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Installation and Initial Start-Up Guide for PSG Ex² Analyser Lines

English Version

Table of Contents:

1. General

PSG lines, which are heated by an electrical heating system, are to be handled in the same way as electrical equipment. The designs and connection systems used correspond to best technological practice. Accordingly, the accepted technical standards must be applied during installation, initial start-up and operation.

1.1. Chemical stability

In the PSG Project Data Sheet, the medium is specific by the customer. In accordance with this specification, the use of PTFE, PFA, stainless steel or other materials is defined for the inner tubes.

1.2. Thermal stability

The maximum ambient temperature for the lines is determined in each case by the substance used as the jacket material:

Jacket material		PSG article number	During laying	Before and after installation
PVC Polyvinyl chloride	YM4	54xxxxxx	-15 / +50	-45 / +100
PE - LD low density polyethylene	2YM1 and 2YM2	54xxxxxx	-20 / +50	-60 / +70
PE - LD low density polyethylene	2YM1 and 2YM2	54xxxxxx	-20 / +50	-60 / +70
TPU Thermoplastic polyurethane	TPU	54xxxxxx	-40 / +50	-60 / +120

Table 1: Overview of thermal stability

The temperatures of the medium that flows through the inner tube max be no more than 20% higher than the maximum holding temperature stated on the data sheet.

1.3. Compressive strength

The compressive strength of the inner tubes (e.g.: PTFE) is temperature-dependent. The following applies:

Tube size in mm (OD) PTFE	Temperature 20 °C	Temperature 200 °C
6 x 1	55 bar	16 bar
8 x 1	40 bar	12 bar

Table 2: Compressive strength of PTFE

Tube size in mm (OD) 316L stainless steel	Temperature 20 °C	Temperature 200 °C
6 x 1	390 bar	350 bar
8 x 1	260 bar	235 bar

Table 3: Compressive strength of 316L stainless steel

2. Temperature measurement and control

To measure temperature, sensors are mounted on the exterior of the inner tube. A basic distinction is made between control and limitation. The ambient temperature conditions at the sensor mounting point influence the behaviour of the control system as a whole and, in turn, the line's inner temperature.

To ensure that a temperature maximum is not exceeded, the sensor should be placed in the region that is subject to the highest ambient temperature. For applications using a minimum temperature, the temperature sensor should be installed at the point with the lowest ambient temperature. Accordingly, for safety reasons, the sensor should be located in the region subject to the highest ambient temperature.

Sensors from safety temperature limiters must always be located at the place subject to the highest ambient temperature. As a rule, the limiter is set to the maximum temperature permitted. For control purposes, the sensor can then be set to match customer requirements.

