/s]} = 0{,}5999\,[g/cm^3]$$

4.) Calculate the maximum density (solids content and carrier liquid):

$$\rho_{max} = \text{Maximum solids content} \times \left(1 - \frac{\rho_{carrier}}{\rho_{solids}}\right) + \rho_{carrier}$$

Short procedure:

If the measuring value is in [t/h] and the flow signal is in the unit [m³/h], the following formula can be used:

$$\rho_{max} = \frac{\text{Maximum mass flow rate } [t/h]}{\text{Maximum Flow rate } [m^3/h]} \times \left(1 - \frac{\rho_{carrier}\,[g/cm^3]}{\rho_{solids}\,[g/cm^3]}\right) + \rho_{carrier}\,[g/cm^3]$$

5.) Please observe the procedure overleaf for entering these values:

Rotary switch	Display	Entry	Meaning
1	0	0345	Entry of the programming level
2	XX	31	Select mode 31 ”solids content“
3	X		Check the selected calibration mode 1: One point- / 2: Two point calibration mode
1	0345		Depending on the prior check or the selected calibration mode, the corresponding programming level gets selected: 0445: One point calibration 0545: Two point calibration
9	11	1	Selection of the calibration set ’no.1’ for modification
2	XXXX	1.250	Check, if the correct value for $\rho_{carrier}$ is entered; this value can only be modified in the calibration modes ’One’ or ’Two point calibration’ Example 1.250 g/cm^3
3	XXXX	1.740	Entry of ρ_{max} to define the analogue output Example: 1,739 [g/cm^3]
9	1	11	Activation of the calibration set ’no.1’
1	0	1045	Entry of the programming level
2	3.3	31 3.3	Entry of the original measuring unit for the flow measurement Volume-unit / Time unit 1 cm^3 / 1 s = Seconds [s] 2 dm^3 / 2 min = Minutes [min] 3 m^3 / 3 h = Hours [h] 4 in^3 / 4 d = Days [d] 5 ft^3 6 yd^3 (GB) 8 fl.oz (US) 7 fl.oz (GB) 9 Gal (GB) 10 Gal (US) Example – m^3/h (e.g. 20 m^3/h)
			The entry of the Maximum flow rate must be divided and be entered as : Mantissa (1045/3) and as exponent (1045/4)
3	9999	5556	Entry of the value of the mantissa of the Maximum flow rate [cm^3/s] Example: 5556 x 10^0 [cm^3/s]
4	1	0	Entry of the exponent of the maximum flow rate [cm^3/s] Example: 5556 x 10^0 [cm^3/s]

Rotary switch	Display	Entry	Meaning
6	3.3	3.3	Entry of the unit of solids content [mass/time unit] 1 = g 1 = Seconds [s] 2 = kg 2 = Minutes [min] 3 = t 3 = Hours [h] 4 = oz 4 = Days [d] 5 = lb 6 = sh cwt 7 = cwt 8 = sh tn 9 = tn **Example: [t/h]**
8	1.500	6.800	Entry of the solids density „ρ_{solids} [g/cm^3]“ **Example:** 6,800 [g/cm^3]
0			End

4.9.2 Mode 32; Mass flow rate

The FMG 573 Z/S uses the units [g/cm^3] and [cm^3/s] for the calculation of the mass flow rate [g/s]. For all slurries and liquids, the mass flow rate is calculated with the following formula:
Flow rate [cm^3/s] x Density [g/cm^3] = Mass flow rate [g/s]
Depending on the application, the industrial branch and the country, the internal unit [g/s] can be converted into the usual international engineering units, e.g. [t/h].

Definition of the measuring range

The corresponding maximum value of the analogue output (20 mA/10 V) is internally calculated with the formula:
Maximum flow rate [cm^3/s] x Maximum density [g/cm^3] = ρ_{max} Mass flow [g/s^3].
To define the measuring range, the maximum density [g/cm^3] must be calculated:

Example

- Measuring value/Output signal: 0 ... 18 t/h = 0/4 ... 20 mA
- Maximum flow rate: 8 m^3/h
- Minimum density: ρ_{min} = 1,0 [g/cm^3]

Procedure

1.) Convert the required display reading from the original unit, e.g. [t/h], into the unit [g/cm^3]:

$$18\ \mathrm{t/h} \times \frac{1000000\ [\mathrm{g/t}]}{3600\ [\mathrm{s/h}]} = 5000\ [\mathrm{g/s}]$$

2.) Convert the signal of the maximum flow rate from the original unit e.g. [m^3/h], into the unit [cm^3/s]:

$$8\ \mathrm{m^3/h} \times \frac{1000000\ [\mathrm{cm^3/m^3}]}{3600\ [\mathrm{s/h}]} = 2222\ [\mathrm{cm^3/s}]$$

3.) Calculate the maximum density:

$$\text{Max. Density} = \frac{\text{Max. mass flow rate.}}{\text{Max. flow rate}} = \frac{5000\ [\mathrm{g/s}]}{2222\ [\mathrm{cm^3/s}]} = 2{,}25\ [\mathrm{g/cm^3}]$$

Short procedure: only if the output signal is [t/h] and the flow rate is measured in [m^3/h]

$$\text{Max. density} = \frac{\text{Max. mass flow rate}\ [\mathrm{t/h}]}{\text{Max. flow rate}\ [\mathrm{m^3/h}]}$$

4.) Entry of the values:

Rotary switch	Display	Entry	Meaning
1	0	0345	Entry of the programming level
2	XX	32	Entry of the mode
3	X		Check the selected calibration mode: 1: One point calibration / 2: Two point calibration
1	0345	 0445 0545	Entry of the programming level, depending on the calibration mode: One point calibration Two point calibration
9	11	1	Selection of the calibration set no.1 for modification
2	X.XXX	1.000	Entry of the minimum density ρ_{min} [g/cm^3]
3	XXXX	 2.250	Entry of the calculated ρ_{max} value to define the end of the measuring range of the analogue output Example: 2.250 [g/cm^3]
9	1	11	Confirmation of the calibration set no.1
1	0	1045	Entry of the programming level
2	3.3	3.3	Entry of the original unit of the flow rate measurement Volume unit / time unit 1 cm^3 — 1 = Seconds [s] 2 dm^3 — 2 = Minutes [min] 3 m^3 — 3 = Hours [h] 4 in^3 — 4 = Days [d] 5 ft^3 6 yd^3 (GB) 7 fl.oz (GB) 8 fl.oz (US) 9 Gal (GB) 10 Gal (US) Example – m^3/h (e.g. 8 m^3/h)
			The entry of the maximum flow rate must be devided and be entered as: mantissa (1045/3) and as exponent (1045/4)
3	9999	 2222	Entry of the value of the mantissa of the maximum flow rate [cm^3/s] Example: 2222 x 10^0 [cm^3/s]
4	1	 0	Entry of the exponent of the maximum flow rate [cm^3/s] Example: 2222 x 10^0 [cm^3/s]
6	3.3	3.3	Entry of the unit of the mass content: 1 = g — 1 = Seconds [s] 2 = kg — 2 = Minutes [min] 3 = t — 3 = Hours [h] 4 = oz — 4 = Days [d] 5 = lb 6 = sh cwt 7 = cwt 8 = sh tn 9 = tn Example: [t/h]
0			End

4.10. Relay set points / Counter functions

The FMG 573 Z/S features two independent relay outputs.

They operate depending on the programmed settings either as

- totaliser (see Chapter 4.10.2) or as
- two limit switches (see Chapter 4.10.3).

4.10.1 Totaliser function

The FMG 573 Z/S can perform a totaliser function. Therefore it features an internal totalising counter and two relay contacts:

Relay No.1 is directly operated by the internal totalising counter.

Depending on the programmable weighting factor 1 ... 9999 and the selected technical unit, a pulse [50 ms] is released.

Additionally a suppression of the creeping quantity in [%] can be selected in (level 0245/switch position 2). The default value is 3 %.

Relay No. 2, it's function depends on the selected mode 0 ... 3 :

Mode 0

1.) The internal totaliser counts up to a prior programmed value

2.) As soon as this value is reached, relay No.2 will give a pulse and the totaliser will be reset to zero and the counting procedure will be started again.

3.) A new counting process will be started, if during the display of the totaliser before reaching the preset value, the „E“-Enter button is pressed.

Mode 1

1.) Relay No. 2 switches and stays switched as soon as the programmed value is reached.

2.) The totaliser continues adding.

3.) A new counting procedure (reseting to ’0’) is initiated by pressing the ”E“-Entry button. Display of the totaliser in level 0245/switch position 7.

Mode 2

1.) The totaliser counts until the preset value is reached.

2.) Relay 2 switches, and stays switched, as soon as this value is reached, and the totalising is stopped.

3.) A new counting sequence (resetting to ‘0‘) is started when displaying the totaliser (level 0245/switch position 7) by pressing of the “E“-Enter button.

Mode 3

1.) The counter counts continuously.

2.) Relay 2 switches each time the totaliser reaches the preset value.

$$\text{Relay 2} = \frac{\text{counter (relay 1)}}{\text{preset value}}$$

3.) The totaliser is reset to zero, if the ”E“-enter button is pressed while the totaliser is on display.

a) Settings for the totaliser functions

Rotary switch	Display	Entry	Meaning
1	0	0145	Entry of the programming level
2	1.0	X.X 2.0 2.1 2.2 2.3	Enter the number of the mode for relay 1 and relay 2, as described above: Mode 0 Mode 1 Mode 2 Mode 3
1	0145	0245	Entry of the programming level
2	3.0 %	X.X	Entry of the suppression of creeping quantity [in % of the maximum mass flow rate]
4	9999	XXXX	Entry of the pulse value for the totaliser/relay 1
5	3	X	Entry of the enineering unit for the totaliser 1 = [g] 2 = [kg] 3 = [t] (default value) 4 = [oz] 5 = [lb] 6 = [sh cwt] 7 = [cwt] 8 = [sh tn] 9 = [tn]
7	1000	XXXX	Entry of the preset value (for relay 2)
0			End

b) Display/reset of the totaliser

Rotary switch	Display	Entry	Meaning
1	0	0245	Entry of the programming level
6	XXXX		Display of the totaliser, reset by pressing the ”E“-enter button
0			End

4.10.2 Limit switch function

The relays may also be programmed as limit switches.

The switching behaviour of each relay is defined by three parameters:

1.) Set point:
0 ... 100 % related to the output measuring range

2.) Hysteresis:
0 ... 100 %; for a two point control with one relay, this value defines the on/off cycle.

3.) Fail safe modes: minimum- or maximum safety;
This determines the use of the relay:
• Minimum as low value alarm
• Maximum as high value alarm
This setting also defines whether the hysteresis is added to or deducted from the actual set point

Default values

	Set point	Hysteresis	Fail safe mode
Relay 1:	10 %	3 %	Minimum
Relay 2:	90 %	3 %	Maximum

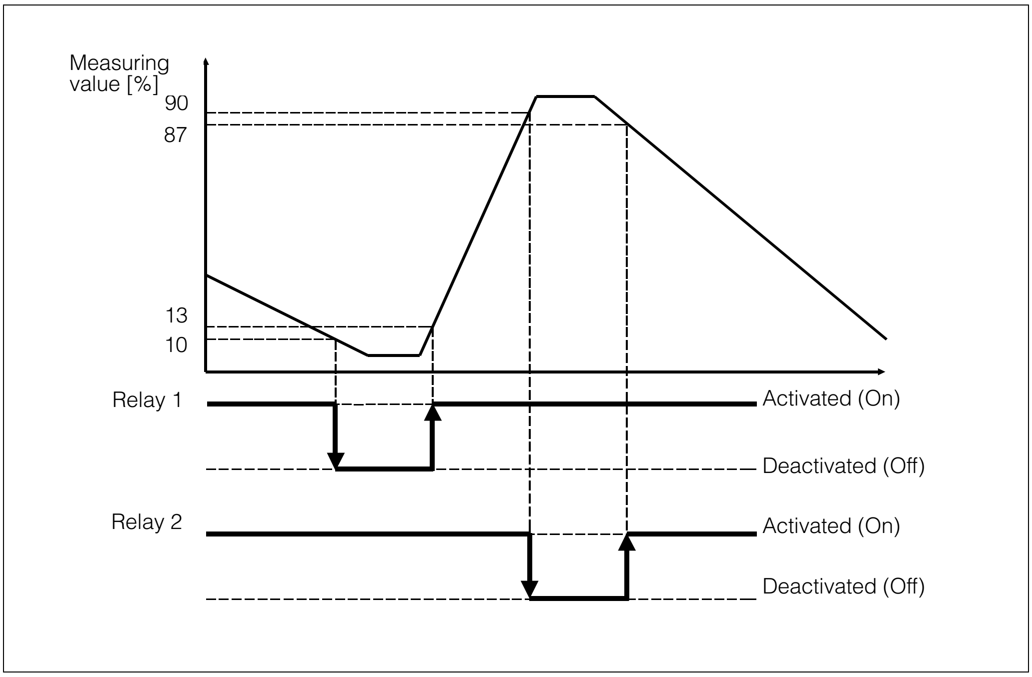


Fig. 1.1
Minimum and maximum fail-safe mode

Procedure

Rotary switch	Display	Entry	Meaning
1	0	0045	Entry of the programming level
2	10.0 %	XX	Entry of the set point in [%] of relay 1
3	90.0 %	XX	Entry of the set point in [%] of relay 2
1	0045	0245	Entry of the programming level
2	3.0 %	XX	Entry of the hysteresis in [%] of relay 1
3	3.0 %	XX	Entry of the hysteresis in [%] of relay 2
1	0245	0145	Entry of the programming level
2	1.0	 1.0 1.1	Entry of the fail safe mode of relay 1 Minimum (default value) Maximum
3	1.1	 1.0 1.1	Entry of the fail safe mode of relay 2 Minimum Maximum (Default value)
0	XXXX		End

