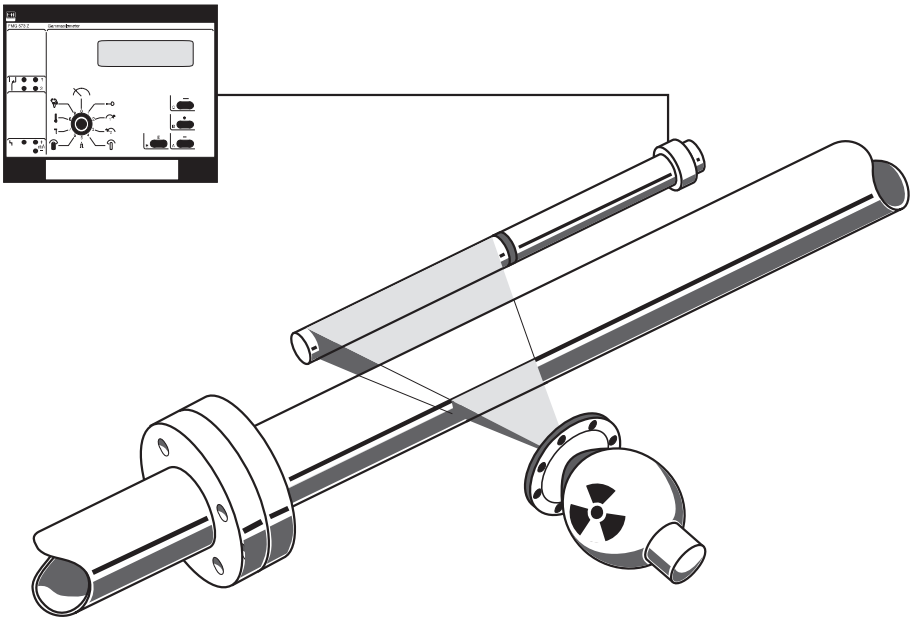
Technical
Information
TI 110F/00/en

Radiometric Density Measurement
System FMG 573 Z/S+DG 57-Density

For measuring density and mass flow using a high sensitivity rod scintillator and low activity radioactive source



Applications

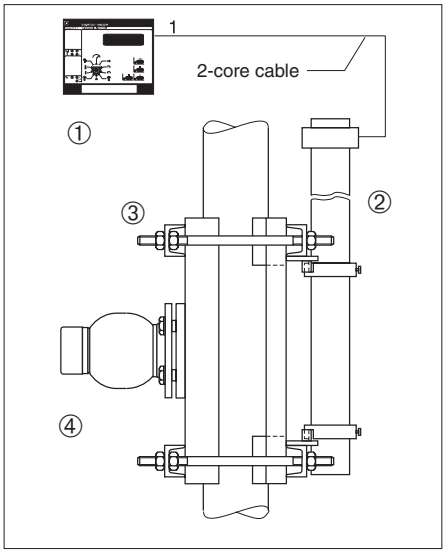
- Chemical industry:
  Concentration measurements, monitoring polymerisation processes, identifying different liquids in piping systems
- Mining, quarrying and mineral processing:
  Measurement of solids contents in slurries and sludge, monitoring sedimentation rates
- Environmental protection:
  Lime feed production for flue gas desulphurisation units, monitoring sedimentation tanks for sewage sludge in treatment plants
- Pulp and paper:
  Concentration measurement of alkalis
- Oil industry:
  Density measurement of drilling mud, identification of oil types transported through the same piping

Features at a Glance

- Non-contact measurement independent of process conditions such as pressure, temperature, viscosity, flowrate or corrosion.
- Easy installation (and retrofitting) by clamping the measuring system onto the piping.
- Rugged, insensitive to vibration
- Rod scintillation detector with self-monitoring and automatic compensation for long-term ageing
- High statistical accuracy despite extremely low source activity, even with short time constants
- Same transmitter for measuring density, mass flow, level and interface layers
- No expensive cable required
- RFI immune through redundant digital transmission (plausibility control)

Endress+Hauser
The Power of Know How

Measuring System



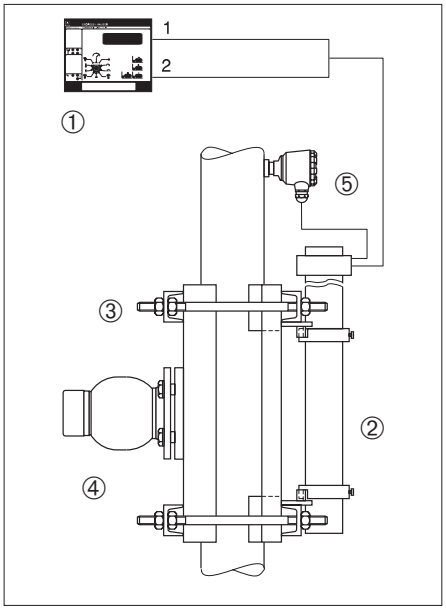
Density measurement
① FMG 573
② DG 57
③ clamping device
④ QG 020/100

Density Measurement
The density measuring system consists of the following units:

- radioactive source
- QG 020/100 source container
- DG 57-density, scintillation detector
- clamping device for detector and source container (for piping systems)
- FMG 573 Z/S transmitter.

The following technical units can be assigned to the analogue signal and display:

- density [g/cm^3]
- % concentration
- % solids [mass]
- solids content [% volume]
- solids content [mass/volume]



Density measurement with temperature compensation
① FMG 573
② DG 57
③ clamping device
④ QG 020/100
⑤ TMT 2530 Z

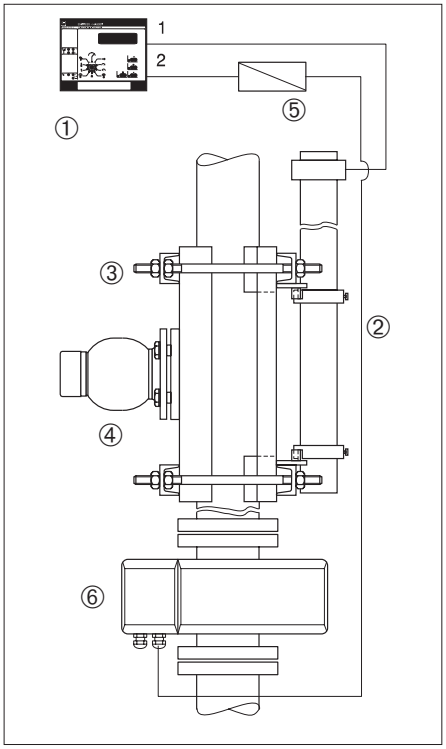
Density Measurement with Temperature Compensation
In this application the temperature of the medium is accurately measured using the

- TMT 2530 Z temperature measurement system.