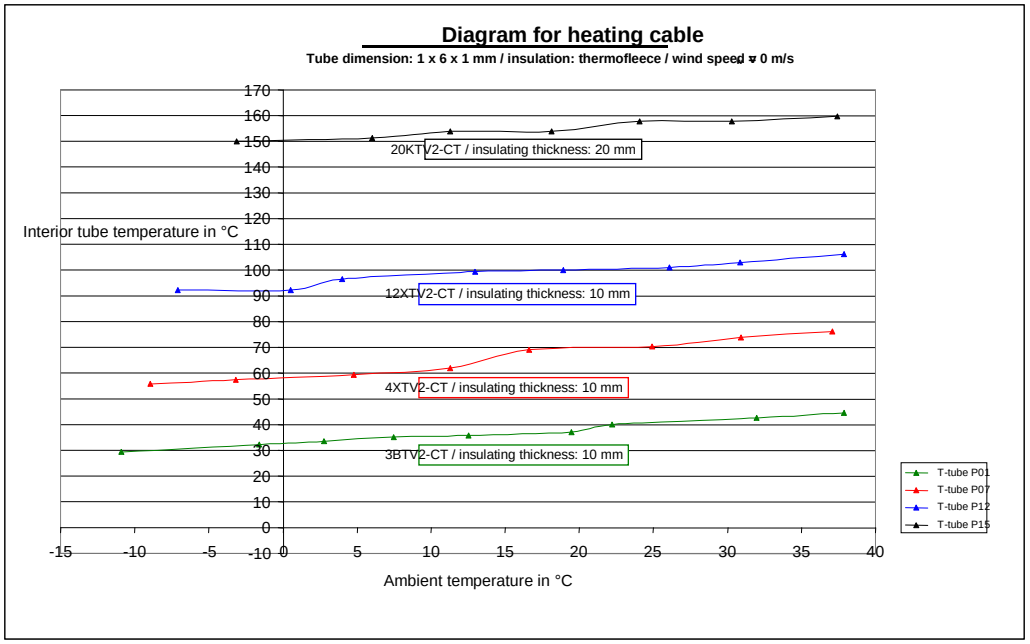


Figure 1: Factors influencing the ambient temperature

Sensors from safety temperature limiters must always be located at the place subject to the highest ambient temperature. As a rule, the limiter is set to the maximum temperature permitted. For control purposes, the sensor can then be set to match customer requirements.

3. Installation and laying

3.1. Transportation and storage instructions

To avoid problems when handling or laying the lines, a number of issues must be borne in mind. This section lists some general instructions, which must be followed at all times.

3.1.1. Transportation

- Drums must be unloaded from the goods vehicle either by using ramps, a crane or a forklift.
- Drums should be unloaded as near as possible to the place where they will be used, to avoid having to roll them over long distances. Do not subject drums to shocks or collisions.
- To guard against excessive mechanical wear and tear, any transfer of lines from one drum to another should be kept to an absolute minimum.

3.1.2. Storage

- Any drums warehoused or stored on building sites must be secured against unintentional or unauthorised rolling elsewhere.
- Tube bundle ends must be protected against the ingress of dirt and moisture.
- The use of shrinkable end caps will be required. When sections are removed, the tube bundle ends must be sealed off using shrinkable end caps.
- Usable leftover lengths should be left on the drum where possible or rewound onto a drum of a sufficient core diameter (= minimum bending radius of the tube bundle).
- In general, the minimum bending radius can be assumed to be 8 to 10 times the outer diameter of the line.

3.2. Drum handling instructions

As a general rule, heated analyser lines should not be laid in protective conduits and closed cable trays, since this could lead to the lines becoming overheated.

Instead, lines must be laid on exposed narrow-gauge cable trays and secured using metal cable clamps. Maximum spacing between cable clamps: 1.4 m. The spacing between the lines as laid should be at least 20 mm. Where analyser lines are laid outdoors, protect as well as possible (from excessive heat loss caused by gusts of wind or other weather conditions). Supply lines running through wall and ceiling ducts must not be obstructed.

No forces exerted by bending or motion should be present directly at the connecting ends. Flanges, screw fittings and valves must not be misused as line access points or suspension points. Where lines are laid vertically, observe the minimum spacing for line fixing points. Alternatively, we recommend attaching strain relief cabling. Coiled lines must be uncoiled using the proper procedure, to ensure they are not subjected to torsion stresses.

	▪ The lines are not able to withstand torsional loading. ▪ Lines must be installed so that the tube axis and direction of movement are in the same plane. ▪ Always observe the minimum bending radiuses at all times. Insulation should be inspected at regular intervals.

3.2.1. Preparing the drum

- Suspend the drum with its core parallel to the ground and so it can rotate freely in a payout frame with a braking mechanism.
- Remove any shrink-wrap packaging on the drum beforehand.
- Release the outermost bundle end from the spool disc fastener.
- Do not remove the capping protecting the bundle ends.
- Uncoil the tube bundle from the top of the cable drum, using as flat an arc as possible and while keeping the bending radius as small as possible.