4.11. Programming matrix mass flow

0	**Operating level**	**Basic settings**	**• Relay functions • Totaliser**	**• Operation mode • Calibration mode**	**1-point calibration**	**2-point calibration**	**Re-calibration**	**Operation with measure-ment mode 31 and 32**	**Service**
1	Code 0045	Code 0145	Code 0245	Code 0345	Code 0445	Code 0545	Code 0945	Code 1045	Code 1145 see Chapter 6
2	Switchpoint relay 1 [%] **I0.0**	Relay 1: safety mode 1.0 minimum safety 1.1 maximum safety **I.0**	Relay 1: hysteresis [%] or creeping quantity supression [%] **3.0**	Operation mode 31 Solids content 32 Massflow **I0**	Start of the density measuring range ρ_{min} [g/cm^3] **I.000**	Start of the density measuring range ρ_{min} [g/cm^3] **I.000**		01 = cm^3 02 = dm^3 03 = m^3 04 = inch^3 05 = ft^3 06 = y^3 (GB) 07 = fl.oz (GB) 08 = fl.oz US 09 = Gal. (GB) 10 = Gal. (US) 1 = second 2 = minute 3 = hour 4 = day **3.3**	
3	Switchpoint Relay 2 [%] **90,0**	Relay 2: safety mode 1.0 minimum safety 1.1 maximum safety **I.I**	Relay 2: hysteresis [%] if used as a set point **3.0**	Calibration mode 1: 1 point calibration 2: 2 point calibration **2**	End of the density measuring range ρ_{max} [g/cm^3] **2.000**	End of the density measuring range ρ_{max} [g/cm^3] **2.000**		Maximum flow rate [cm^3/s] Entry of the mantissa **0**	
4	Higher calibration pulse rate [N/100 ms] at ρ_{min} **5.000**	Isotope: 0: Co 60 1: Cs 137 **I**	Pulse value for the totaliser mode **9999**	Lock-/unlock Code 0045 4+ 6 1111: Unlock 9999: Lock **9999**	Linear absorp-tion coefficient µ: (calculated from 2-point calibration) **6.154**	K-factor **I.000**		Maximum flow rate [cm^3/s] Entry of the exponent **0**	
5	Actual pulse rate [N/100 ms] integrated **xxxx**	Current output 0: 0 ... 20 mA 1: 4 ... 20 mA **0**	Engineering unit of the totaliser 1: g 6: sh cwt 2: kg 7: cwt 3: t 8: sh tn 4: oz 9:tn 5: tb **3**	Length of the radiation beam through the process fluid [mm] **200**	Absorption coefficient K x 1000 **I.000**	Selection of the calibration point 1: ρ_{low} 2: ρ_{high} 31: $\rho_{cal}=\rho_{low}$ 32: $\rho_{cal}=\rho_{high}$ **I**	Current measured value	Actual flow rate Display of the mantissa **xx**	
6	Lower calibration pulse rate [N/100 ms] at ρ_{max} **4.000**	Analogue output during alarm 02: - 10% 12: 110% 20: Hold 30: Continue 11: 100 % 01: 0 % **I2**	Totaliser Relay 1 only for the totaliser mode >E< resetting to 0 **0**		Actual pulse rate [N/100 ms] integrated, press >E< to calibrate **xxxx**	Actual pulse rate [N/100 ms] integrated, press >E< to calibrate **xxxx**	Entry recalibration mode 0 = manual 1 = automatic	Unit of the mass flow 1 = g 2 = kg 3 = t 4 = oz 5 = lb 6 = sh cwt 7 = cwt 8 = sh tn 9 = tn 1 = second 2 = minute 3 = hour 4 = day **3.3**	
7	Integration constant 0 ... 1000 s **60**	Frequency for the start of the measuring range of input 2 ≙ 0/4 mA **200**	Preset value for relay 2 Only totaliser mode **I.000**	Actual measuring value, engineering unit as selected in 1045/6 **xxxx**	Calibration pulse rate [N/100 ms] **xxxx**	Calibration pulse rate [N/100 ms] **xxxx**	τ for recalibration	Density of the carrier fluid $\rho_{carrier}$ [g/cm^3] **I.000**	
8	**xx**	Frequency for the end of the measuring range of input 2 ≙ 20 mA **I200**	Simulation of the output signal – 10 %...110 % **xx**	Start of the measuring ran-ge of the ana-logue output, engineering units as selec-ted in 1045/6 **xxxx**	Entry of the calibration density, the engineering unit is always [g/cm^3] **I.500**	Entry of the Calibration density, the engineering unit is always [g/cm^3] **I.500**	Error code E 902 during recalibration 0: alarm off 1: alarm on default	Density of the solid ρ_{solid} [g/cm^3] **I.500**	
9	Error analysis Display of the actual error code **E-**	Last error code delete with >E< **Exxx**	Days of operation delete with >E< **xxxx**	End of the measuring range of the analoque output, unit as selected in 1045/6 **xxxx**	Selection of the calibration set 0.1-0.3 Set no. 1.X Activate 2.X Delete **I**	Selection of the calibration set X.1-X.3 Set no. 1.X Activate 2.X Delete **I**	————	Actual density value, non-compensated [g/cm^3] **xxxx**	

5. Density, temperature-compensated

5.1. Introduction

5.1.1 Overview of the configuration

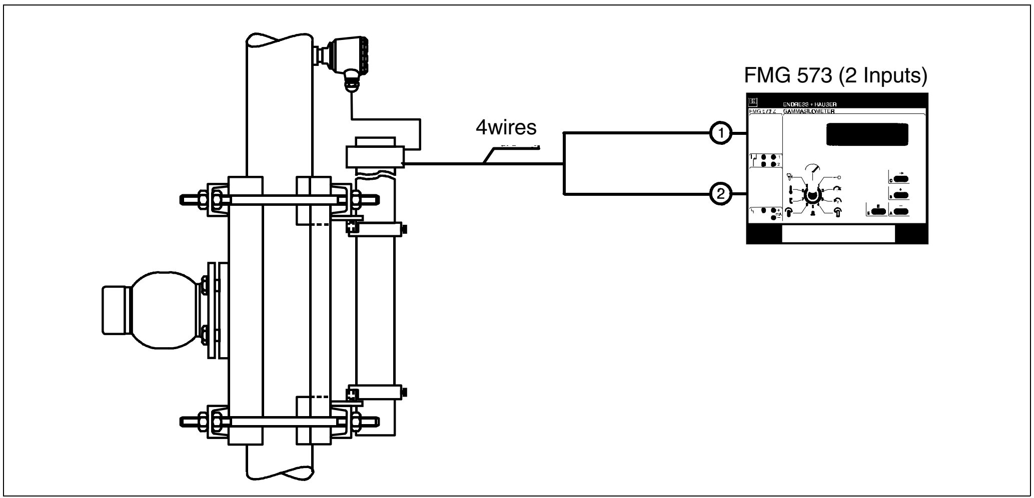


Fig. 5.1
Arrangement for temperature compensated density measurement with sensor TMT 2130 Z

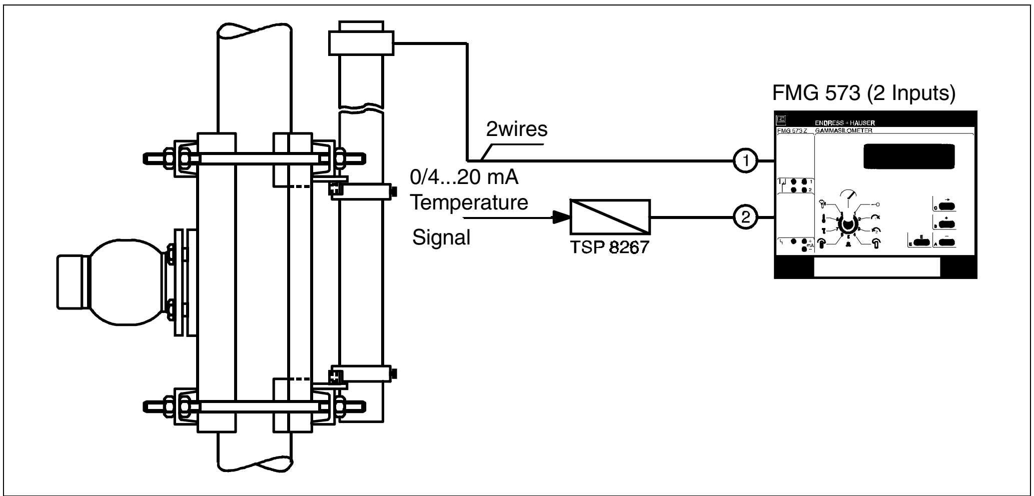


Fig. 5.2
Arrangement for temperature compensated density measurement with 4...20 mA Temperature signal and TSP 8267 converter

5.1.2 Reference for a quick set up

	Chapter	Page
1. Electrical connections:	5.2	68
2. Initial settings of the FMG 573 Z/S:	5.4	74
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• %concentration temperature compensated	5.11	87
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5.2. Electrical connections

Important hint

Please observe, in addition to the following chapters of this manual, our planning instructions and the radiation protection laws relevant for your application; and also, for application in explosion hazardous areas, observe the test certificates and the local explosion protection laws.

5.2.1 Installation of the transmitter FMG 573 Z/S

The FMG 573 Z/S is a 28 pitch wide unit in 19“ technology. It can be mounted either in a 19“ Racksyst rack or in a field housing (IP65). The female connector of the rack or of the field housing must comply with DIN 41612, type F.

The transmitter FMG 573 Z/S must be installed outside the explosion hazardous areas.

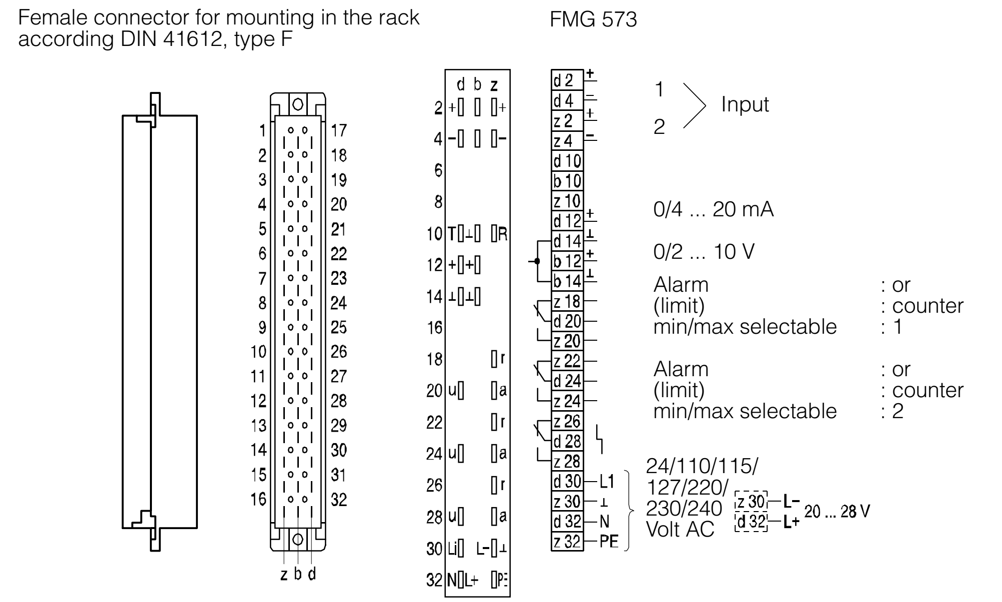


Fig. 5.3
Pin assignment and coding pins

Typical error codes

E401 No signal from the DG 57:
Check the wiring and its polarity.