The temperature-dependent signal is digitised and sent to the transmitter as a PFM signal. Any analogue signal for existing temperature measurements must be converted into a PFM signal using a TSP 8267 converter.

The following technical units can be assigned to the analogue signal and display:

- density [g/cm^3]
- % concentration
- °Be, °Bx °API,°Twaddell on request



Mass flow measurement
① FMG 573
② DG 57
③ clamping device
④ QG 020/100
⑤ TSP 8267
⑥ flowmeter

Mass Flow Measurement
Density measurement is combined with an electromagnetic measurement of flowrate, e.g. using an Endress+Hauser flowmeter.

The conversion of the analogue flow signal into a PFM signal requires the

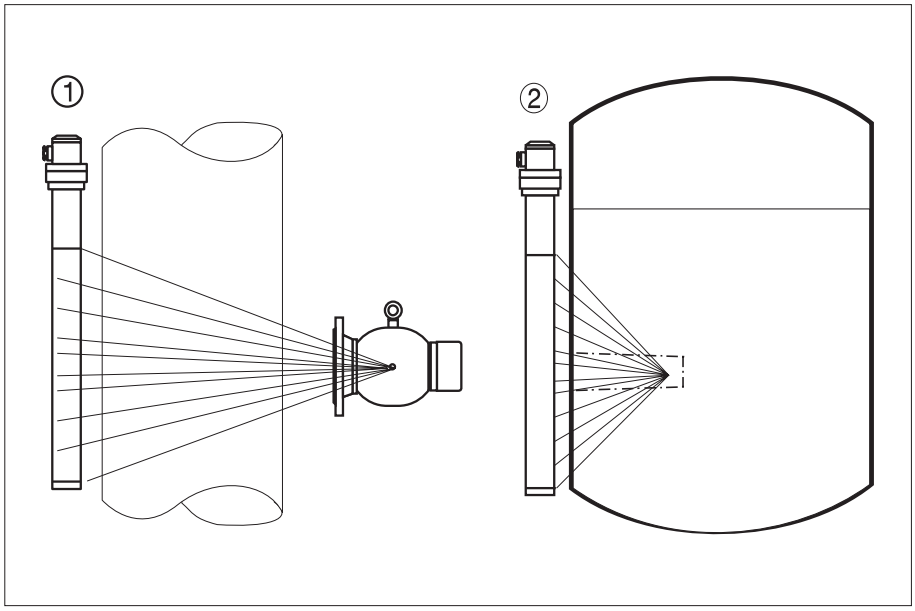
- TSP 8267 converter.

The following technical units can be assigned to the analogue signal and display:

- total mass flowrate e.g. [t/h]
- solids content of mass flowrate, e.g. [kg/h]

Two relay outputs are available for totalisation and a preset value.

Function and Accuracy



Radiometric measurement system for
① density in piping
② density in tanks

The medium to be measured is exposed to a beam of gamma radiation emitted along a uniform measuring path by a radioactive source. The degree to which the radiation is attenuated is a function of the density of the medium.

$$FS = e^{-\mu \bullet D \bullet \Delta\rho}$$

FS = attenuation factor
μ = absorption coefficient
$\Delta\rho$ difference in density
D = measuring path through medium

A detector converts the attenuated radiation into a signal proportional to its intensity. The signal is then processed and evaluated by the FMG transmitter and converted into a standard 0/4...20 mA signal.

Accuracy
Accuracy is largely determined by three factors:
- Stability of the detector
- Statistical variation in the countrate
- Accuracy when calibrating.

Stability of the Detector
The measuring uncertainty of the detector is largely eliminated by the following:

- using specially selected components
- compensating for long-term ageing using reference pulses
- compensating for temperature drift (typically <0.01 % per Kelvin).

Statistical Variation in Countrate
This factor is typical for every radiometric measuring system and is due to the statistical nature of source decay. It is determined by the following factors:

- internal diameter of the piping
- density measuring range $\Delta\rho$
- type of source
- dose rate at the detector or detector sensitivity
- acceptable time constant (τ).

Measurement uncertainty is calculated using the following formula with 2σ confidence intervals:

$$\text{Meas. uncertainty } (2\sigma) = \frac{\pm 2\sqrt{N}}{\sqrt{\tau}}$$

N = pulse rate “counts/s”
τ = integration time “s”

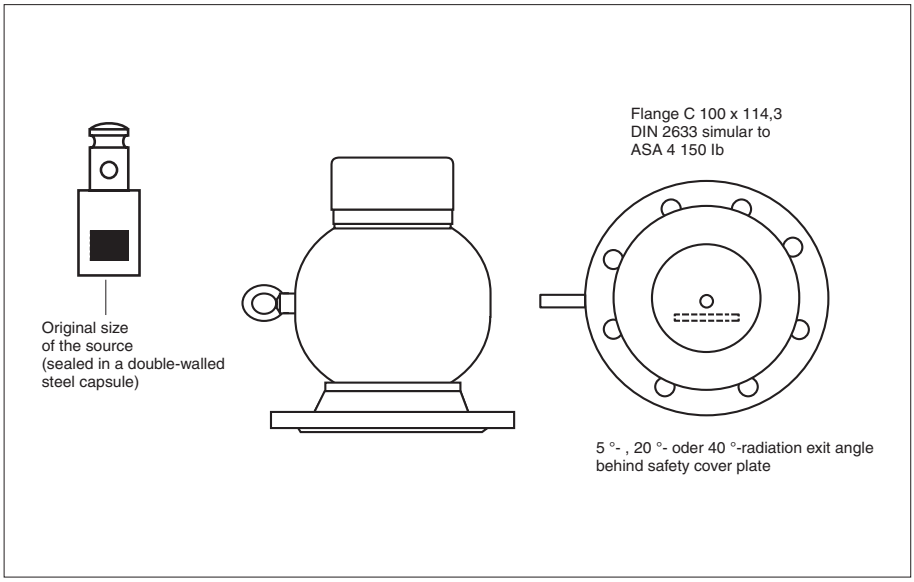
The formula shows that statistical variation can be reduced by using a high pulse rate and by increasing the integration time.