Figure: Payout frame

3.2.2. Testing the heating cable

Before laying the line, we recommend testing the functionality of the heating cable used in the line. To do so, please proceed as follows:

- For a functional test, at least 500 V DC must be present between the heating cable and the heating cable jacket.
- For inspection, we recommend the use of a digital voltmeter.
- The IEEE 515 standard recommends a voltage of 2500 V DC for polymer-insulated heating cables.
- The figure for resistance should be at least 100 megaohms.
- The results of the test must be entered into the PSD Test Report (included at the end of this document).

Figure: Digital voltmeter

3.2.3. Laying out the tube bundle (with a max. diameter of 42 mm)

This procedure is suitable only for short and straight tube bundle sections. In addition, the procedure as described is to be used only for tube bundles with a maximum diameter of 42 mm:

- Uncoil the tube bundle from the top of the cable drum, using as flat an arc as possible and while keeping the bending radiuses as small as possible.
- While paying out the tube bundle, ensure that the tube jacket cannot be damaged as a result of the tune bundle loop that leads back to the drum scraping along the ground.
- Support the tube bundle with rollers every 2 to 3 metres. A second worker at the drum must actuate the brake lightly to stop the drum continuing to rotate and thus prevent the tube bundle compressing or kinking.
- As the tube bundle is slowly rolled off the drum, workers must carry it forward and lay it carefully in the cable conduit so that it lies straight.

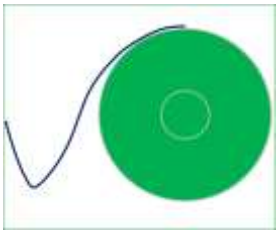


Figure: Laying out the tube bundle

3.2.4. Laying out the tube bundle (diameter >= 43 mm)

For tube bundles and lines with a diameter greater than 43 mm, layout must be carried out in reverse order:

- Uncoil the tube bundle from the **bottom** of the cable drum, using as flat an arc as possible and while keeping the bending radiuses as small as possible.
- While paying out the tube bundle, ensure that the tube jacket cannot be damaged as a result of the tune bundle loop that leads back to the drum scraping along the ground.
- Support the tube bundle with rollers every 2 to 3 metres. A second worker at the drum must actuate the brake lightly to stop the drum continuing to rotate and thus prevent the tube bundle compressing or kinking.
- As the tube bundle is slowly rolled off the drum, workers must carry it forward and lay it carefully in the cable conduit so that it lies straight.

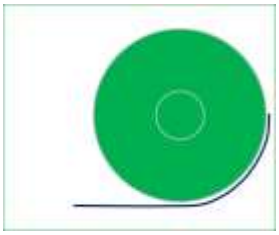


Figure: Laying out the tube bundle

3.2.5. Using a winch to uncoil the tube bundle from the drum

This procedure is suitable for long tube bundle sections, and also for winding conduit routes that are interspersed with obstacles:

- If on-site conditions permit, than the drum must be set up as follows: for sections with drops in elevation, at the higher end of the section; for winding section routes, at the section end that is closest to the most curved part of the entire section.
- The cable winch is to be set up as a straight continuation of the payout section.
- Corner ground rollers are to be placed at bends.
- Rollers are to be located as appropriate for the tube bundle's minimum bending radius.
- If damage to the outer jacket is possible, ground rollers must be placed every 2 to 3 metres on straight sections.

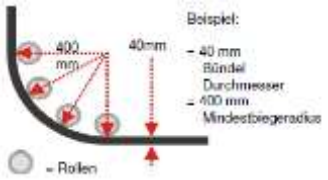


Figure: Roller placement

3.2.6. Using a mesh pull sock for pulling in the tube bundle

A suitable mesh pull sock is fitted over the tube bundle end and connected to the winch cable.

- Uncoil the tube bundle from the top of the cable drum, using as flat an arc as possible and while keeping the bending radius as small as possible.
- While paying out the tube bundle, ensure that the tube jacket cannot be damaged as a result of the tune bundle loop that leads back to the drum scraping along the ground.