E402 No signal from the TSP 8267 or the TMT 2530 Z:
Check the wiring and it’s polarity.

E901 Pulse rate is out of the measuring range:
normal indication, when the measuring line is not yet fully calibrated.

5.2.2 Installation of the PFM converter TSP 8267 (PFM: pulse frequency modulation)

This converter with 4 pitch width in 19“ technology converts common analogue signals (0/4...20 mA or 0/2...10 V) into the Endress+Hauser specific PFM-signal with a frequency of 200 ...1200 Hz. It can be installed beside the FMG 573 Z/S

Note

The analogue inputs are not intrinsically safe.
A barrier will therefore be required for Ex applications.

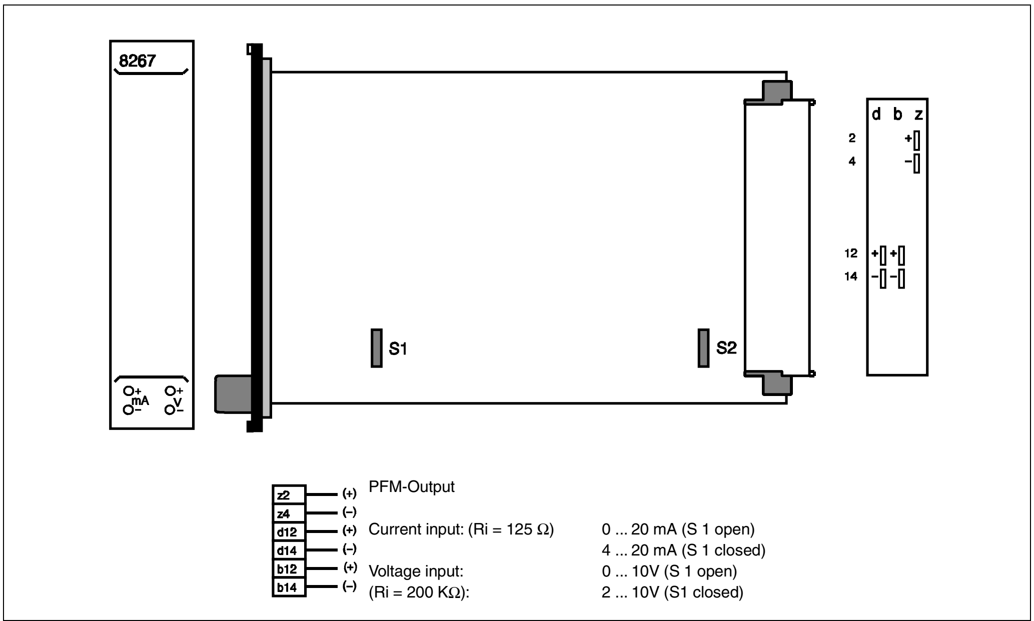


Fig. 5.4
TSP 8267
19" Racksyst card

5.2.3 Wiring in non-explosion hazardous areas

a) Temperature measurement with the probe TMT 2530 Z of Endress+Hauser

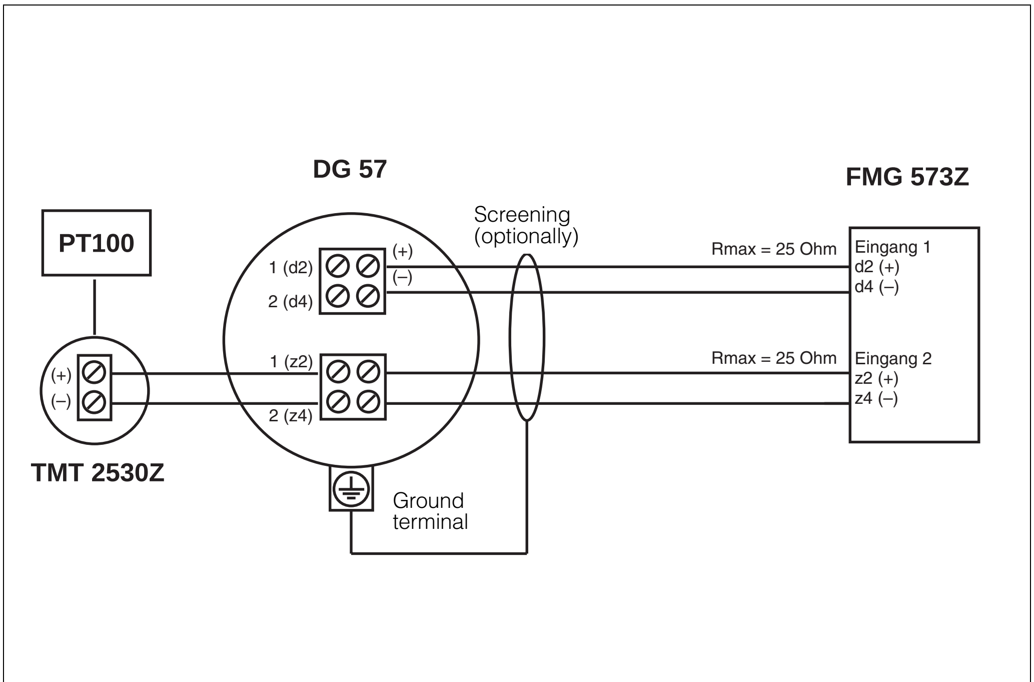


Fig. 5.5
wiring in non-explosion hazardous areas with TMT 2530 Z temperature sensor

b) Existing temperature measurement with an analogue output and by use of the converter TSP 8267

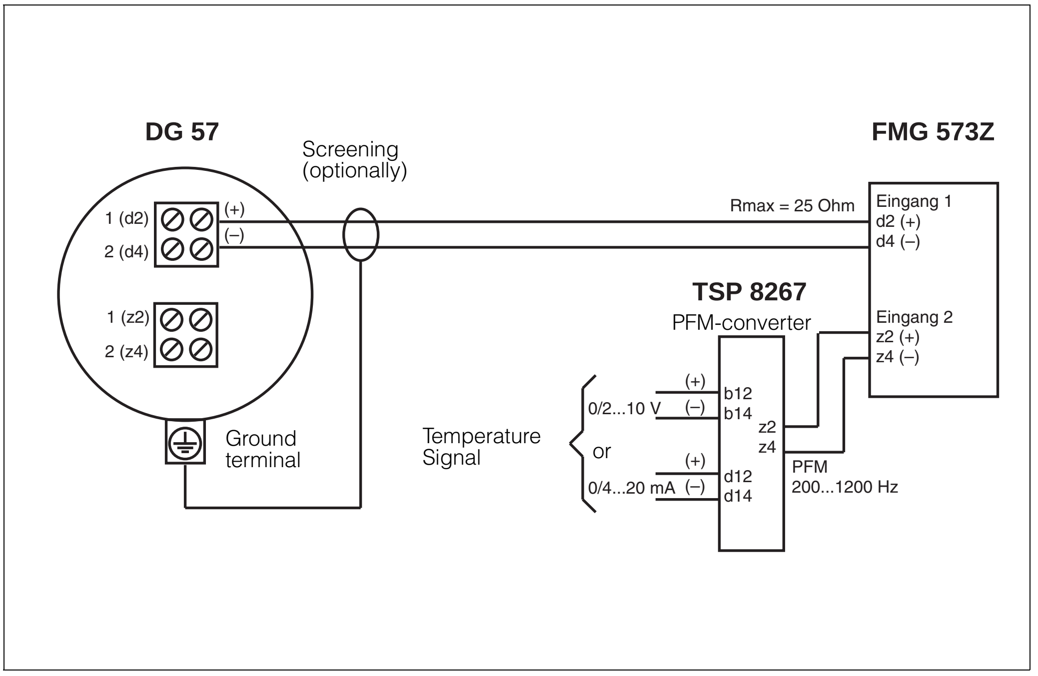


Fig. 5.6
Wiring in non-explosive areas with temperature sensor and analogue TSP 8267

5.2.4 Application in explosion hazardous areas according to (EEx ib) II

Existing temperature measurement with analogue output and with the converter TSP 8267

- Check the maximum allowed inductance and capacitance values of the wiring as stated in the PTB- certificates.

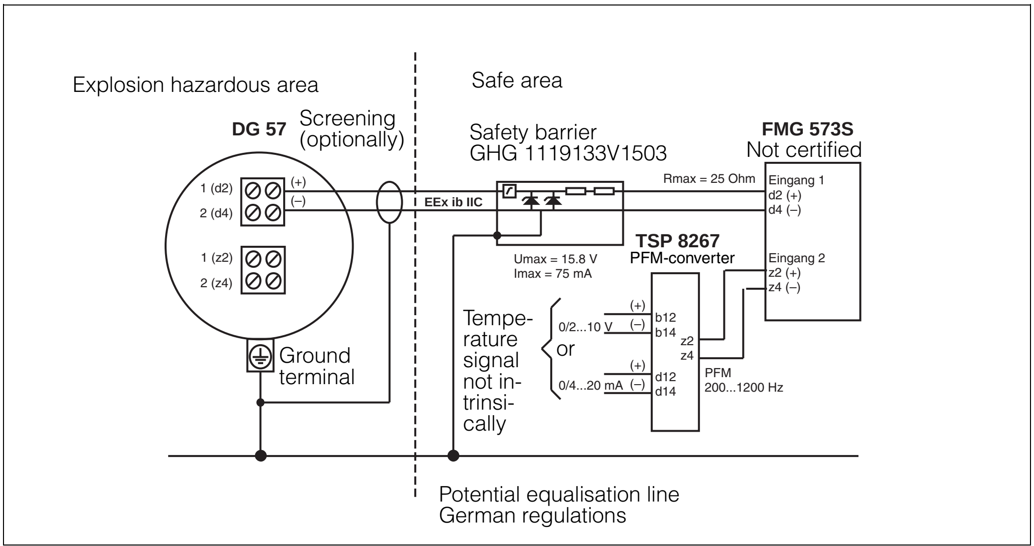


Fig. 5.8
Wiring in explosion hazardous areas with analogue temperature sensor and TSP 8267 to EEx ib IIB/IIC

5.2.5 Installations in explosion hazardous areas according to (EEx ib) IIB/IIC

a) Endress+Hauser temperature measurement with the TMT 2530Z-probe

- Observe the operation manual of the safety barrier and the PTB- certificates.
- the intrinsically safe circuit of the safety barrier must be connected to the potential equalisation line or plant grounding system. The wiring, including the detector housing, must also be connected to the potential equalisation line.
- check the maximum allowed inductance and capacitance values of the wiring as stated in the PTB- and safety barrier certificates.

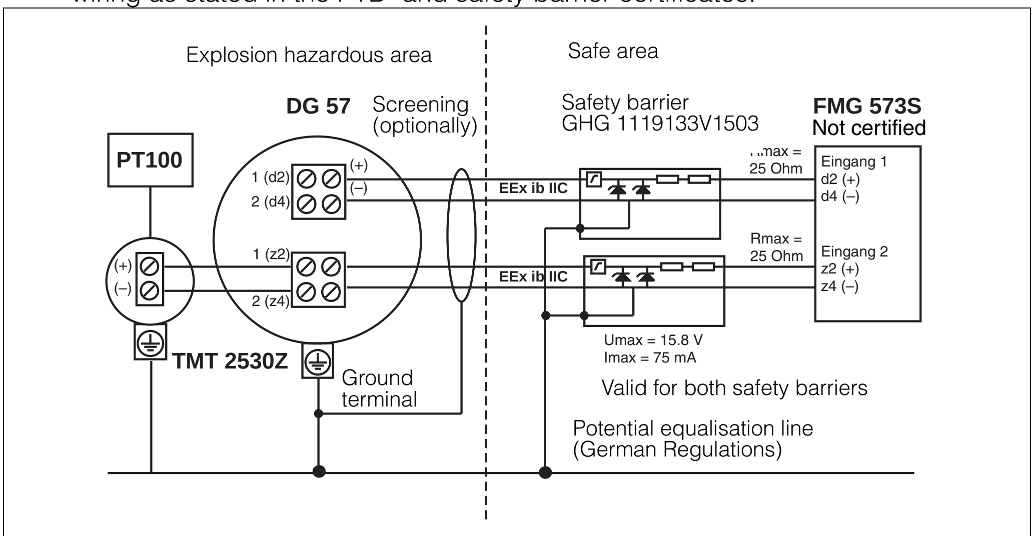


Fig. 5.9
Wiring in explosion hazardous areas with temperature sensor TMT 2530 Z temperature sensor to EEx ib IIB/IIC

5.3. Calibration

5.3.1 General remarks

The radiometric density measuring system requires on-line calibration. Normally this is performed with the process liquid under process conditions. The actual density must be determined by a laboratory sample. The calibration value is always entered in the unit (g/cm3).