Calibration
The measuring system has a calibration program to calculate accurately the linearisation curve required for the particular application. The following calibrations can be carried out when commissioning:

- 1-point calibration, for rapid commissioning
- 2-point calibration, for high accuracy over the entire measuring range
- An application-specific calibration with up to 20 measuring points

Up to 4 sets of calibration parameters can be stored, so that the measuring system can easily be adapted to the most varied requirements met in process conditions.

Source Container and Source



Source container
QG 020/100, standard
version with source
Dimensions in mm
1" = 25.4 mm

Source Container, with Safety Lock
The source containers QG 020 and QG 100 are available with the version TSP 013337 for use in density measurement. Other versions: pneumatic or electric actuation.

Emission angle of beam outlet channel:
- 40° for piping up to DN 600
- 20° for piping larger than DN 600
- 5° for diagonal beams through the piping

Radioactive Source
The measuring system offers special advantages with regard to applications requiring caesium Cs 137 or cobalt Co 60. The isotope and activity strength depend on the specific application for which they are used. The high sensitivity of the rod scintillator ensures that extremely low activity sources can be used.

Source Type and Position
The measuring principle makes necessary a careful selection of source type and position of the measuring system. This is done using known data for $\Delta\rho$, density measuring range "g/cm^3", and D internal diameter "mm" set out in the table below.

D x $\Delta\rho$	15…30	30…300	300…600
Source	Cs 137	Cs 137	Co 60
Position	diagonal beam	normal beam	normal beam

Example:
- internal diameter D = 150 mm
- density range = 1.15...1.38 g/cm^3
  $\Delta\rho$ = 0.23 g/cm^3
- D x $\Delta\rho$ = 150 x 0.23 = 34.5
- Result:
  Cs 137 source with a normal beam

Source container QG 020/100

Version

E	European	modified for density measurement	TSP 013337-0000
R	Standard	modified for density measurement	TSP 013337-0001
S	Swedish	modified for density measurement	TSP 013337-0000

Mounting flange / material

P1	Flange DN100 PN16/ steel
P2	Flange DN100 PN16/ stainless steel 1.4571
R1	Flange similar to ANSI14" 150psi/ steel
P1	Flange similar to ANSI14" 150psi/ stainless steel 1.4571

Emission angle

A	5 deg.
B	20 deg.
C	40 deg.

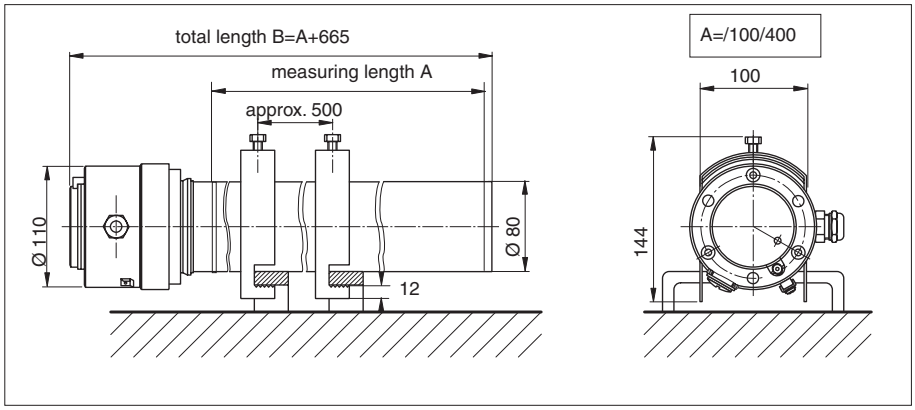
QG ★★★- ☐☐☐ **Complete order code +** **TSP 013337-**

★★★ 020 or 100

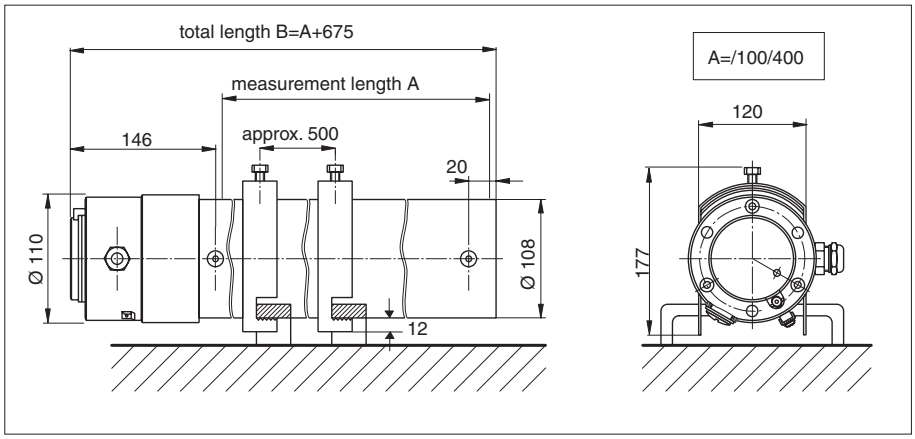
Radioactive source **Cs 137 or Co 60** ☐ **MBq/GBq**

Order key for
QG 020/100 source
container and
source

Scintillation Detector DG 57



Dimensions in mm
detector DG 57



Dimensions in mm
detector and water
cooling jacket

Detector DG 57-Density, 400/100 mm
The DG 57 scintillation detector has the highest sensitivity and comprises a plastic scintillator with a photomultiplier and detector electronics. The detector is encased in a corrosion-resistant steel tube and can be mounted with clamps.

The high degree of sensitivity requires a high pulse rate which reduces statistical variation and results in a highly accuracy measurement. An active closed reference circuit with reference pulses carries out self-monitoring and automatic compensation for long-term ageing, ensuring detector reliability and a long operating life.