During pulling-in work, an appropriate number of workers should be spread out along the pulling-in section:

- A worker at the drum must actuate the brake lightly to stop the drum continuing to rotate and thus prevent the tube bundle compressing or kinking. This worker must also ensure that the bundle is paid out from the drum using a correct, even motion, and must also check that no damage is present on the tube bundle.
- Workers must also be positioned at any conduit points crossed by beams or with angled sections, etc., so as to ensure the smooth pull-in of the bundle and avoid damage.

Figure: Mesh pull sock

- One worker (in a supervisory role) must accompany the start of the bundle and ensure that the shackle and the tube end that immediately follows it do not catch in the cable rollers, that the bundle runs smoothly over the rollers and that it runs smoothly into any openings that are present.
- At short intervals, the person operating the winch must report the tractive force values caused by the pull-in of the bundle to the person monitoring the drum and thus also to the person supervising the pull-in work. Winching must be halted if unusually high tractive forces are experienced.
- At critical places and pull-in sections without a clear line of sight, extra workers must be posted who can warn in case of danger.

3.2.7. Laying out the bundle without twisting in front of obstacles

This method of working can be used if the tube bundle section is interspersed with obstacles and the entire section can be split into one sub-section with obstacles and one sub-section without obstacles:

- The space available within the sub-section free of obstacles must permit the temporary laying down of the entire bundle.
- In the first work phase, the bundle must be pulled-in as far as the first obstacle and laid straight.
- In the second work stage, the bundle must be laid out in a sufficiently wide arc, in wide snaking lines or in double loops – consult the diagram for details – so that the bends are not tighter than the bundle's minimum permitted bending radius and so that the remaining laying work can proceed without requiring the use of tight bends or twisting of the bundle.
- Following this, the bundle is pulled in carefully through the obstacle by hand.

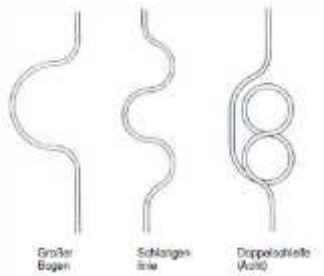
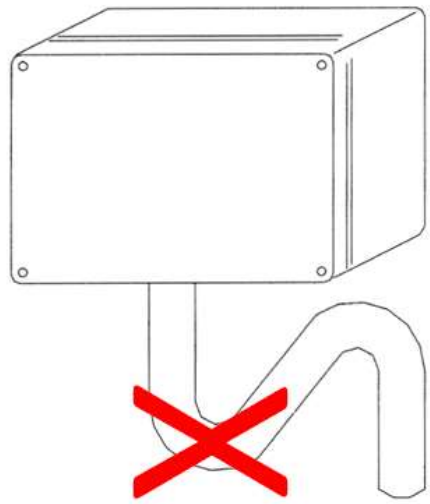
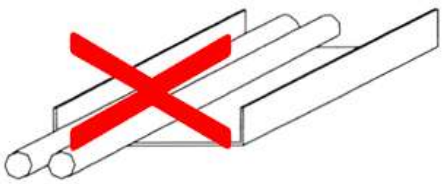


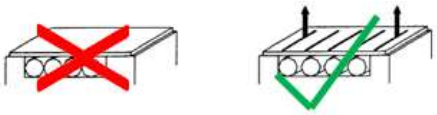
Figure: Avoiding twisting

3.3. Fixing and installation

	▪ Tube bundles can be secured to existing structures, as well as to narrow-gauge cable trays and ladders. ▪ To attach the tube bundles, use suitable tensioning straps or fixing clamps.
	With heated lines, use cable clamps on exposed C-sections to mount them. Spacing: 25 mm (thumb width) between the individual lines. Fixing: Horizontal 1.2 m Vertical 3.5 m Bending radius: 8–10 x the outer diameter Min. laying temp.: -5 °C

3.3.1. Fixing instructions

	**Do not** lay heated lines in protective tubing.
	During installation, take care to avoid the formation of water traps, especially at sampling points.
	Do not lay heated lines in bundles along cable runs, especially not in closed cable runs.