- As with any system that requires an online calibration, the possible accuracy depends directly on the quality of the laboratory analysis.
- Check, that during the laboratory analysis, the medium temperature is the same as the process temperature.

After calibration, a calibration plate can be manufactured, which can then be used to check the calibration or recalibrate the system at a later date.

5.3.2 One point or two point calibration

To achieve a reliable measurement, the two point calibration should be used. In this case, the FMG 573 Z/S calculates automatically the linear absorption coefficient (μ) from the calibration data.

- For reliable measurements, the difference between the two calibration values should be at least one third of the measuring range.

If this is difficult to achieve with the process fluid, water can be used for one calibration value.

Use a one point calibration for a quick start up, if only one density value can be calibrated initially.

In this case, the correct linear absorbtion coefficient must be entered manually. Contact Endress+Hauser for the correct value of the linear absorption coefficient for your application

The one point calibration provides a sufficient accuracy around the calibration value. This may be sufficient for control but the slope of the calibration curve might be too steep or too shallow.

Later, during operation, the calibration can be upgraded with a second calibration point to achieve best accuracy.

5.3.3 Calibration sets

Up to three different calibration sets can be programmed. This can be useful if different products are to be measured in the same pipe.

- Example: Slurries with different carrier liquids and the same solids density - the output signal is 'solids content' [mass/volume]. Depending of the calibration mode, each of the four sets consists of the following parameters:

1.) Two point calibration

  - Density measuring range ρ_{min} and ρ_{max}
  - Calibration densities (ρ_1, ρ_2) and the corresponding pulse rates (N_1, N_2)

2.) One point calibration

  - Density measuring range ρ_{min} and ρ_{max}
  - Linear absorption coefficient [μ]
  - Calibration density and the corresponding pulse rate (ρ_1, N_1)

5.4. Programming the FMG 573 Z/S

The transmitter FMG 573 Z/S is delivered with certain default settings. The initial set up is done to check and possibly change the default parameters before starting the calibration procedure.

Software reset
In order that you do not have to check all the default settings, we recommend a software reset prior to the first set up. This ensures, that accidental or unauthorised entries are reset to the original default values.

Caution:
If calibration was already performed and values had been entered into the FMG 573, these values will be lost by a software reset.

5.4.1 Software-reset

Rotary switch	Display	Entry	Meaning
1	0	2607	Entry of the programming level
9	0	2607	With ”E“ the software reset is performed. Default values are activated. E 204 is displayed and the alarm relay will switch. After a short while, the error code Ex 901 appears. (Normal indication if the calibration is not yet fully completed).

5.4.2 Initial set up

Rotary switch	Display	Entry	Meaning
1	0	3500	Entry of the programming level (sensor data)
6	XXXX		The displayed sensor number must match with the sensor number of the DG 57Z connected!
1	3500	0145	Entry of the programming level
4	1	 0 1	Selection of the isotope: this influences the decay compensation Co 60 Cs 137 (default)
5	0	 0 1	Selection of the analogue output 0 mA ... 20 mA/0 V ... 10 V (default) 4 mA...20 mA/2 V ... 10 V
6	12	 01 02 11 12 20 30	Selection of the analogue output during ‘alarm‘ Start of the display range, e.g. 4 mA/2 V (the values depends on the prior selection) – 10 % of the display range, e.g. 2,4 mA/1,2 V 20 mA/10 V 110 % of the display range, e.g. 21,6 mA/10,8 V (default) Hold the last value Continue, if possible
1	0145	0345	Entry of the next programming level
2	10	20	Entry of the mode temperature compensation
1	0345	0745	Entry of the programming level T-compensation

Rotary switch	Display	Entry	Meaning
2	4.0	 2.0 3.0 4.0	Entry of the kind of temperature signal: TMT 2530 Z TSP 8267 (converted analogue to PFM signal Built in detector temperature (Default) **Note:** The second digit defines the compensation method, this is explained in Chapter 5.9 ...6.11.
3	– 200	XXXX	**Note:** Necessary only when TSP 8267 is used. (prior entry: '3.0'): Start of the measuring range of the temperature analogue signal [°C].
4	300	XXXX	Necessary only when TSP 8267 is used. Entry of the end of the measuring range of the temperature analogue signal [°C]
5	25	20	Entry of the reference temperature, e.g. 20
1 or 0			Continue the calibration or end

Typical error codes

E901 The pulse rate is out of the measuring range: normal indication when the measuring line is not yet fully calibrated.

5.4.3 Display of the actual uncompensated density value [g/cm^3]

The actual uncompensated density value measured by the FMG 573 Z/S can be displayed.

Rotary switch	Display	Entry	Meaning
1	0	1045	Entry of the programming level
9	X.XXX(X)		Display of the density [g/cm^3]
0			End

5.4.4 Locking the access to the calibration data

Locking the access shall prevent changes of the calibration data by accidental or unauthorised alterations.

Rotary switch	Display	Entry	Meaning
1	0	0345	Entry of the programming level
3	X	9999 2 1	To lock the entry Activating the two point calibration Activating the one point calibration
0			End

5.4.5 Change of output damping:

By increasing this parameter, the influence of the statistical variation is reduced.
The default value is 60 s.

Please observe the Chapter 1.4.2 for the physical influences.

Rotary switch	Display	Entry	Meaning
1	0	0045	Entry of the programming level
7	60	XX	Entry of the output damping time 1 ... 1000 s.
0			End

5.5. Two point calibration

Note

- The complete measuring line (DG 57, FMG 573 Z/S) must have been in operation for at least 6 hours with the radiation switched on and with product in the pipe.
- When the pipe is empty, switch off the radiation (leave system in operation)
- The integration time must be set to 60 s (default value)
- Make sure that the source holder is always fixed when in operation (refer to Chapter 2.3.3). Note all entered values as well as the date, the calibration values and the pulse rates.

Rotary-switch	**Display**	**Entry**	**Meaning**
1	0	0345	Entry of the programming level
2	X	10	Density measurement
3	X	2	Check if the calibration mode 'Two point calibration' is selected (default value)
5	200.0	XXX.X	Entry of the inner pipe diameter or the real length of the radiation path through the product.
1	0345	0545	Entry of the programming level
9	XX	1	Selection of the calibration set 1
2	1.000	X.XXX	Entry of the beginning of the density measuring range in [g/cm^3]; – If the output signal should be dry solids [Weight/Volume], enter the density of the carrier liquid [g/cm^3].
3	2.000	X.XXX	Entry of the end of the density measuring range in [g/cm^3]
Fill pipe with calibration fluid of density ρ_1 (lower density value): wait at least 5 min.			
5	1	1	Selection of lower calibration point: density ρ_1
6	XXXX(X)	ENTER	Current pulse rate [N/100 ms]. Press ENTER to store
7	XXXX		Check stored pulse rate [N/100 ms]
8	0.0000	XXXX(X)	Enter density of calibration liquid [g/cm^3].
Fill pipe with calibration fluid of density ρ_2 (upper density value): wait at least 5 min.			
5	1	2	Selection of upper calibration point: density ρ_2
6	XXXX(X)	ENTER	Current pulse rate [N/100 ms] Press ENTER to store
7	XXXX		Check stored pulse rate [N/100 ms]
8	0.0000	XXXX(X)	Enter density of calibration liquid [g/cm^3].
9	1	11	Active calibration set no. 1
0			End

Typical error codes

E820 ρ_{min} **>** ρ_{max} **–** enter the correct values in switch position No. 2 and No. 3
or The calibration densities ρ_1 and/or ρ_2 are out of the entered measuring range, which is defined by ρ_1 and ρ_2.

E821 The calibrated density value ρ_1/ρ_2 or the pulse rate N1/N2 is = 0, or the calibration density ρ_1 is bigger then ρ_2 **–** correct the values in switch position No. 5, No. 7 and No. 8

E901 The pulse rate is out of the defined measuring range: Check, if ρ_{min} and ρ_{max} are entered correctly or the pipe is empty or only partly filled.

5.5.1 Production of a calibration plate

A steel calibration plate (for thickness contact E+H) is placed in the beam between the source container and pipe. This simulates a density increase in the fluid flowing through the pipe. The equivalent density value is noted and stamped on the plate.

Rotary-switch	Display	Entry	Meaning
If possible, fill the pipe with calibration fluid with the low density value (ρ_1) Switch off radiation, insert steel plate, switch on radiation and wait at least five minutes			
0	X.XXXX		Note displayed density value to 4th decimal point (press ⇒ to display to this resolution)
1	0	0345	Entry of programming level
3	XXXX	1	Selection of one point calibation
1	X.XXXX	0445	Entry of programming level
9	XX	1	Selection of the calibration set no. 1
6	XXXX(X)	ENTER	Current pulse rate [N/100ms] Press ENTER to store
7	XXXX		Check stored pulse rate [N/100 ms]
8	0.0000	X.XXX(X)	Entry of the noted density [g/cm^3]
9	1	11	Activate the calibration set No. 1
0			End
Switch off radiation, remove steel plate, switch on radiation and wait at least five minutes			

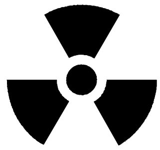
5.5.2 Automatic recalibration using calibration plate

A periodic recalibration of the system is recommended in oder to compensate any measuring errors which may occur due to wear of or build-up in the pipe. The measuring conditions of the initial plate calibration must be reproduced. The system must have been operating for at least an hour before calibration.

Rotary-switch	Display	Entry	Meaning
Fill the pipe with the calibration fluid used to produce the calibration plate			
1	X.XXXX	0945	Entry of programming level
6	X.XXXX	1	Entry of calibration mode: 1 = automatic*
1	X.XXXX	0445	Entry of programming level
8	X.XXXX		Check that calibration plate value is displayed – if not, enter as follows
9	1	1	Selection of the calibration set no. 1
8	0.0000	X.XXX(X)	Entry of the density on plate [g/cm^3]
9	1	11	Activate the calibration set No. 1
Switch off radiation, insert steel plate, switch on radiation and wait at least five minutes			
Short-circuit connections z10 and b10 for at least one second The recalibration starts automatically and lasts about 10 minutes, during which the error message E 902 is displayed			
Switch off radiation, remove steel plate, switch on radiation and wait at least five minutes			

*For procedure with manual start of the recalibration see Section 6.1.1.

5.6. One point calibration



Note:

- The complete measuring line (DG 57, FMG 573 Z/S) must have been in operation for at least 6 hours with the source container switched on and with product in the pipe.
- When the pipe is empty, switch off the radiation (leave system in operation)
- The integration time must be set to 60 s (default value)
- Make sure that the source holder is always fixed when in operation (refer to Chapter 2.3.3). Note all entered values as well as the date, the calibration values and the pulse rates.