- A water jacket is available for ambient temperatures between +40 °C…+120 °C.

The active measuring length A is 100 mm or 400 mm.

Detector DG 57

Certificate, approvals
A ATEX II 2G/EEx d ib IIC T6 s. XA 057F
H ATEX II 2G/EEx d IIC T6 s. XA 057F
M ATEX II 2G/EEx de IIC T6 s. XA 057F
D ATEX II 2D IP65 T 60 °C s. XA 112F

Material
1 Pipe in 1.4301

Measuring length
A 400 mm
H 100 mm
P 100 mm, with water cooling jacket
R 400 mm, with water cooling jacket

Electrical connection
1 1 x water-proof gland PG 16

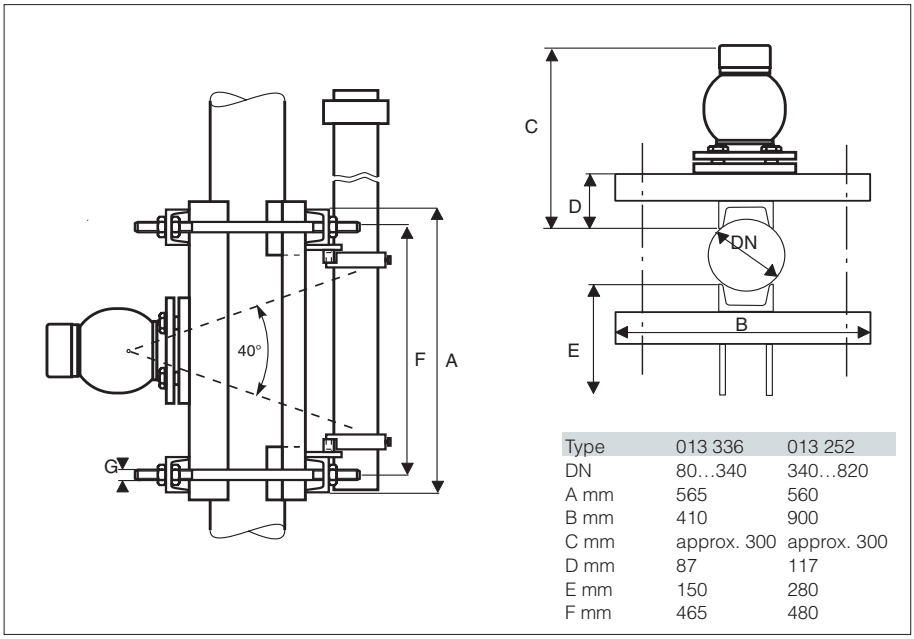
Application
B for density measurement (measuring length 400 mm/100 mm)

Source
1 Cs 137
2 Co 60

Complete order code

Order code for
detector DG 57

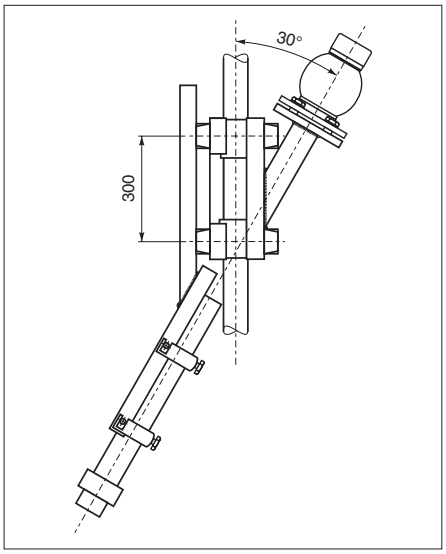
Clamping devices

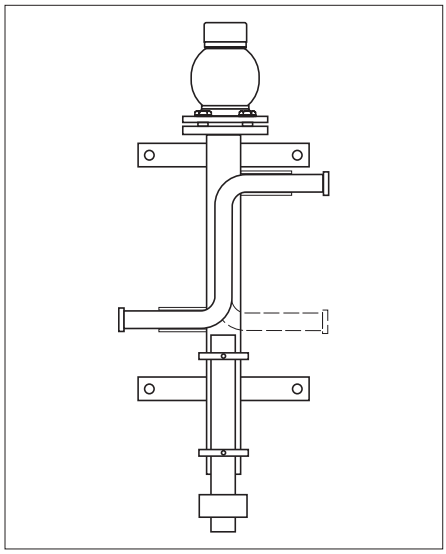


Type	013 336	013 252
DN	80…340	340…820
A mm	565	560
B mm	410	900
C mm	approx. 300	approx. 300
D mm	87	117
E mm	150	280
F mm	465	480

Positioning for normal beam

Clamping device dimensions (mm) type TSP 013 336/013 252





Left:
Positioning for diagonal beam, pipe clamping device TSP 015354 for DN 80...200

Right:
measuring path for density measurement

Clamping devices
The following methods are available:
- Clamping devices for piping DN 80...340, Type 013336
- Clamping devices for piping DN 340...820, TSP 013252
- Measuring path for density measurement (KLEMMD)
- Coated measuring pipes, fittings for diagonal beams through piping, clamps for pipes >DN 820 or complete measuring paths with small pipe diameters on request.

Clamping devices for density measurement

Nominal diameter
1 80…340 mm TSP 013336
2 340…820 mm TSP 013252
3 80…200 mm for diagonal beam TSP 015354