	If heated tubes are laid in a closed conduit or duct, then this will cause heat build-up. **Remedy:** tubes must not touch each other. In addition, ensure that ventilation is adequate. Cable spacing 25 mm.
	If e.g. powder-type substances, adhesives or other thermally insulating materials are tipped onto heated tubes, this creates local instances of overheating. **Remedy**: Always clean off such materials and resolve the cause of the problem.

- As a rule, tube bundles must be laid at a sufficient distance to objects that radiate heat.
- If temperature-controlled tube bundles are laid next to each other, they must not touch.
- Maintain a spacing of 20 mm between bundles.
- If this is not possible, then a special version must be used. This version uses an aluminium foil layer under the outer jacket: this lowers the jacket temperature at the point at which the bundle touches.
- Temperature-controlled tube bundles must not be laid in protective tubing, since the potential heat build-up could mean the outer jacket heats up beyond permitted levels.
- Each tube bundle must be secured individually.
- While laying, take care to ensure that you do not damage any tube bundles already laid.
- After bends and before tube connections, installation is easier if you lay the tube bundle straight for 30–50 cm.

The following fixing distances are recommended:

Laying type	Fixing values
Laying - Horizontal - Vertical	 0.5 m – 1.5 m 1.0 m – 2.0 m
In an arc section	0.3 m – 0.5 m (arc size)

Table 4: Fixing distances

3.3.2. Installation notes

The laying of tube bundles is subject to the same standards as for electrical cable. Before starting laying work, make a visual inspection of the tube bundle to confirm it has no visible damage and that the bundle ends are capped and are secured to the drum disks. Compare the label on the drum flange with the shipping document to confirm that the details of the tube bundle model type and length are as stated. During laying work, observe temperature limits and minimum bending radiuses at all times. For temperature increases of 50 °C, take the following length changes into account for straight tube bundle sections:

Tube bundle type	Change in length
Tube bundle with metal tubes	0.8–0.9 mm/m of tube
Tube bundle with plastic tubes	7.5–10.0 mm/m of tube

Table 5: Changes in length for tube bundles

The stranding of the tubes in the bundle and the arcs present in the installation path are normally able to balance out any changes in length due to temperature.

	▪ Always use an opposing spanner when tightening screw-threaded valves and connections. ▪ At all times, only use clamps, tensioning straps or similar support systems that do not significantly compromise the thermal insulation layer (indentations not deeper than 10% of the line diameter). ▪ Do not route lines over sharp edges and openings. Where installations need to be very rugged, we recommend an outer jacket made from corrugated metal hose. ▪ Always follow the installation instructions supplied with the PSG ready-made kits. Check that the tubing, sensors, control system, line diameters and fuses all match up properly with one another. ▪ Using the wrong sensors and overloading control systems can destroy the analyser lines. ▪ Note that the starting current for self-regulating heaters can be up to 5x higher (depending on the outside temperature).

3.4. End finishing for analyser lines

If the analyser lines supplied have been pre-finished by the manufacturer at the factory, then laying can start immediately after the checks described in Section 4.

If the analyser lines have been supplied on drums or as partially-finished goods, then length sizing and end finishing work can also be completed on-site by a suitably-qualified company.

Connection systems and accessories

The use of shrinkable end caps gives the analyser lines a reliable form of protection against the ingress of moisture and dust. The insulation material retains its proper function and corrosion is prevented.

The individual tubes exiting at the line ends and the heating cables must also be thermally insulated (or heated) right up to the valve connectors and protected with shrink tubing.

To do so, use only the tube start/end finishing sets that have been authorised by the manufacturer. PSG supplies all of the necessary accessory parts for the connection systems, as well as the operating instructions needed to complete the end finishing work to a professional standard.

4. Tests

The analyser lines supplied by PSG have already been extensively tested at the factory.