Rotary switch	Display	Entry	Meaning
1	0	0345	Entry of the programming level
3	2	1	Selection of the one point calibration mode
5	200.0	XXX.X	Entry of the inner pipe diameter or the real length of the radiation path [mm]. **Note:** This value must be entered exactly. It directly influences the calculation of the absorbtion.
1	0	0445	Entry of the programming level
9	1	1	Selection of the calibration set no.1
2	1.000	X.XXX	– Entry of the beginning of the density measuring range [g/cm^3]. – If the analogue signal is solids content (mass/volume), entry of the density of the carrier liquid [g/cm^3].
3	2.000	X.XXX	Entry of the end of the density measuring range [g/cm^3]
4	6.154	XXXX	Entry of the linear absorbtion coefficient [μ]
6	XXXX(X)		Actual pulse rate [N/100 ms] Procedure 1. Fill the pipe with the calibration fluid. 2. Wait for at least 5 minutes, before you read out the pulse rate. 3. As soon as the pulse rate remains reasonably constant, store it by pressing the Enter-button.
7	XXXX		Display of the stored pulse rate [N/100 ms]
8	1.500	X.XXX(X)	Entry of the density value of the applied calibration fluid [g/cm^3]
9	1	11	Activation of the calibration set no. 1
0			End

5.7. Upgrade of a one-point to a two-point calibration

Rotary switch	Display	Entry	Meaning
1	0	0345	Entry of the programming level
3	1	2	Selection of the two point calibration mode
1	0345	0545	Entry of the programming level
9	11	1	Modification of the calibration set no.1
5	1	 31 32 1 2	1. Transformation of the calibration data (Density and pulse rate) from the one point calibration: * The value of the one point calibration will be used as ρ_1: lower calibration density * The value of the one point calibration will be used as ρ_2: higher calibration density. Confirm by pressing the Enter button 2. Selection of the second calibration value depending on the prior entry ρ_1 = lower calibration density (if 32 was selected) ρ_2 = higher calibration density (if 31 was selected)
6	XXXX(X)		Actual pulse rate [N/100 ms] Procedure 1. Fill the pipe with the calibration fluid 2. Wait at least for 5 minutes before you read out the pulse rate 3. As soon as the pulse rate remains reasonably stable, store it by pressing the Enter button.
7	XXXX		Display of the stored pulse rate [N/100 ms]
8	X.XXX(X)	X.XXX(X)	Entry of the density value of the applied calibration fluid [g/cm^3]
9	1	11	Activating of the calibration set No.1
0			End

Typical error codes

E801 $\rho_{min} > \rho_{max}$. Enter the correct values in switch position 2 and 3 .

E810 Calibration density of the one point calibration is out of the range defined by ρ_{min} and ρ_{max} .

E901 Pulse rate is out of the display range:
Check if ρ_{min} and ρ_{max} are entered correctly or the pipe is empty or only partly filled.

5.8. Selection of displayed value units

The FMG 573 Z/S has different possibilities for calculating temperature compensated values.

Depending on the application, the industrial branch and the country, one of the following possibilities can be adjusted.

5.9. Density in the unit [g/cm^3] or other engineering units, temperature compensated

Temperature changes in liquids result in density changes. The FMG 573 Z/S uses a temperature compensation formula (see Chapter 5.10) to convert the actual density value and the temperature into the density at selected reference temperature (e.g. 20 °C) independently of the temperature compensation. The technical unit of the display can be selected:

Rotary switch	Display	Entry	Meaning
1	0	0845	Entry of the programming level
2	1	1	Check, if the conversion mode 1 is selected
3	1.01	X.XX	Entry of the unit (mass/volume): 1 = g 01 = cm^3 2 = kg 02 = dm^3, l 3 = t 03 = m^3 4 = oz 04 = inch^3 5 = lb 05 = ft^3 6 = sh cwt 06 = yard^3 (GB) 7 = cwt 07 = fl.oz (GB) 8 = sh th 08 = fl.oz (US) 9 = tn 09 = gal (GB) 10 = gal (US)
0			End, or proceed with the entry of the temperature compensation

Typical error codes

E900 Displayed value is bigger than > 9999: check, if the selected engineering unit fits into the display range.

5.10. Temperature compensation with formula

Physical facts

The relationship between density and temperature can be described by the following formula:

$\rho_{Ref} = \rho + (\vartheta - \vartheta_{Ref}) \times tk1 + (\vartheta - \vartheta_{Ref})^2 \times tk2$

Measuring values: ρ actual density [g/cm^3]
ϑ: actual temperature [°C]
Values to be entered: ϑ_{Ref}: reference temperature [°C]
tk1: linear temperature coefficient
tk2: quadratic temperature coefficient
Calculated value: $\rho_{Ref:}$ Density at the reference temperature

There are two methods to obtain the required data:

A) Values from physical tables, as described below

B) By empirical evaluation as described in Chapter 5.10.2

5.10.1 Temperature compensation using data from physical tables

a) Calculation of the linear temperature coefficient

$$tk1 = \frac{\rho_a - \rho_b}{\vartheta_a - \vartheta_b}$$

Example: liquid chlorine

from physical tables:

ρ_a = 1,47 g/cm^3, ϑ_a = 0 °C
ρ_b = 1,38 g/cm^3, ϑ_b = 30 °C

$$tk1 = \frac{1{,}47 - 1{,}38}{0\ °C - 30\ °C} = -0{,}003\ g/cm^3/°C$$

b) Calculation of the quadratic temperature coefficient

The relationship between temperature and density is nonlinear. However, the entry of the quadratic temperature coefficient to achieve an increased accuracy is only necessary for larger temperature ranges.

1. First the linear temperature coefficient must be known or be calculated, see above.
2. Now calculate the density value for a larger temperature range ρ_c using only the linear temperature coefficient:
   $\rho_c = \rho_a \pm d\vartheta \times tk1$
3. Now the quadratic temperature coefficient can be calculated from the difference of the calculated density value (see above) and the real density, for example taken from a physical table:

$$tk2 = \frac{\rho_{real} - \rho_c}{(\vartheta_\alpha - \vartheta_c)^2}$$

Example: liquid chlorine

Values from a physical table:

ρ_a = 1,47 g/cm^3, ϑ_a = 0 °C
ρ_{real} = 1,11 g/cm^3, ϑ_c = 100 °C
tk1 = – 0,003 g/cm^3/°C (calculated)

Calculation

1.) ρ_C = 1,47 + (100 x – 0,003) = 1,17 g/cm^3

2.) $tk2 = \dfrac{1{,}11 - 1{,}17}{(0 - 100)^2} = 0{,}000006\ g/cm^3/°C$

3.) Both temperature coefficients must be entered as an exponential value

- as mantissa (1 ... 9999), only integer numbers
- as exponent (0 ... – 9)

Example: tk2 to be entered: 0,000006 = 6 x 10^{-6}

Entry: mantissa = 6, exponent = – 6

Planning „Temperature compensated density measurement"
Example:

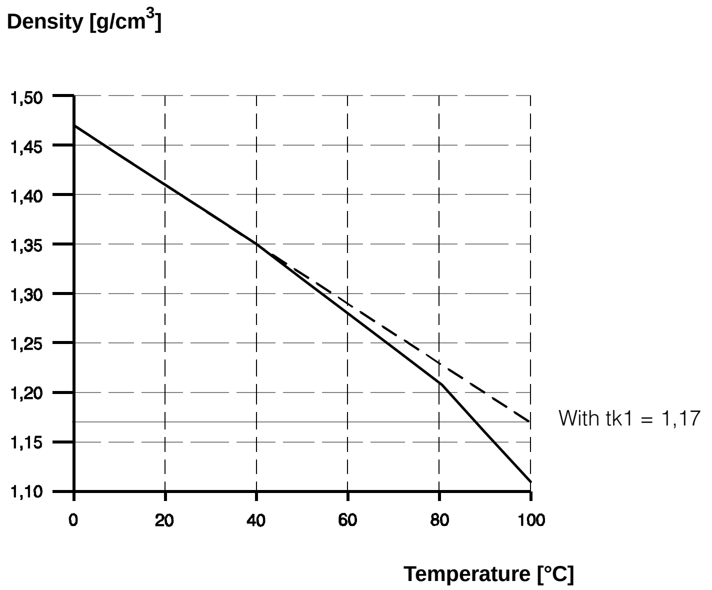


Fig. 5.11
Example of
density as a function
of temperature

Procedure

Rotary switch	Display	Entry	Meaning
1	0	0845	Entry of the programming level
2	1	1	Check
1	0	0745	Entry of the programming level
2	X.0	X.0	Check, if the correct kind of temperature measurement is selected. The first digit was selected depending on the temperature signal (compare Chapter 5.4.1)
5	25	X	Entry of the reference temperature [°C]
6	0	XXXX 3	Entry of the mantissa of the linear temperature coefficient tk1. Entry as a integer value without the „–“-prefix Example: – 0,003 = 3 x 10^{-3}
7	0	XX 3	Entry of the exponent of the linear temperature coefficient tk1 Example: – 0,003= 3 x 10^{-3}
8	0	XXXX 6	Entry of the mantissa of the quadratic temperature coefficient tk2 Example: 0,000006 = 6 x 10^{-6}
9	0	XX 6	Entry of the exponent of the quadratic temperature coefficient tk2 Example: 0,000006 = 6 x 10^{-6}
0			End

5.10.2 Temperature compensation based on empirical values

The calculation of the linear and the quadratic temperature coefficient must be based on measuring values, if no physical table values are available
Requirements: One point calibration or two point calibration is already performed.

Rotary switch	Display	Entry	Meaning
1	0	0345	Entry of the programming level
2	10	20	Selection of the mode temperature compensation >ENTER<
1	0345	0745	Entry of the programming level
2	4.0	 2.0 3.0	Entry of the temperature signal TMT 2530 Z TSP 8267 (converts analogue signal into a PFM-signal)
0			End

Obtain the measuring values (Density and the related temperature). Fill the pipe with the process fluid. Choose, if possible, a density value in the middle of the selected measuring range.

Procedure

Rotary switch	Display	Entry	Meaning
1	0	1045	Entry of the programming level
9	XXXX(X)		Display of the actual, uncompensated density: 1. Press the ➔-button, to display the last digit of the measuring value: wait for at least 5 minutes, before you take a reading 2. Note the reading, as soon the density value remains stable, e.g. ρ_a = 1,1028 g/cm^3
1	1045	0045	Entry of the programming level
8	XXX		Display of the actual temperature for this density value. 1. Note this value, e.g. ϑ_a = 15 °C. 2. Cool down or warm up the process fluid by approximately 10 °C 3. Note this value, as soon as the displayed temperature remains relatively stable, ϑ_b = e. g. 26 °C.
1	0	1045	Entry of the programming level
9	XXXX(X)		Display of the uncompensated density value at the temperature Tb: note this value, in the example = 1,0959 g/cm^3

Calculate the linear temperature coefficient:

$$tk_1 = \frac{\rho_a - \rho_b}{\vartheta_a - \vartheta_b}$$

Example:

$$tk_1 = \frac{1{,}1028 - 1{,}0959}{15 - 26\ °C} = -\ 0{,}0006273\ g/cm^3/°C$$

Rotary switch	**Display**	**Entry**	**Meaning**
1	0	0845	Entry of the programming level
2	1	1	Check
1	0	0745	Entry of the programming level
2	X.0	X.0	Check, if the mode 'temperature compensation 2.0' or '3.0' is selected
3	– 200	XXXX	Start of the measuring range [°C] of the temperature signal. Entry necessary only when using the TSP 8267 (Prior entry: 3.0)
4	300	XXXX	End of the measuring range [°C] of the temperature signal. Entry necessary only when using the TSP 8267
5	25	15	Enter the temperature value ϑ_a Example: 15 [°C]
6	0	6273	Entry of the mantissa of the linear temperature coefficient without the „–" prefix: tk1 = Example: 0,0006273 = 6273 x 10^{-7}
7	0	– 7	Entry of the exponent of the linear temperature coefficient tk1 Example: 0,0006273 = 6273 x 10^{-7}
1	0	0345	Entry of the programming level
6	XXXX(X) 1,1028 1,0967		Display of the temperature compensated density value (at $\vartheta_{Ref} = \vartheta_a$ = 15 °C) Increase the temperature of the process fluid for at least further 50 °C, e.g. to 75 °C. Read out and note after 5 minutes (at constant temperature = 75 °C) the density value, as soon it stays stable. 1. If there is no difference between the ϑ_a-value, e.g. display value 1,1028, then the tk is linear and no further settings must be done 2. The original value changes, e.g. to 1,0967 (this complies to ρ_c=1,0967 at ϑ_c=75 °C). Using this value, the quadratic tk_2 can be calculated $tk_2 = \frac{\rho_a - \rho_c}{\vartheta_a - \vartheta_c^2} = \frac{1.1028 - 1.0967}{(15 - 75)^2}$ tk_2 = 0.0000017
1	0	0745	Entry of the programming level
5	15		Entry of the reference temperature [°C], e.g. 20 °C
8	0	17	Entry of the mantissa of the quadratic temperature coefficient tk_2 Example: 0.0000017 = 17 x 10^{-7}
9	0	7	Entry of the exponent of the quadratic temperature coefficient tk_2 Example: 0.0000017 = 17 x 10^{-7}
0			End

5.11. Temperature compensation using a table

Temperature fluctuations in liquids cause changes in density. By using an existing table (density versus temperature), the FMG 573 Z/S allows the calculation of the density referred to a selected temperature of e.g. 30°C (reference temperature) from the current density and temperature measurement.

Up to 21 pairs of density and temperature values can be entered in the table. The desired reference temperature and density value are selected from the table. The difference between the reference density and every other density value must now be calculated, see following example.