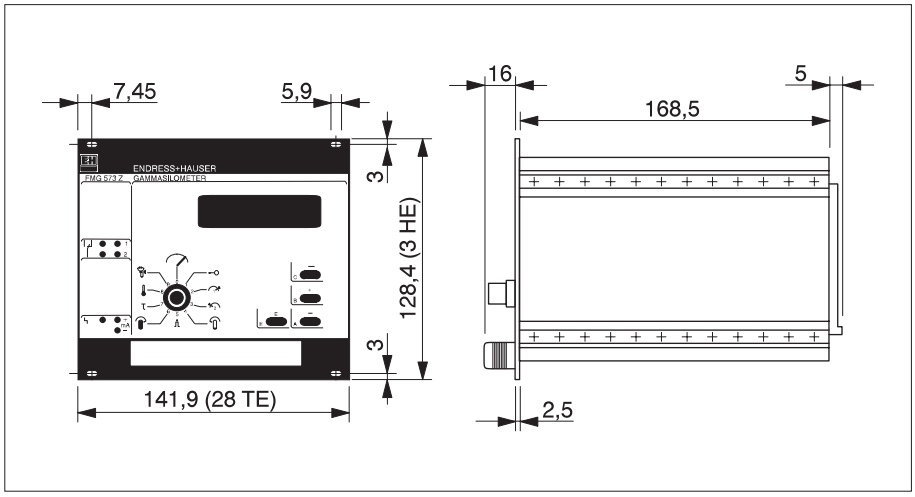
Material, clamps
A Steel, epoxy lacquered
B Steel, galvanised

Material, mounting material
1 Steel, galvanised

Order code for clamps

KLEMM- ☐☐☐ **Order code**

Gammasilometer FMG 573



Dimensions (mm) of transmitter FMG 573 Z/S

Gammasilometer FMG 573 Z/S
The microprocessor-controlled transmitter carries out the following functions:

- power supply to the detector and temperature transmitter
- automatic determination of linearisation curve required as a function of process data (pipe diameter, density range, absorption coefficient of the medium)
- automatic compensation of the natural source decay for Cs 137 or Co 60
- conversion of the internal density units "g/cm^3" into other international units
- evaluation of self-monitoring signals from the detector and display of error messages on fault condition.

Gammasilometer FMG 573 Z/S

Variant
Z to be operated without Safety barrier
S to be operated with Safety barrier*

Certificate
R without Certificate

Version
1 for 1 detector DG 57 /density

Power supply
J 240 V_{AC}, 50/60 Hz
A 220 V_{AC} (230V, +10%, -15%), 50/60 Hz
G 127 V_{AC}, 50/60 Hz
F 115 V_{AC}, 50/60 Hz
B 110 V_{AC}, 50/60 Hz
D 24 V_{AC}, 50/60 Hz
E 24...28 V_{AC}

Output
1 0/4…20 mA, 0/2…10 V, change-over contact

FMG 573	☐	-	☐	☐	☐	☐	Complete order code

* This variant must not be operated without safety barrier.
Order code of the safety barrier: 016240-2015

Order code for transmitter FMG 573

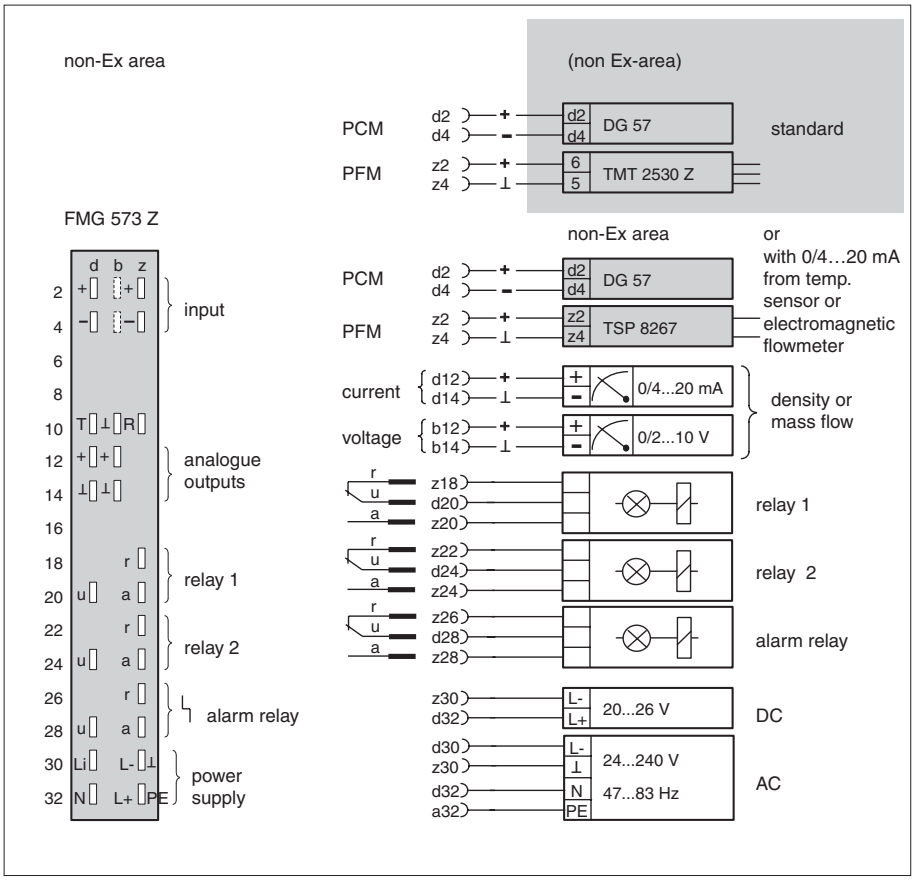
Electrical Connection

The detector is supplied with power via the FMG 573 Z/S transmitter:

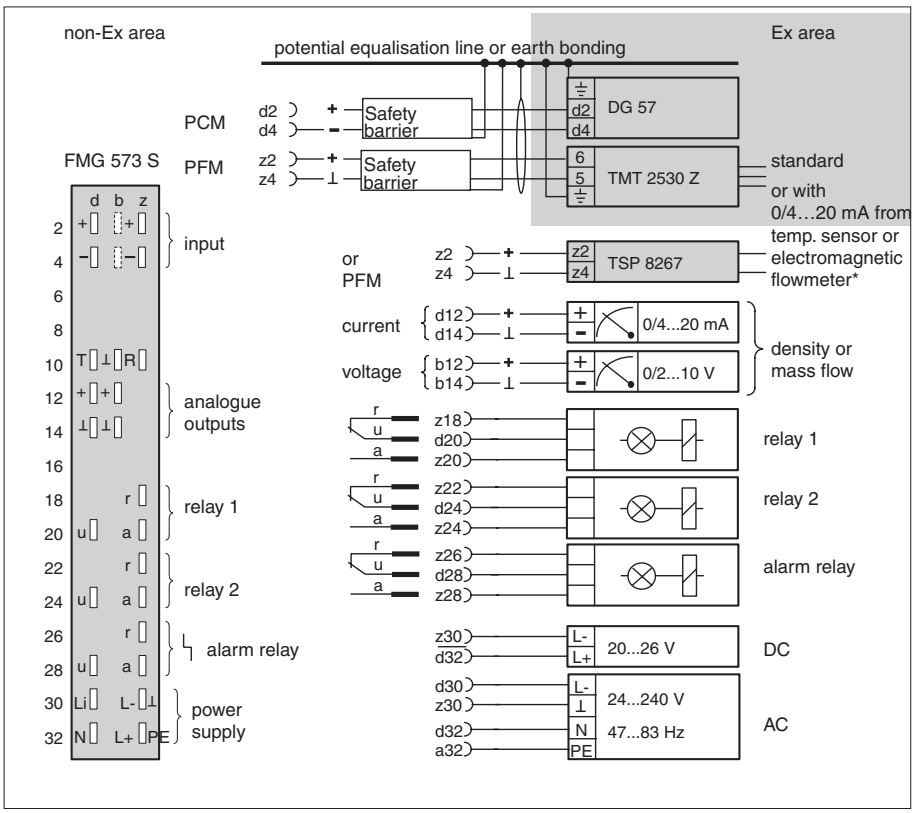
- two-core, commercial installation cable, resistance max. 25 Ohm per core
- screened cable is recommended in electrical or magnetic fields.

- Type of Protection: [EEx ib] IIB / IIC with Zener barrier and FMG 573 S

All local regulations governing explosion protection must be observed when laying cables in hazardous areas

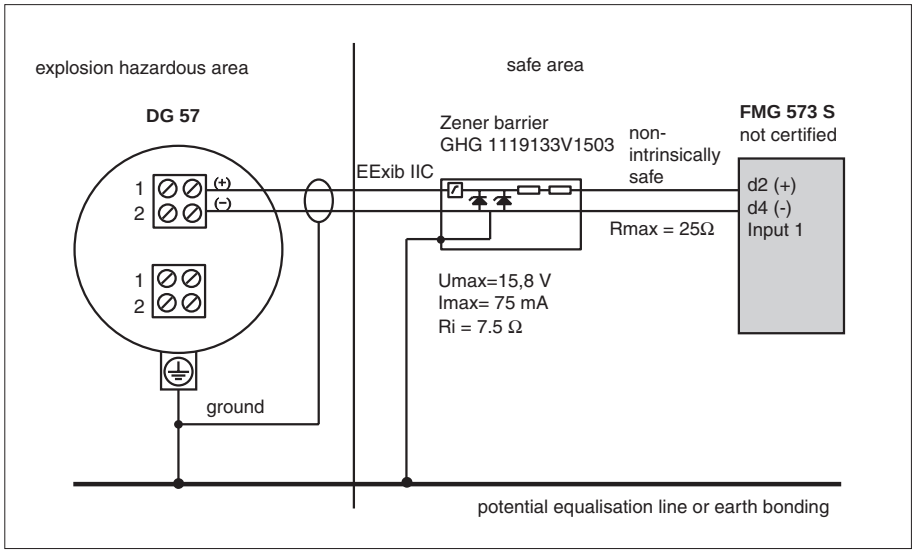


Connection diagram for use in non-explosion hazardous areas

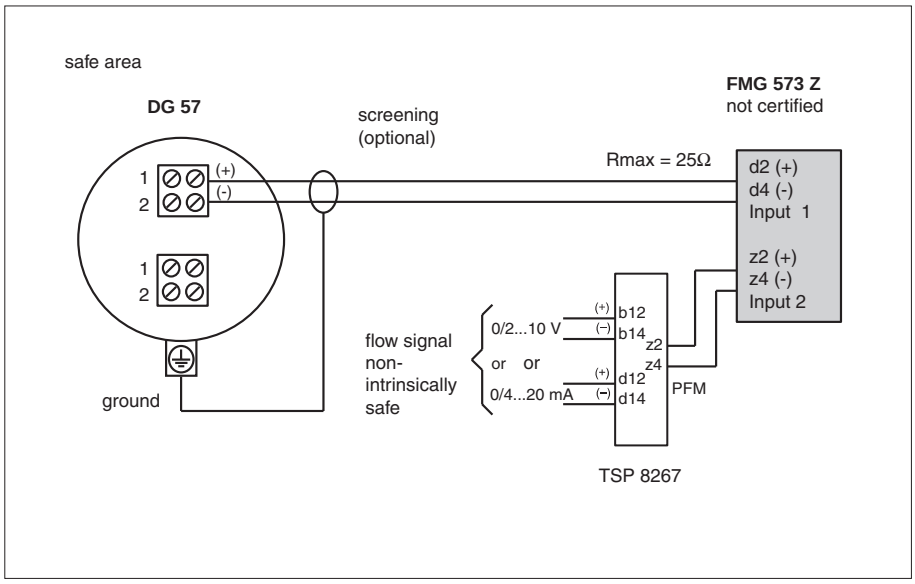


Connection diagram (EEx ib) IIC for FMC 573 S
*Ex-protection for temperature sensor/ electromagnetic flowmeter must be incorporated in the transmitter.

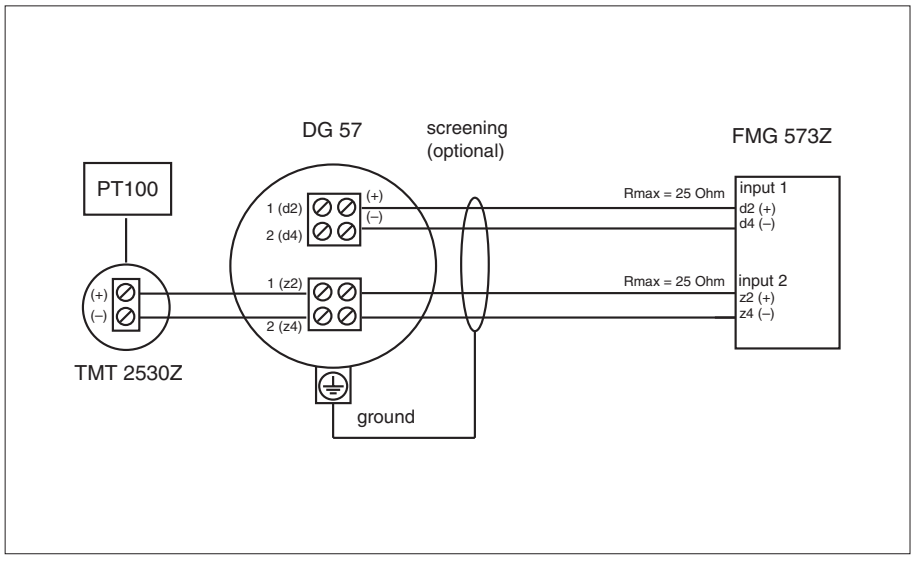
Detector Connection



Density measurement
Connection diagram for
[EEx ib] IIB/IIC with
FMG 573 S



Mass flow measurement
Connection diagram for
non-explosion
hazardous areas for
FMG 573 Z



Temperature-compensat
ed density measurement
Connection diagram for
non explosion hazardous
areas with FMG 573 Z

Accessories

U/F Converter TSP 8267
This converts an analogue 0/4…20 mA or 0/2…10 V into a PFM signal. The converter has the following functions:

- temperature input for density measurement with the Gammasilometer FMG 573 Z/S using an existing temperature measurement system with an analogue output. Not required for the TMT 2530 Z
- flowrate input for mass flowrate with density measurement using the Gammasilometer FMG 573 Z/S and a flowmeter.

Available as 4 HP, 19" Racksyst card with 28-pole plug to DIN 41 612, Type F.

Flowmeter
For mass flow measurements, the density determination is combined with flowrate measurement from an electromagnetic flowmeter. Depending on pipe diameter and flowrate, the following Endress+Hauser flowmeters are suitable:

- Variomag or Tecmag

A TSP 8267 converter is required for converting the analogue flow signal into a PFM signal. Technical data are given in the corresponding documentation.

Control Panel Housing
35 HP steel plate housing with screw terminals at rear. For mounting the Gammasilometer FMG 573 and TSP 8267 U/F converter.

Temperature Sensor
A suitable sensor must be used for density measurement with temperature compensation. This can be:

- a sensor with a PFM signal, e.g. Omnigrad TMT 2530 Z or
- a sensor with a 0/4…20 mA output e.g. Omnigrad TMT 2034 Z in connection with the TSP 8267 U/F converter.

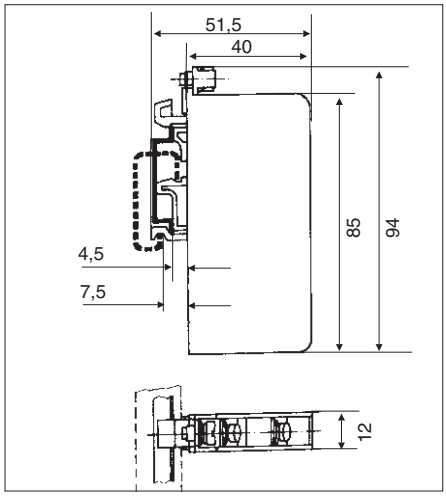
Technical Data, TMT 2530 Z:

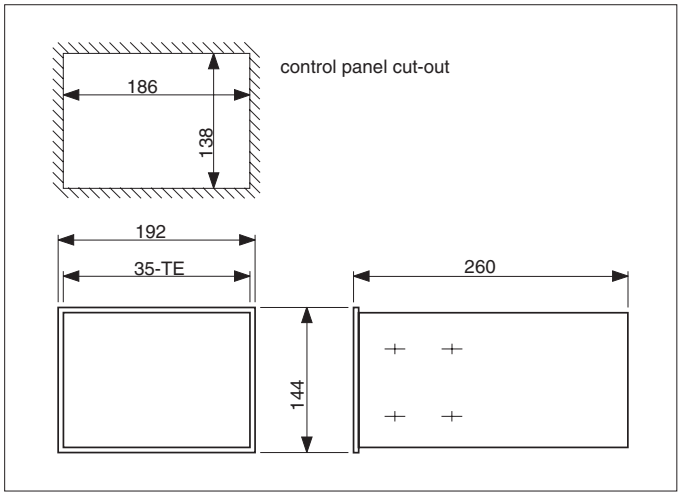
- Measuring range: -200 °C…+850 °C
- Operating temperature: -20 °C…+60 °C
  Storage temperature: -40 °C…+85 °C
- Pt 100 measurement current: 1 mA
- Power supply: 14.8 V, 10 mA

Zener Barrier
A Zener barrier must be connected between the FMG 573 S transmitter and the DG 57 detector to ensure protection class [EEx ib] IIC. Type GHG 1119133 V 1503 from ABB is recommended. Technical data:

- Certificate of conformity: PTB No. Ex 85.B.2082 X
- Operating temperature:-40 °C…+40 °C
  Storage temperature: -40 °C…+80 °C
- Installation area: Outside the Ex area in a housing, protection to IEC 144: min. IP 20

Dimensions Zener barrier





Dimensions in mm of control panel housing

1" = 25.4 mm

Ordering key, accessories

U/F Converter TSP 8267	**Order No.**	**208267-0000**
Zener barrier	**Order No.**	**016240-2015**
Temperature sensor	**see Temperature Measurement Program**	
Flowmeter	**see Flow Measurement Program**	
Control panel housing TSP	**Order No.**	**09011-0000 (Non-Ex)** **09011-0001 (Ex)**

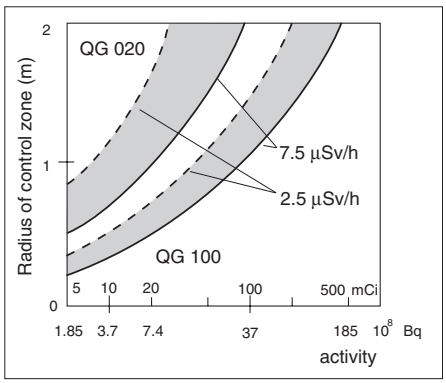
Technical Data

Radioactive Source

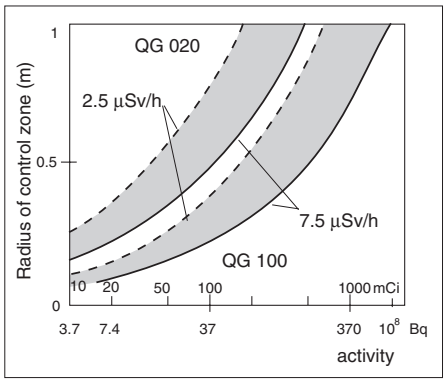
- Cs 137 (glass-ceramic caesium) or Co 60 (metallic cobalt)
- double sealed and welded stainless steel capsule
- Classification C 66646 to ISO 2919 or DIN 25426, Part 1
  (Guaranteed source protection against extreme temperatures, pressures as well as impact, vibration and puncturing.)

Source Container QG 020/100

- Housing:
  steel, RAL 1004 yellow paint with warning symbol in black
- Dimensions:
  see figure on page 4 and TI 194F
- Max. ambient temperature: +250 °C
- Shielding material: lead
- Shielding
  QG 020: approx. 5.2 HVL with Co 60
  approx. 7.6 HVL with Cs137
  QG 100: approx. 7.5 HVL with Co 60
  approx. 10.5 HVL with Cs 137
- Max. control area, measured from central point of source container: see figures below.



Control zones for QG 020 and QG 100 with Co 60 source
—— 7.5 µSv/h
- - - 2.5 µSv/h



Control zones for QG 020 and QG 100 with Cs 137 source
—— 7.5 µSv/h
- - - 2.5 µSv/h

- Radiation emission channel: 5°, 20°, 40° (in one plane), outlet channel closed by steel cover plate
- Weight:
  QG 020: approx. 40 kg
  QG 100: approx. 87 kg
  1 kg = ca. 2.2 lbs

Detector DG 57

Scintillation detector 100 and 400 mm

DG 57	100	400
Sensitivity for		
Cs 137 [c/s per mSv/h]	1560	3900
Weight [kg]		
1 kg = ca. 2.2 lbs	12.6	14.0
Weight with cooling jacket [kg]	18.0	19.5

- Dimensions: see figure on page 5
- Housing material: stainless and acid-resistant steel 1.4301
- Protection: IP 65
- Cable gland: NPT $^1/_2$", G $^1/_2$", M 20 x 1,5
- Mounting accessories: 2 clamps in 1.4301 (supplied)
- Permissible ambient temperature:
  -20 °C... +50 °C
  with water cooling: +40 °C...+120 °C
  A water cooling jacket is recommended for temperatures above +40 °C
- Type of protection:
  EEx d ib IIB/IIC T6,
  EEx d IIB/IIC T6,
  EEx de IIB/IIC T6
  with Zener barrier GHG 1119133 V 1503, ABB and Version FMG 573S only
- Power supply from FMG 573
  - voltage approx. 13.3 V
  - base current approx. 50 mA, short-circuit proof
- Output signal: PCM signal, base current superimposed with pulses of approx. 15 mA and approx. 200 ms duration
- Sensitivity adjustment and function monitoring: automatic with reference pulses

Water Cooling Jacket

- Material: stainless and acid-resistant steel 1.4301
- Dimensions: see figure on page 5
- Connection: 2 x G$^1/_2$ A,
  40...200 l/h
- max. water temperature 40 °C
- water pressure 4 - 6 bar

Technical Data

Transmitter FMG 573 Z/S

- Dimensions: see figure on page 7
- Housing: 19" Racksyst board 28 HP wide
- Plug connection: Plug strip to DIN 41612, Type F
- Protection: IP 20 front panel, IP 00 connection strip
- Weight: 2.2 kg
- Permissible ambient temperature: -20 °C...+60 °C
  Permissible storage temperature: -40 °C...+75 °C
- Power supply: 24/110/115/127/220/230/240 V AC +15 %/-10 %, 50...60 Hz; 20...28 V DC
- Power consumption: approx. 23 VA, approx. 15 W
- Data backup: CMOS RAM, battery buffer for 8 years min.
- Analogue outputs: 0/4...20 mA (selectable) RL max. 500 Ohm
  0/2...10 V (selectable) RL min. 1 kOhm
  Test sockets for current output on the front panel
- Output signal linear, proportional to density
- Relay outputs: 2 potential-free changeover contacts for limit values or for totaliser/preset counter;
  1 potential-free change-over contact for fault indication.
- Switching capacity: U=250 VAC; I = 4 A; P~=500 VA, cosj > 0.7
  P= 100 W at 48 V, 50 W at 250 V
- Input 1: PCM signal from DG 57; 13.3 V/48 mA, two-core, common installation cable, max. 25 Ohm per core
- Input 2: PFM signal from TMT 2530 Z or from TSP 8267 (analogue/PFM converter)
- Type of protection: [EEx ib] IIB/IIC with Zener barrier and FMG 573 S
- Time constant: 1...1000 s, adjustable
- Statistical accuracy: up to æ0.0001 g/cm3 depending on density range, measuring path and time constant with 7.5 mSv/h at scintillator
- 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.

Supplementary Documentation

- ❑ Gammasilometer, Gammapilot
  System Information SI 016F/00/en
- ❑ Detector DG 57
  Technical Information TI 180F/00/en
- ❑ Source Container QG 020/100
  Technical Information TI 264F/00/en
- ❑ Analogue/PFM Converter TSP 8267 Z
  Technical Information Sheet
  TSP-01122-i-4
- ❑ Temperature Measuring System "Omnigrad" TMT 2530 Z
  System Information SI 5.89E
- ❑ Endress+Hauser Flow Measurement Programme PG 001D/06/en

Endress+Hauser
GmbH+Co. KG
Instruments
International
P.O. Box 2222
D-79574 Weil am Rhein
Germany

Tel. (0 76 21) 9 75-02
Fax (0 76 21) 9 75-3 45
http://www.endress.com
info@ii.endress.com

Endress+Hauser
The Power of Know How

05.02/PT1

TI 110 F/00/en/06.03
EHF/CV8.0