Nonetheless, incorrect transportation, interim storage or non-observance of minimum bending radiuses when laying the lines can cause damage to the outer jacket, heating cable insulation or tubes that transport the medium.

Accordingly, the following tests must be performed on analyser lines once laying of the lines is complete. A Test Report must also be completed (see Section 5.3).

4.1. Tightness test

A pressure drop test must be used to test the process line for tightness.
To perform the test, one end of the line is sealed tight and a hand pump is used to create a pressure of 1 bar at the other end. If the pressure remains constant for approx. 5 minutes (as verified by a manometer), the line is considered to be tight.
Alternatively, the pressure test can also be carried out with negative pressure once the pump is connected. Observe the maximum permitted pressure or negative pressure for the media tubing at all times.

The test must not be carried out during the line's warm-up phase.

As an alternative to a hand pump, synthetic air (high-purity air) can be used for the tightness test.

NEVER use oil-bearing compressor air to pressurise the lines!

4.2. Insulation test

The insulation test for the sample gas lines is performed without connecting supply voltage. Measurements are taken using a calibrated insulation test unit (e.g. METRISO 5000A from Gossen-Metrawatt).
Follow manufacturer instructions to determine the insulation resistance. To do so, a sampling DC voltage of 1000 V/2500 V is created between the L1/N outer conductor (short-circuited) and the PE protective conductor.
As measured, the insulation resistance value must be at least 100 MΩ.

The test voltage for insulation readings taken on self-regulating heating cables of the
BTV, QTV, XTV, KTV or VPL types (from Tyco) is specified as 2500 V.

4.3. Connection the media tubes

Connect up the stainless steel or PTFE/PFA media tubes by using standard, commercially-available screw fittings or connectors. Always ensure that you select the correct connection accessories – especially as regards connector diameter, pressure/temperature rating and material stability!

4.4. Electrical connections to heating line and sensors

All electrical connection work must be performed by suitably-qualified electricians.

Connect up the heating line and the sensors (Pt100) as shown in the enclosed wiring diagrams. Thermo-couples must be connected using appropriate compensating cables.

The use of residual current devices to protect heating circuits is mandatory.
The line-side fuse rating will depend on the line length, the type of heating cable used, the heating cable rating and the ambient temperature conditions. For relevant details and recommendations, please consult the respective data sheets supplied by the heating cable manufacturer.
Please also bear in mind that the switch-on current when the heating cable is cold can be up to three times higher than the rated current. Here, we recommend type “C” circuit breakers, as specified by EN 60898.

Line diameters for connection cables must be determined in accordance with the relevant German VDE guidelines. Ensure the correct connection of the equipotential bonding (PE conductor) to the customer-side earthing system.

5. System start-up

Before the analyser lines are brought online for the first time, ensure compliance with the installation and safety instructions as given in Section 3 and perform the tests as described in Section 4. If the lines have been deployed in potentially explosive atmospheres, then you must also observe the European Union ATEX guidelines (ATEX Product Directive 94/9/EC) in addition to these general instructions:

- Safe operation can be assured only by ensuring compliance with the preceding installation and safety instructions, compliance with ATEX directives and careful inspection of the analyser lines (post-installation).
  The testing company must document the results of testing by completing the Test Report and returning this to PSG.
- All modifications of, tampering with or repairs to the lines or components are prohibited and will immediately void all product warranties.
- All work must be completed only by using the procedures as described.
- Other instructions (e.g. PSG Ready-Made Kits) must be followed at all times: here, too, non-observance will lead to the immediate revocation of product warranties.
- All installation steps described must be performed only by qualified technical personnel.

5.1. Initial start-up instructions

Self-regulating heating cables do not have to be connected to a temperature controller, since selecting the heating cable type/heating cable rating sets the holding temperatures to the specified value.
For critical applications that require temperature thresholds to be set for the heating cable (e.g. for Ex applications), we recommend the use of a temperature limiter, which, as shipped, has already been preset to the maximum temperature permitted.