The preparations, electrical connection and calibration (one or two point) correspond to those described in this chapter.

Rotary switch	Display	Entry	Meaning
1	0	0345	Entry of the programming level
2	XX	20	Check that density measurement with temperature compensation has been selected
1	345	0745	Entry of the programming level
2	4	 2.1 3.1	Operating mode "temperature compensation using a table with TMT 2530Z as per table with TSP 8267 as per table (0/4...20 mA signal converted to PFM signal)
3	–200	XXXX	Start of temperature signal measuring range [°C] Entry required for TSP 8267 only 3.1 entered on previous step
4	200	XX	Start of temperature signal measuring range [°C] Entry required for TSP 8267 only
5	25	20	Entry of the reference temperature

Example: Water

Required reference temperature: 20°C
Temperature range: 0°C...80°C

T °C	Density ρ g/cm^3	Table No.	Difference Δρ g/cm^3
0	0.9998	1	0.0016
10	0.9997	2	0.0015
20	**0.9982**	3	0.0000
30	0.9957	4	0.0025
40	0.9922	5	0.0060
50	0.9880	6	0.0102
60	0.9832	7	0.0150
70	0.9778	8	0.0204
80	0.9718	9	0.0264

The differential value (correction) is entered as figures behind the decimal point:

e.g. 0.9982 (at reference temperature) – 0.9997 (at 10°C) = 0.0015
is entered as 0015 (without sign)

The reference density is calculated according to the diagram:

$\rho_{ref} = \rho \pm$ correction (differential value)

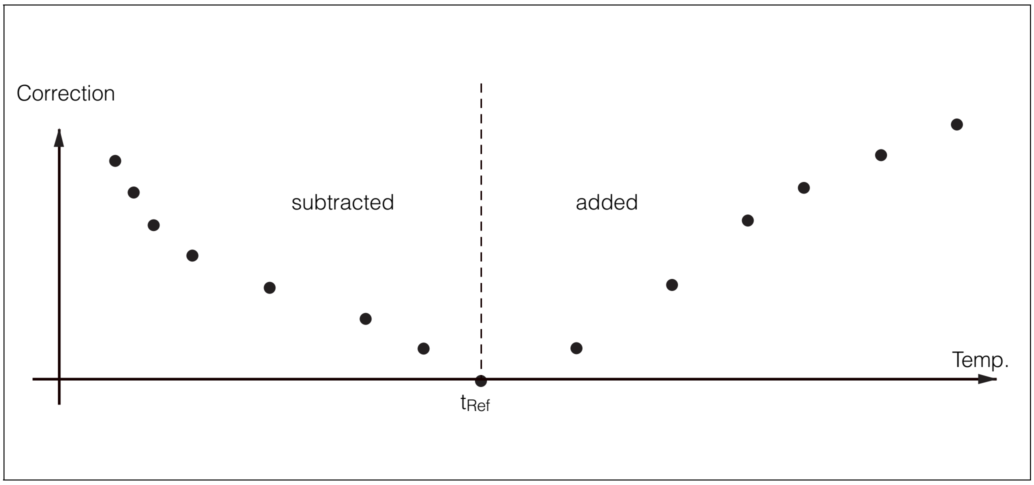


Fig. 1.1
Correction as a function of temperature

The table is entered as follows:

Rotary switch	Display	Entry	Meaning
1	0 or XXXX	0645	Entry of the programming level
7	X	1	Check/Enter table no. 1
8	0	0	Enter first temperature (0°C)
9	0	0016	Enter correction (0.0016)
7	1	2	Enter table no. 2
8	0	10	Enter second temperature (10°C)
9	0	0015	Enter correction (0.0015)
etc			
7	8	9	Enter table no. 8 (last)
8	0	80	Enter last temperature (10°C)
9	0	0264	Enter correction (0.0264)
0			End

Temperature-compensated density is now displayed at rotary switch position No. 0. The temperature of the medium is displayed at rotary switch position No. 8. The uncompensated density value can be displayed at rotary switch position no. 0 in level 1045. The PFM frequency (input 2) can be viewed in level 2610, rotary switch position 9.

Deleting the table

Enter the value 33 at rotary switch position 7 in level 645. All the current values are deleted and a new table can be entered.

5.12. Temperature compensated concentration %

The FMG 573 Z/S provides a non linear conversion of the density into a temperature compensated % concentration measurement.

This is achieved by entry of

1. a table with up to 18 points of density values at their related temperature values and
2. a correction factor for the temperature range at an average concentration.

Example: H_2SO_4 in H_2O

H_2SO_4 in H_2O, the reference temperature is 25 °C
Required measuring range: 30 ... 70%, average 50 %
Temperature range: 0 ... 75 °C

Values from physical tables:	1	2	3	4	5
%	30	40	50	60	70
Density (25 °C)	1,220	1,305	1,400	1,505	1,615
Density (0 °C)			1,435		
Density (75 °C)			1,360		

Calculation

1. For 0 °C

$$K = \frac{\text{Density at 0 °C}}{\text{Density at 25 °C}} = \frac{1{,}435\ [g/cm^3]}{1{,}400\ [g/cm^3]} = 1{,}025$$

2. For 75 °C

$$K = \frac{\text{Density at 75 °C}}{\text{Density at 25 °C}} = \frac{1{,}360\ [g/cm^3]}{1{,}400\ [g/cm^3]} = 0{,}971$$

Rotary switch	Display	Entry	Meaning
1	0	0845	Entry of the programming level
2	1	31	Entry of the conversion into % concentration
7	1	1	Enter the value of table no. 1
8	0.0 %	30.00	Entry of the % concentration value; the first value of the table will define the start of the measuring range Example: 30%
9	0.000	1.220	Entry of the corresponding density value Example: 1,220
7	1	2	Entry of the table no. 2
8	0,0 %	40.00	Entry of the % concentration value. Example: 40 %
9	0.000	X.XXX 1.305	Entry of the corresponding density value Example: 1,305 g/cm^3
			etc. enter the values of no.3 and no.4

Rotary switch	Display	Entry	Meaning
7	4	5	Entry of the table value no. 5
8	0.0 %	70.00	Entry of the % concentration; the last value of the table will define the end of the measuring range Example: 70 %
9	0.0000	1.615	Entry of the corresponding density value Example: 1,615 [g/cm^3]
1	0	0745	Entry of the programming level
5	0	25	Entry of the reference temperature Example: 25 °C
1	0	0945	Entry of the programming level
2	0	1	Entry of the table value no.1
3	1.000	1.025	Entry of the correction factor for the lowest temperature (below this temperature, this factor will be used)
4	0	0	Entry of the corresponding temperature Example: 0 °C
2	1	2	Entry of the table value no.2
3	1.000	1.000	Entry of the correction factor for the next temperature (the reference temperature must be entered also) Example: 1,000
4	0	25	Entry of the corresponding temperature Example: reference temperature 25 °C
2	2	3	Entry of the table value no.3
3	1.000	0.971	Entry of the correction factor of the last temperature value (above this temperature, this factor will be used)
4	0	75	Entry of the corresponding temperature Example: 75 °C
0			End

Typical error codes

E710 The values for % concentration must strictly increase or decrease: check, correct, or delete the table; to delete it, the value 33 must be entered in switch position 7. Then the table must be entered again.

E711 The density values must strictly increase or decrease: Check, correct, or delete the table; to delete it, the value 33 must be entered in switch position 7. Then the table must be entered again.

E712 The temperature values must strictly increase or decrease: Check, correct, or delete the table; to delete it, the value 33 must be entered in switch position no.7. Then the table must be entered again.

5.13. Set points/relays

5.13.1 Introduction

The FMG 573 Z/S features two independent relays, which for the density measurement mode can be used as set points.

The switching behaviour of each relay is defined by three parameters:

1.) Set point:
0 ... 100 % related to the output measuring range

2.) Hysteresis:
0 ... 100 %; for a two point control with one relay, this value defines the on/off cycle.

3.) Fail safe modes: minimum- or maximum safety;
This determines the use of the relay:
- Min. as low value alarm
- Max. as high value alarm

This setting also defines whether the hysteresis is added to or deducted from the actual set point

Default values

	Set point	Hysteresis	Fail safe mode
Relay 1:	10 %	3 %	Min.
Relay 2:	90 %	3 %	Max.

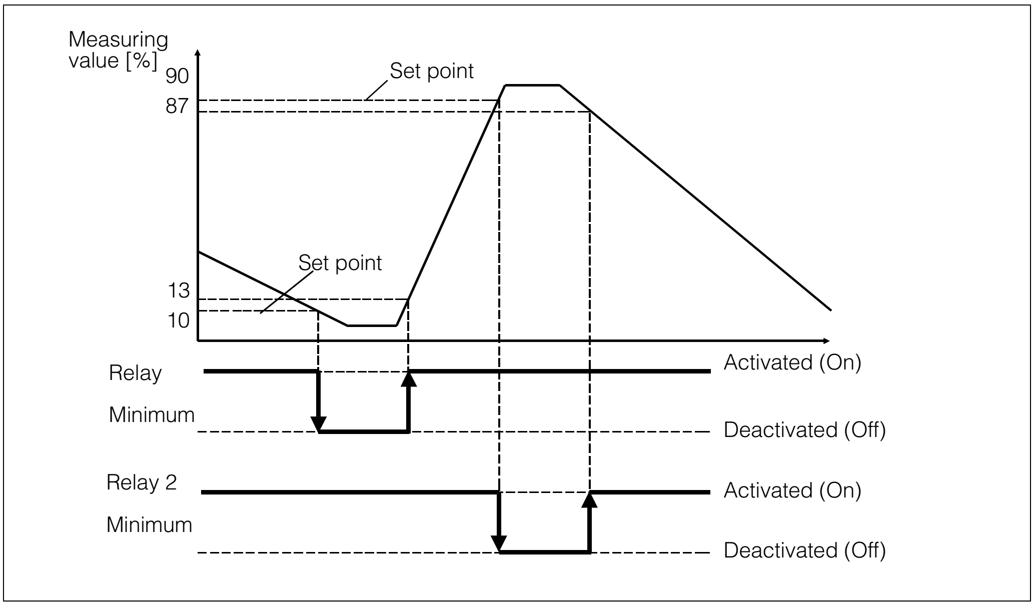


Fig. 5.12
Minimum and Maximum fail-safe mode

Procedure

Rotary switch	Display	Entry	Meaning
1	0	0045	Entry of the programming level
2	10.0 %	XX	Entry of the set point in [%] of relay 1
3	90.0 %	XX	Entry of the set point in [%] of relay 2
1	0045	0245	Entry of the programming level
2	3.0 %	XX	Entry of the hysteresis in [%] of relay 1
3	3.0 %	XX	Entry of the hysteresis in [%] of relay 2
1	0245	0145	Entry of the programming level
2	1.0	 1.0 1.1	Entry of the fail safe mode of relay 1 Minimum (default value) Maximum
3	1.1	 1.0 1.1	Entry of the fail safe mode of relay 2 Minimum Maximum (default value)
0	XXXX		End

5.14. Programming matrix for density measurement with temperature compensation

0	**Operating level**	**Basic settings**	**• Relay functions • Totaliser**	**• Operation mode • Calibration mode**	**1-point calibration**	**2-point calibration**	**Temperature compen-sation**	**Selection of units, conversion density to % conc.**	**% concentration f (ϑ) Recalibration**
1	Code 0045	Code 0145	Code 0245	Code 0345	Code 0445	Code 0545	Code 745	Code 845	Code 945
2	Switchpoint relay 1 [%] **I0.0**	Relay 1: safety mode 1.0 minimum safety 1.1 maximum safety **I.0**	Relay 1: hysteresis [%] or creeping quantity supression [%] **3.0**	Operation mode 31 Solids content 32 Massflow **I0**	Start of the density measuring range ρ_{min} [g/cm^3] **I.000**	Start of the density measuring range ρ_{min} [g/cm^3] **I.000**	Compensation method XO: from formula X1: from table Temperature measurement 2.X: TMT 2350Z 3.X: 0/4...20 mA TSP 8267 4.X detector temp. **I.000**	Selection of engineering unit 1: g/cm^3 31: % conc. = f (θ) **1**	% conc. = f (ϑ) Entry of table no. 1...18 33 deletes all values **1**
3	Switchpoint Relay 2 [%] **90,0**	Relay 2: safety mode 1.0 minimum safety 1.1 maximum safety **I.I**	Relay 2: hysteresis [%] if used as a set point **3.0**	Calibration mode 1: 1 point calibration 2: 2 point calibration **2**	End of the density measuring range ρ_{max} [g/cm^3] **2.000**	End of the density measuring range ρ_{max} [g/cm^3] **2.000**	Start of temperature measuring range (TSP 8267) [°C] **-200**	1: g 01: cm^3 2: kg 02: dm^3 (l) 3: t 03: m^3 4: oz 04: inch^3 5: lb 05: ft^3 6: s cwt 06: y^3 (GB) 7: cwt 07: fl.oz (GB) 8: s ton 08: fl.oz US 9: ton 09: Gal. (GB) 10: Gal. (US) **1.01**	% conc. = f (ϑ) Entry of correction factor **1.000**
4	Higher calibration pulse rate [N/100 ms] at ρ_{min} **5.000**	Isotope: 0: Co 60 1: Cs 137 **I**	Pulse value for the totaliser mode **9999**	Lock-/unlock Code 0045 4+ 6 1111: Unlock 9999: Lock **9999**	Linear absorp-tion coefficient µ: (calculated from 2-point calibration) **6.154**	K-factor **I.000**	End of temperature measuring range (TSP 8267) [°C] **0**	**XXXX**	% conc. = f (ϑ) Entry of corresponding temperature **0**
5	Actual pulse rate [N/100 ms] integrated **xxxx**	Current output 0: 0 ... 20 mA 1: 4 ... 20 mA **0**	Engineering unit of the totaliser 1: g 6: sh cwt 2: kg 7: cwt 3: t 8: sh tn 4: oz 9:tn 5: tb **3**	Length of the radiation beam through the process fluid [mm] **200**	Absorption coeeficient K x 1000 **I.000**	Selection of the calibration point 1: ρ_{low} 2: ρ_{high} 31: $\rho_{cal}=\rho_{low}$ 32: $\rho_{cal}=\rho_{high}$ **I**	Entry of reference temperature [°C] T_{ref} **xx**	**XXXX**	Current measured value in units as selected in 0845 **XXXX**
6	Lower calibration pulse rate [N/100 ms] at ρ_{max} **4.000**	Analogue output during alarm 02: - 10% 12: 110% 20: Hold 30: Continue 11: 100 % 01: 0 % **I2**	Totaliser Relay 1 only for the totaliser mode >E< resetting to 0 **0**		Actual pulse rate [N/100 ms] integrated, press >E< to calibrate **xxxx**	Actual pulse rate [N/100 ms] integrated, press >E< to calibrate **xxxx**	Linear temperature coefficient Entry of negative mantissa tk1 **0**	Current measured value in units as selected in 0845 **XXXX**	Entry calibration mode 0: manual 1: automatic **0**
7	Integration constant 0 ... 1000 s **60**	Frequency for the start of the measuring range of input 2 ≙ 0/4 mA **200**	Preset value for relay 2 Only totaliser mode **I.000**	Actual measuring value, engineering unit as selected in 1045/6 **xxxx**	Calibration pulse rate [N/100 ms] **xxxx**	Calibration pulse rate [N/100 ms] **xxxx**	Linear temperature coefficient Entry of negative exponent tk1 **0**	% conc. = f (θ) Entry of table no. 1...18 33 deletes all values **1**	τ for recalibration **0.000**
8	**xx**	Frequency for the end of the measuring range of input 2 ≙ 20 mA **I200**	Simulation of the output signal – 10 %...110 % **xx**	Start of the measuring ran-ge of the ana-logue output, engineering units as selec-ted in 1045/6 **xxxx**	Entry of the calibration density, the engineering unit is always [g/cm^3] **I.500**	Entry of the Calibration density, the engineering unit is always [g/cm^3] **I.500**	Quadratic temperature coefficient Entry of negative mantissa tk2 **0**	% conc. = f (θ) Entry of % concentration value **0.00%**	Error code E902 during recalibration 0: alarm off 1: alarm on default **0.000**
9	Error analysis Display of the actual error code **E-**	Last error code delete with >E< **Exxx**	Days of operation delete with >E< **xxxx**	End of the measuring range of the analoque output, enginee-ring unit as selected in 1045/6 **xxxx**	Selection of the calibration set 0.1-0.3 Set no. 1.X Activate 2.X Delete **I**	Selection of the calibration set X.1-X.3 Set no. 1.X Activate 2.X Delete **I**	Quadratic temperature coefficient Entry of negative exponent tk2 **0**	% conc. = f (θ) Entry of corresponding density value [gm/cm^3] **xxxx**	————

6. Maintenance

In regular intervals (approx. 6 month), the following parameters should be checked:

Sensor temperature °C (Operating level 3500 (3573), switch position 8)

This field displays the highest temperature which has been present at the DG 57 during operation. If the limit of 50 °C is permanently exceeded, countermeasures have to be taken, e.g.

- usage of a detecteor with water cooling jacket
- thermal screening
- change of mounting position

Average reference % (Operating level 3500 (3573), switch position 2)

This parameter is a measure for the relative sensitivity of the detector. It is used internally by the software in order to compensate for sensitivity changes which might occur in the course of time.

The value should be between 30% and 80%.

If the value is beyond this range, the inspection frequency should be increased (approx. every 3 months) and replacement of the detector should be scheduled.

If the value is below 5% or above 95%, the detector should be replaced.

7. Service/Record

7.1. Additional functions

7.1.1 Manual recalibration with calibration plate

If the measured density is different to the real value, the internal calibration curve can be corrected by means of a calibration plate. The automatic mode is described in Sections 3.5, 4.5 and 5.5. The manual mode is as follows:

- The system must have been operating for at least an hour before calibration.
- The corrected density value is displayed at 0045/0 and 0945/5.

Procedure

Rotary-switch	Display	Entry	Meaning
Fill the pipe with the calibration fluid used to produce the calibration plate Switch off radiation, insert steel plate, switch on radiation and wait at least five minutes			
1	X.XXXX	0945	Entry of programming level
6	X.XXXX	0	Entry of calibration mode: 0 = manual
1	X.XXXX	0445	Entry of programming level
6	X.XXXX	ENTER	Store current pulse rate
8	X.XXXX		Check that calibration plate value is displayed – if not, enter as follows
9	XX	1	Selection of the calibration set no. 1
8	0.0000	X.XXX(X)	Entry of the density on plate [g/cm^3]
9	1	11	Activation of the calibration set no. 1
The recalibration starts automatically and lasts about 10 minutes, during which time the error message E 902 is displayed			
Switch off radiation, remove steel plate, switch on radiation and wait at least five minutes			

7.1.2 Manual density correction using a density sample

If a two-point calibration was made with well separated calibration points, the density can be manually corrected by taking samples at regular intervals via a simple one-point calibration mode. To this end:

- note the pulse rate at the time of sampling
- determine the density ρ_{true} of the sample in the laboratory
- perform calibration as shown below

Procedure

Rotary switch	Display	Entry	Meaning
1	0	0345	Entry of the programming level
3	2	1	Selection of the one-point calibration mode
1	0	0945	Entry of the programming level
6	0	0	Entry calibration mode: 0 = manual
1	X.XXX	0445	Entry of the programming level
9	XX	1	Select calibration set (= 1)
7	X.XXX	XXXX	Entry of pulse rate at time of sample
8	X.XXX	X.XXX	Entry of density measured in laboratory
9	1	11	Activate calibration set
0			End

7.1.3 Change of density measuring range after calibration

The density measuring range can be changed at any time after calibration by entering new values in 0445/2 and 0445/3..

Procedure

Rotary switch	Display	Entry	Meaning
1	0	0345	Entry of the programming level
3	1	1	Entry calibration mode
1	0	0445	Entry of programming level
9	11	1	Select calibration set no.1
2	X.XXX(X)	X.XXXX	Entry lower range density value in g/cm^3
3	X.XXX(X)	X.XXXX	Entry upper range density value in g/cm^3
9	1	11	Activate calibration set no.1
0			End

7.1.4 Increasing the turndown of the 4...20 mA output

The 4...20 mA output signal is normally assigned to the start (0%) and the end (100%) of the density range determined during calibration. This may result in a display range of e.g. 1.00 to 1.50 g/cm^3. It is possible to set other signal ranges by entering new 4 mA and 20 mA values in the "scaling" menu.

Procedure

Rotary switch	Display	Entry	Meaning
1	0	1145	Entry of the programming level
2	XXXX	1	Activate the scaling/splitting range
3	X.XXX	e.g. 1.1	4 mA value: press ENTER to store
4	X.XXX	e.g. 1.4	20 mA value: press ENTER to store
0			End 0> density value

7.1.5 Dynamic adaptation of the output damping

The output damping (τ) causes the measured value to react slowly on any sudden change in density, e.g. when the flow in the pipeline is interrupted or switched on again. In order to increase the responsiveness of the display under such conditions, a factor can be entered at 11/7. This comes into effect when the density change exceeds the threshold entered at 11/6 and for a period of 3τ. Afterwards, the standard output damping value is used again. The function can be checked by switching the radiation on and off.

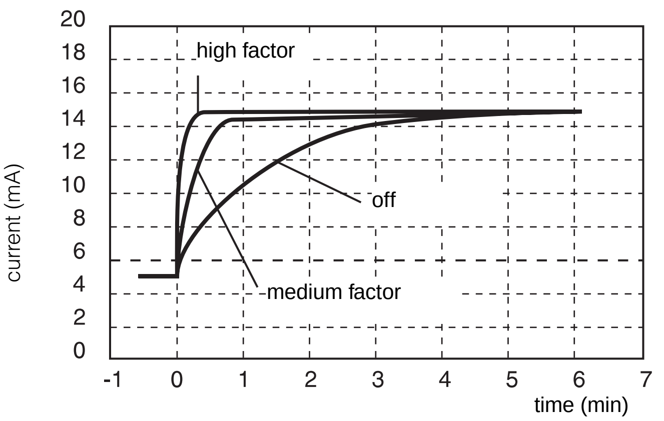


Fig. 7.1:
Effect of damping factor

Procedure

Rotary switch	Display	Entry	Meaning
1	0	1145	Entry of the programming level
6	100	30	Entry Δ pulse rate (threshold) between 1...100% Press ENTER to enter value
7	1	e.g. 3	Entry factor (1...10) by which the output damping is to be shortened. The higher the factor, the faster the response, but the more unsteady the display/output. A factor of 2 or 3 is recommended.
0			End

7.2. Reprogramming a replaced FMG 573 Z/S

After the initial set up, e.g. selection of the operation mode, the set points etc., the calibration data must be entered again: In case of a one point calibration, we recommend a new calibration during operation.
For a two point calibration, there are two possibilities to enter the calibration data:
- The data of the replaced FMG 573 Z/S can still be displayed (A).
- Only the original data from the first calibration are available (B).

(A) The data of the replaced FMG 573 Z/S can still be displayed:

1: Display the following data at the defect transmitter and note them.

Rotary switch	Display	Entry	Meaning
1	0	0345	Entry of the programming level
5	XXXX		Display of radiation beam path (mm)
1	0	0545	Entry of the programming level
9	11	1	Select the calibration set no.1 for modification
2	X.XXX		Display of the start of the density measuring range in g/cm^3
3	X.XXX		Display of the end of the density measuring range in g/cm^3
4	X.XXXX	1	Absorption coefficient (one-point calibration only) (from 0445/4)
7	XXXX		Display of the stored pulse rate in N/100 ms
8	X.XXX		Display of the calibration density in g/cm^3
. . . These values must now be entered in the replacement unit. . .			
9	1	11	Activation of the calibration set no.1 etc.
1	XXXX	0345	Entry of the programming level
5	XXXX	XXXX	Entry of radiation beam path (mm)
1	XXXX	0945	Entry of the programming level
6	XXXX	XXXX	Entry of recalibration time
1	XXXX	1145	Entry of the programming level
			If appropriate, turndown and adaptive filter
0			End

(B) with the original values of the first calibration

Based on the **Date,** the **calibration densities** and the corresponding **pulse rates**, the actual values, depending on the decay of the radioactive source, must be calculated. These values then must be entered into the replacement unit.

- Cs 137: $N_{actual} = \dfrac{N_{original}}{2^{\frac{\text{number of the month passed}}{362}}}$ where N is the pulse rate

- Co 60 : $N_{actual} = \dfrac{N_{original}}{2^{\frac{\text{number of the month passed}}{63}}}$ where N is the pulse rate

7.3. Error codes

If the self check routines of the FMG 573 Z/S detect a unreasonable condition, an error is generated and in rotary switch position 9 an error code is displayed.

Depending on the significance of the error, the alarm relay (A) switches.

A warning (W) will only cause the display of the error code (the alarm relay does not switch).

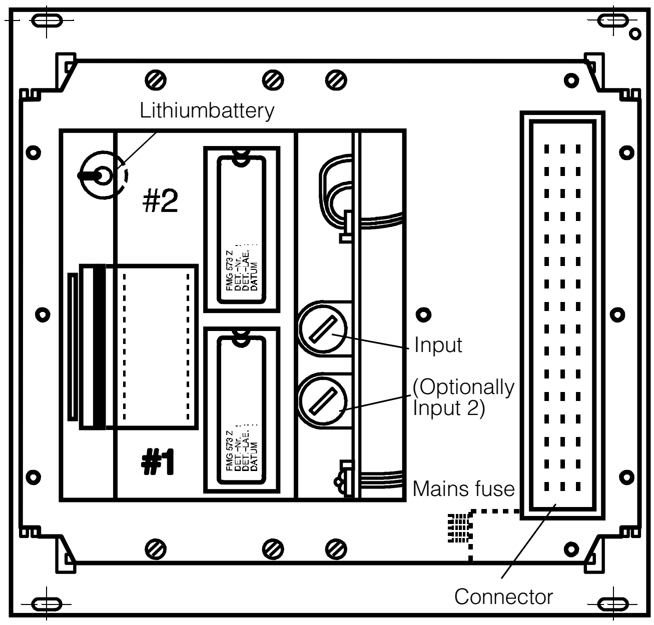
Error- code	M: C:	Meaning corrective actions
E204 (A)	M: C:	Temperature signal from the DG 57 < –30 °C or >80 °C Replace the DG 57; the detector can continue to measure, if in programming level 0145, rotary switch position 6 the value 30 is entered
E205 (A)	M: C:	The pulse rate of the detector is too low Replace the detector DG 57
E206 (A)	M: C:	The reference value is out of the permitted range Replace the detector DG 57
E400 A)	M: C:	No measuring value from the DG 57 and the flow signal or the temperature signal is not reasonable Check the wiring
E401 (A)	M: C:	No signal from the detector DG 57 a) Check the wiring. Take into account the polarity. b) If the wiring is correct, check the voltage at the terminals of the detector. The value should be: 13,7 +/- 3V. If the volatage is correct, a mistake is present at the detector. Exchange detector. c) If the voltage is not correct at the detector, check for the same voltage at the output of the transmitter FMG 573. If the output voltage is not correct, the transmitter is defective.
E402 (A)	M: C:	No signal from the flow or temperature measurement Check the wiring
E403 (A)	M: C:	The frequency of the PFM-signal from the flow or the temperature measurement is too low a) Check and possibly correct the operation mode of the temperature compensation: see Chapter 5.4.1 b) check and possibly correct the selected range: Programming level 0145, rotary switch position 7
E404 (A)	M: C:	The frequency of the PFM signal of the flow or temperature measurement is too high a) Check and possibly correct the operation mode of the temperature compensation: see Chapter 5.4.1 b) check and possibly correct the selected range: programming level 0145, rotary switch position 8
E410 (A)	M: C:	The calculated density value is lower than zero The pulse rate at the detector is extremely high, e.g. the pipe is empty or only partly filled

Error code	**M: C:**	**meaning corrective actions**
E502 (A):	M: C:	The temperature at the DG 57 is higher then 55 °C Ensure, that the temperature at the detector does not exceed 50 °C: check or install a water cooling jacket
E507 (A)		Call the service of Endress+Hauser
E700 (A)	M: C:	Electro magnetic interference at input 2 Enter in level 0445 respectivly in level 0545, rotary switch position 9 the value 11
E710 (A)	M: C:	Input error of the conversion table The values of the %concentration must strictly increase or decrease
E711 (A)	M: C:	Input error of the conversion table The density values must strictly increase or decrease
E712 (A)	M: C:	Input error of the correction table – % concentration = f (ϑ) The temperature for each table value must be different
E713 (A)	M: C:	Input error of the conversion table The density values must strictly increase or decrease
E730 (A)	M: C:	Input error of the correction table: % concentration or density values depending on the temperature The temperature values must strictly increase Input error of the entry of the density measuring range during the calibration
E801 (A)	M: C:	Input error of the entry of the density measuring range The value in programming level 0445 respectively in 0545, rotary switch position 2 (ρ_{min}) must be smaller than the value in rotary switch position 3 (ρ_{max}).
E810 (A)	M: C:	Input error: the calibration density is out of the measuring range The value entered in programming level 0445, rotary switch position 8 must be within the measuring range defined by switch position 2 (ρmin) and switch position 3 (ρ_{max})
E820 (A)	M: C:	Input error: the density value is out of it's measuring range the values in programming level 0545, rotary switch position 8 must be between the values of switch position 2 (ρ_{min}) and position 3 (ρ_{max}) .
E821 (A)	M: C:	Input error: the calibration is not yet completed, one calibration value for the two point calibration is missing Check the calibration data
E900 (A)	M: C:	The calculated value in engineering units is bigger than 9999 Select a suitable engineering unit for which the display range of 4 digits is sufficient
E901 (W)	M C:	M: The pulse rate is out of the measuring range Perform the one point- or two point calibration
E902 (A or W)	M: C:	Automatic recalibration running Selectable as alarm or warning in 945/8 Disappears when recalibration has finished
E999 (W)	M:	Please call the service of Endress+Hauser

7.4. Trouble shooting

If none of the digits of the display are visible, check the power supply and the fuses.
The picture below shows positions and ratings of the fuses.

Glass fuses of the GAMMASILOMETER FMG 573 Z
Transmitter back plate and the p-c-board for the 2 EPROMS removed



Mains		Fuse for the (intrinsically safe) input	Mains fuse
220 V ... 240 V	50/60 Hz	63 mA	125 mA
110 V ... 127 V	50/60 Hz	125 mA	315 mA
24 V	50/60 Hz	630 mA	1,0 A
24 V DC		630 mA	- - - -
		Semi slow	

7.4.1 Maintenance of the pipe

For any activities inside or at the pipe, e.g. cleaning, the radiation must be “switched off“, the collimating slot of the source container must be closed. For details, refer to the technical information of the QG 020 or QG 100.

7.4.2 Control of the radionuclide

Due to the radioactive decay of the source, its activity decreases over the time. This decrease is compensated by the FMG 573 Z up to a certain degree. If the activity has declined so far that the statistical variation of the radiation is shown by instability of the display (especially in the lower range), a constant reading can be achieved by increasing the integration constant.

If the pulse rate has declined to 50 % of it’s original value, the radionuclide should be exchanged.

7.5. Programming matrix for additional functions

0	**Operating level**	**Basic settings**	**• Relay functions • Totaliser**	**• Operation mode • Calibration mode**	**1-point calibration**	**2-point calibration**	**Selection of units, conversion density to % conc.**	**Re-calibration**	**Other functions**
	Code 0045	Code 0145	Code 0245	Code 0345	Code 0445	Code 0545	Code 845	Code 945	Code 1145
2	Switchpoint relay 1 [%] **I0.0**	Relay 1: safety mode 1.0 minimum safety 1.1 maximum safety **I.0**	Relay 1: hysteresis [%] or creeping quantity supression [%] **3.0**	Operation mode 31 Solids content 32 Massflow **I0**	Start of the density measuring range ρ_{min} [g/cm^3] **I.000**	Start of the density measuring range ρ_{min} [g/cm^3] **I.000**	Selection of engineering unit 1: g/cm^3 31: % conc. = f (θ) **1**		Increased turndown 0: de-activate 1: activate **0**
3	Switchpoint Relay 2 [%] **90,0**	Relay 2: safety mode 1.0 minimum safety 1.1 maximum safety **I.I**	Relay 2: hysteresis [%] if used as a set point **3.0**	Calibration mode 1: 1 point calibration 2: 2 point calibration **2**	End of the density measuring range ρ_{max} [g/cm^3] **2.000**	End of the density measuring range ρ_{max} [g/cm^3] **2.000**	1: g 01: cm^3 2: kg 02: dm^3 (l) 3: t 03: m^3 4: oz 04: inch^3 5: lb 05: ft^3 6: s cwt 06: y^3 (GB) 7: cwt 07: fl.oz (GB) 8: s ton 08: fl.oz US 9: ton 09: Gal. (GB) 10: Gal. (US) **-200**		4 mA value **0**
4	Higher calibration pulse rate [N/100 ms] at ρ_{min} **5.000**	Isotope: 0: Co 60 1: Cs 137 **I**	Pulse value for the totaliser mode **9999**	Lock-/unlock Code 0045 4+ 6 1111: Unlock 9999: Lock **9999**	Linear absorption coefficient µ: (calculated from 2-point calibration) **6.154**	K-factor **I.000**	**0**	**0**	20 mA value **100**
5	Actual pulse rate [N/100 ms] integrated **XXXX**	Current output 0: 0 ... 20 mA 1: 4 ... 20 mA **0**	Engineering unit of the totaliser 1: g 6: sh cwt 2: kg 7: cwt 3: t 8: sh tn 4: oz 9:tn 5: tb **3**	Length of the radiation beam through the process fluid [mm] **200**	Absorption coefficient K x 1000 **I.000**	Selection of the calibration point 1: ρ_{low} 2: ρ_{high} 31: $\rho_{cal}=\rho_{low}$ 32: $\rho_{cal}=\rho_{high}$ **I**	**XX**	Current measured value in units as selected in 0845 **XXXX**	Factor for scaling 1...1000 **1**
6	Lower calibration pulse rate [N/100 ms] at ρ_{max} **4.000**	Analogue output during alarm 02: - 10% 12: 110% 20: Hold 30: Continue 11: 100 % 01: 0 % **I2**	Totaliser Relay 1 only for the totaliser mode >E< resetting to 0 **0**		Actual pulse rate [N/100 ms] integrated, press >E< to calibrate **XXXX**	Actual pulse rate [N/100 ms] integrated, press >E< to calibrate **XXXX**	Current measured value in units as selected in 0845 **0**	Entry calibration mode 0: manual 1: automatic **0**	Percentage Δ pulse rate for adaptive filter 1...100 **0**
7	Integration constant 0 ... 1000 s **60**	Frequency for the start of the measuring range of input 2 ≙ 0/4 mA **200**	Preset value for relay 2 Only totaliser mode **I.000**	Actual measuring value, engineering unit as selected in 1045/6 **XXXX**	Calibration pulse rate [N/100 ms] **XXXX**	Calibration pulse rate [N/100 ms] **XXXX**	% conc. = f (θ) Entry of table no. 1...18 33 deletes all values **0**	τ for recalibration **0.000**	Factor X for adaptive filter 1...10 **0**
8	**XX**	Frequency for the end of the measuring range of input 2 ≙ 20 mA **I200**	Simulation of the output signal – 10 %...110 % **XX**	Start of the measuring range of the analogue output, engineering units as selected in 1045/6 **XXXX**	Entry of the calibration density, the engineering unit is always [g/cm^3] **I.500**	Entry of the Calibration density, the engineering unit is always [g/cm^3] **I.500**	% conc. = f (θ) Entry of % concentration value **0**	Error code E902 during recalibration 0: alarm off 1: alarm on default	Product temperature **XXXX**
9	Error analysis Display of the actual error code **E-**	Last error code delete with >E< **Exxx**	Days of operation delete with >E< **XXXX**	End of the measuring range of the analoque output, engineering unit as selected in 1045/6 **XXXX**	Selection of the calibration set 0.1-0.3 Set no. 1.X Activate 2.X Delete **I**	Selection of the calibration set X.1-X.3 Set no. 1.X Activate 2.X Delete **I**	% conc. = f (θ) Entry of corresponding density value [gm/cm^3] **0**	——— **XXXX**	

6.5.1 Calibration data

	Calibration	Recalibration
Measuring line no.	....	....
Day no.	....	....
Detector no.	....	....
Date	....	....
Process fluid	....	....
Temperature range	....	....
Flow range	....	....
	....	....
Density range ρ min ...ρmax	....[g/cm]3	.... [g/cm3]
Engineering Unit	....	....
ρ1: Lower density calibration value	....[g/cm3]	.... [g/cm3]
N1: Pulse rate for the lower calibration value	.... [N/100 ms]	.....................................[N/100 ms]
ρ 2: Higher density calibration value	....[g/cm3]	.... [g/cm3]
N2: Pulse rate for the higher calibration value	.... [N/100 ms]	.....................................[N/100 ms]
Integration constant	....[s]	.... [s]

Remarks: ....

....

Company name: ....

Address: ....

....

Contact person/phone no.: ....

Calibrated by: ....

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