Once connection and testing work has been completed, system start-up and functional testing can be performed for the heating cable. All readings taken must once again be documented in the Test Report (Section 5.3).

Check the holding temperature of the sample gas line against the specified value. The reading can be taken using a PT100 resistance thermometer, if already integrated, or by using a PT100 dip probe. In addition, a reference reading can be taken by using a portable (battery-operated) thermocouple for manual confirmation.

Readings to be taken include the voltage/current and temperature values when connecting the supply voltage (heating cable cold state) and after running for 60 minutes (heating cable warm state).

5.2. Operating instructions

During the analyser line's warm-up phase, the temperature values must be checked continuously.

Testing of the throughflow rates in the media tubes should be performed, using e.g. scaled float-type flow meters.

5.3. Record of testing the assembly of the several pieces of equipment and components for the Ex analyser line unit, in accordance with German health and safety regulations (BetrSichV s.14 [1])

Key data

Customer:	Contracting party:
Street:	Street:
Postal Code:	Postal Code:
City:	City:
Project reference:	
PSG article number:	PSG transaction no.:

Factory test of goods supplied on drum

Drum no.:	Tightness test at testing pressure [bar] 3):
Line length [m]:	Pressure hold time [min]:
Insulation resistance [MΩ] 1):	Test result, tightness test: [OK/NOK]
Test date:	
Tested by:	Signature:
Tested by:	Signature:

Factory test for factory-finished lines

Drum no.:	Tightness test at testing pressure [bar] 3):
Line length [m]:	Pressure hold time [min]:
Insulation resistance [MΩ] 1):	Test result, tightness test: [OK/NOK]
Voltage [V], measured cold:	Current [I], measured cold:
Temperature after running for 60 min. [°C]:	Set value for temp. limiter [°C]:
Voltage [V], measured warm:	Current [I], measured warm:
Test date:	
Tested by:	Signature:
Tested by:	Signature:

Finished tube starts/ends

Heating cable type:	Manufacturer:
Heating cable rating [W/m]:	Heating cable length [m]:
Total output [W]:	
Finished tube start:	Model no.:
Performed by 2):	Signature:
Finished tube end:	Model no.:
Performed by 2):	Signature:

Post-installation (MC)

Tightness test at testing pressure [bar] 3):	Remarks:
Pressure hold time [min]:	
Test result, tightness test: [OK/NOK]	
Line length [m]:	
Insulation resistance [MΩ] 1):	
Test date:	
Tested by:	Signature:
Tested by:	Signature:

1) Target value > 100 MΩ

2) Please enter “PSG” if the line was supplied factory-finished. We will complete any missing details!

3) Test pressure min. 1 bar; at higher pressures, always observe the max. permitted pressure for the media tube. Alternatively, the leak test can be performed using a negative pressure of between -0.15 bar and -0.25 bar. Use valves that close with an air-tight seal.

System start-up (SAT)

Line-side fuse no.:	Distributor no.:
Ambient temperature [°C]:	
Voltage [V], measured cold:	Current [I], measured cold:
Temperature after running for 60 min. [°C]:	Set value for temp. limiter [°C]:
Voltage [V], measured warm:	Current [I], measured warm:
Test date:	
Tested by:	Signature:
Tested by:	Signature:

Confirmation by installation company

Testing standards: BetrSichV s.14 [1], Directive 94/9 (ATEX)

With my signature, I confirm compliance with the installation and safety instructions as described in this document. A breach of these provisions leads directly to a revocation of the product warranty.

Test results:

Taking into consideration the intended use of the system, the finished Ex analyser line has been subjected to a functional inspection to verify its proper and correct state as regards the installation of the heating system, the assembly/installation of the unit’s individual components and its safe operation. The installation of the Ex analyser line complies with the stated assessment criteria. The operating instructions and installation information for heated Ex analyser lines supplied by PSG Petro Service GmbH & Co. KG must be observed during operation.

Fitter	Competent person
Name:	Name:
Date:	Date:
Signature:	Signature:

Index of Tables: