1. GENERAL

1.1 Short Description

The model DP19-ABB is a robust, easy to carry dew point hygrometer for field use, specially designed for the spot measurement in sulphurhexafluoride (SF_6). Measurements are made at pressures between 10 mbar and 10 bar (1 kPa to 1 MPa). The sample gas flow is effected by pressure difference between gas inlet and outlet, with a minimum of 10 mbar (1 kPa). If the pressure difference is to small or the gas has to be measured in a closed circuit an optional gas pump is available.

The measurement is based on the chilled mirror principle which guarantees direct and precise measurement of the actual humidity with no errors due to inertia and hysteresis. The system is stable and does not require recalibration. A built-in ice test device with simple push button action allows the instrument to be checked for accuracy at 0°C.

The standard version of the DP19-ABB instrument includes a front-mounted, pressure-tight measuring head with triple stage Peltier cooling. Incorporated in the instrument is the unique ORIS-device (patented) for the accelerated measurement at very low humidities. For best measuring results, the whole gas circuit is made of PTFE and stainless steel. A built-in electronic flow meter, which works independent of position, monitors the correct gas flow. An analog output of ± 10 mV/°C is provided for recording or remote indication. For the transport of the instrument and its accessories serves a robust carrying case.

ABB standard equipment for SF_6 - measurement:

- Dew Point Instrument DP19-ABB
- Sampling Line with Control Valve and Quick-Couplings
- Instruction manuals
- Transport Case

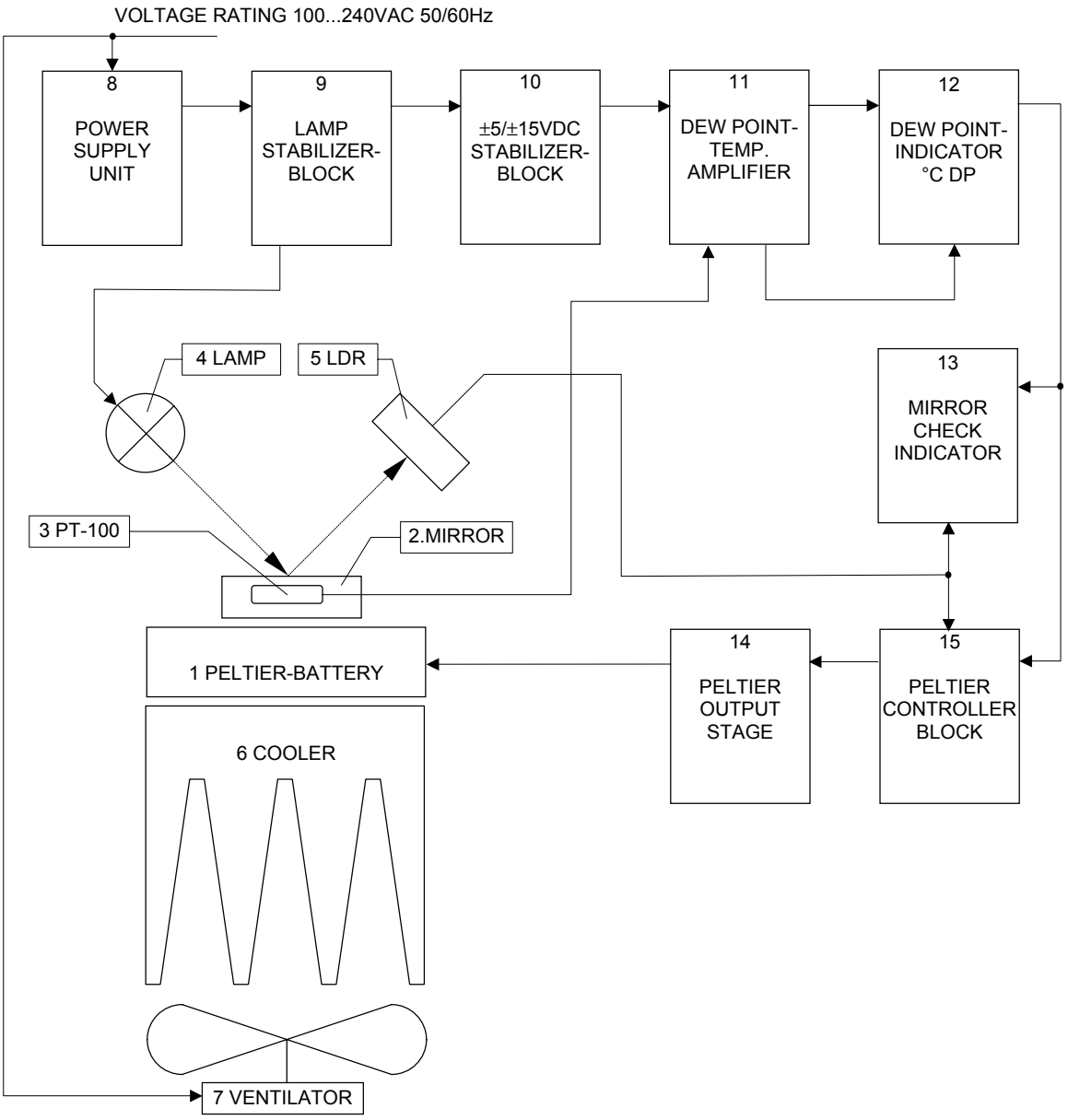
1.2 Specifications

Instrument model:	DP19-ABB
Measuring range:	-60°C Dew Point max. at 10°C ambient temperature -55°C at 20°C ambient temperature -45°C at 35°C ambient temperature Values valid for measurement at atmospheric pressure, at overpressure slightly less.
Accuracy:	≤ ±0.2°C, ±1 digit (standard)
Reproducibility:	≤ ±0.1°C, ±1 digit
Display:	Digital, 3 ½ digits
Analog output:	±10 mV/°C, 0°C = 0 mV, mA optional
Measuring principle:	Dew Point Mirror, rhodium plated, optical detection
Cooling:	Thermoelectric, Peltier-cooling III-stage
Sample gas flow rate:	15 to 60 l/h, nominal 30 to 40 l/h
Sample gas pressure:	Min. 10 mbar up to 10 bar (1 kPa to 1 MPa)
Response time:	2°C/sec. max.
Gas pump:	Optional
Mirror check:	Manual check by pressing the "MODE"-key, position "MIRROR CHECK"
Instrument check:	Manual cooling and accuracy check by pressing the "TEST COOLING"-key
Voltage:	100/ 110/ 127/ 200/ 220/ 240 VAC ±10%, 50/60 Hz
Power consumption:	approx. 160 watts
Ambient temperature:	-10 ...+50°C for storage and operation
Ambient humidity:	Max. 90% RH max., non condensing
Weight:	Approx. 12 kg
Size:	342 (W) x 140 (H) x 326 (D) mm

Options and Accessories:

- Gas Pump
- Various Gas Fittings (Swagelok®, Dilo, Walther etc.)

1.3 Block Diagram



1.4 Description of the Block Diagram

The measuring head mainly consists of the Peltier-battery, a thermo-electric heat pump (1), the dew point mirror (2) and the Pt-100 sensor (3) for the temperature measurement. The temperature sensor is inserted in the dew point mirror, which itself is fixed on the cooling side of the Peltier-battery.

When cooling, the opposite side of the Peltier-battery creates heat, which is carried off through the cooler block (6) and the adjacent ventilator (7).

Dew formation is detected by an optical system with a lamp (4) and a light-dependent resistor LDR (5). The signal of the LDR is processed in the Peltier controller (15) for the output stage (14), so that a constant layer of dew will be formed on the mirror surface.

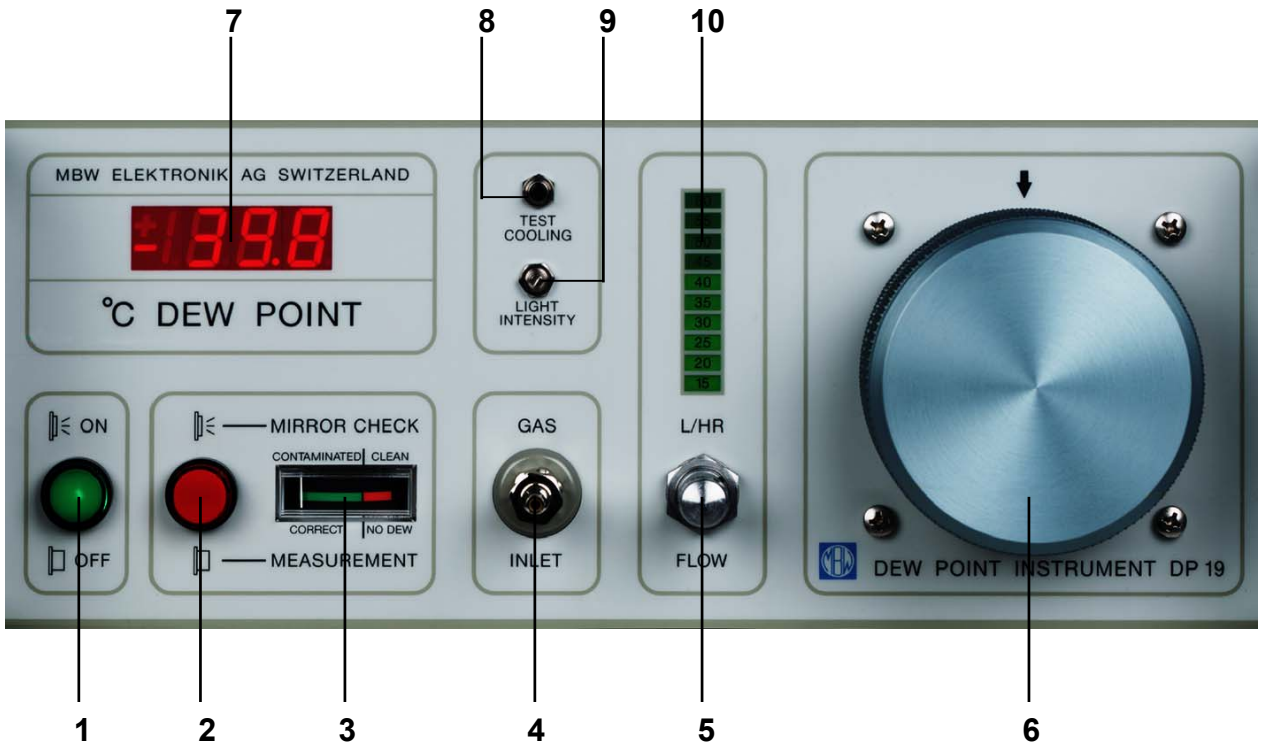
The mirror temperature signal measured by the Pt-100 sensor (3) is transmitted to the amplifier (11), linearized and displayed on the digital indicator (12).

Even slight differences in the luminance of lamp (4) would alter the measuring results and to avoid this possible source of errors, the supply-voltage is precisely stabilised in block (9). In an additional block (10) are the converters for the generation and control of the required auxiliary voltage ±15 V DC.

The power supply unit (8) consists of a transformer and the necessary rectifiers.

2. INSTRUMENT DESCRIPTION

2.1 Front Panel



1 Mains-Switch
2 Mode-Switch
3 Mirror Check Indicator
4 Sample Gas Inlet
5 Flowmeter Valve
6 Measuring Head
7 Dew Point Indicator
8 Test Cooling Button
9 Light Intensity Potentiometer
10 Flow Rate Indicator

1 Mains Switch (ON / OFF)
By pressing this button, the instrument will be switched on (button illuminated)

2 Mode Switch (MIRROR CHECK / MEASUREMENT)
This switch selects the operating function (MEASUREMENT/MIRROR CHECK). To measure dew-point the switch is released and MEASUREMENT-mode is selected. In this position the Peltier cooling-system is operating. To check the current mirror condition, the switch is pressed and the MIRROR-CHECK mode is selected. In this position, the Peltier cooling system is switched off.

3 Mirror Check Indicator
The mirror check indicator indicates how much light of the measuring head lamp is reflected on the mirror and transmitted to the photo-resistor. The indicator is subdivided into a green and a red field. If the indicator needle is in the middle of the red field, "full reflection" is shown, i.e. the mirror is clean and without dew layer. The lower the reflection (because of a dew layer or a possible contamination), the further the indicator needle moves into the green field.

When the instrument is switched on and in MIRROR CHECK mode the indicator needle must be in the middle of the red field (CLEAN). If it diverges (CONTAMINATED), it must be corrected after mirror cleaning with the LIGHT INTENSITY Potentiometer.

When the instrument is in MEASURING mode, i.e. after releasing the Mode switch, mirror cooling starts. After reaching the dew point, a dew or frost layer forms and causes the indicator needle to move from the red field (NO DEW) into the green field (CORRECT).

4 Sample Gas Inlet (GAS INLET)
The sample gas line is connected to the instrument with a Walther quick-coupling. For sample gas supply see 3.2.

5 Flowmeter Valve (FLOW)
With the Flowmeter Valve the correct gas flow can be adjusted. The gas flow should be between 30 to 40 l/h. The gas type can be selected with the "FLOW CAL-selector (8) on the back panel of the instrument.

6 Measuring Head
After releasing the pressure in the gas circuit, the measuring head can be opened by turning it counter clockwise. The inner PTFE part can also be removed. On the inside on the left are the contacts for the photo resistor and on the right those for the lamp. The dew point mirror is mounted in the middle between gas inlet (above) and gas outlet (below) (for mirror cleaning see 5.1.)

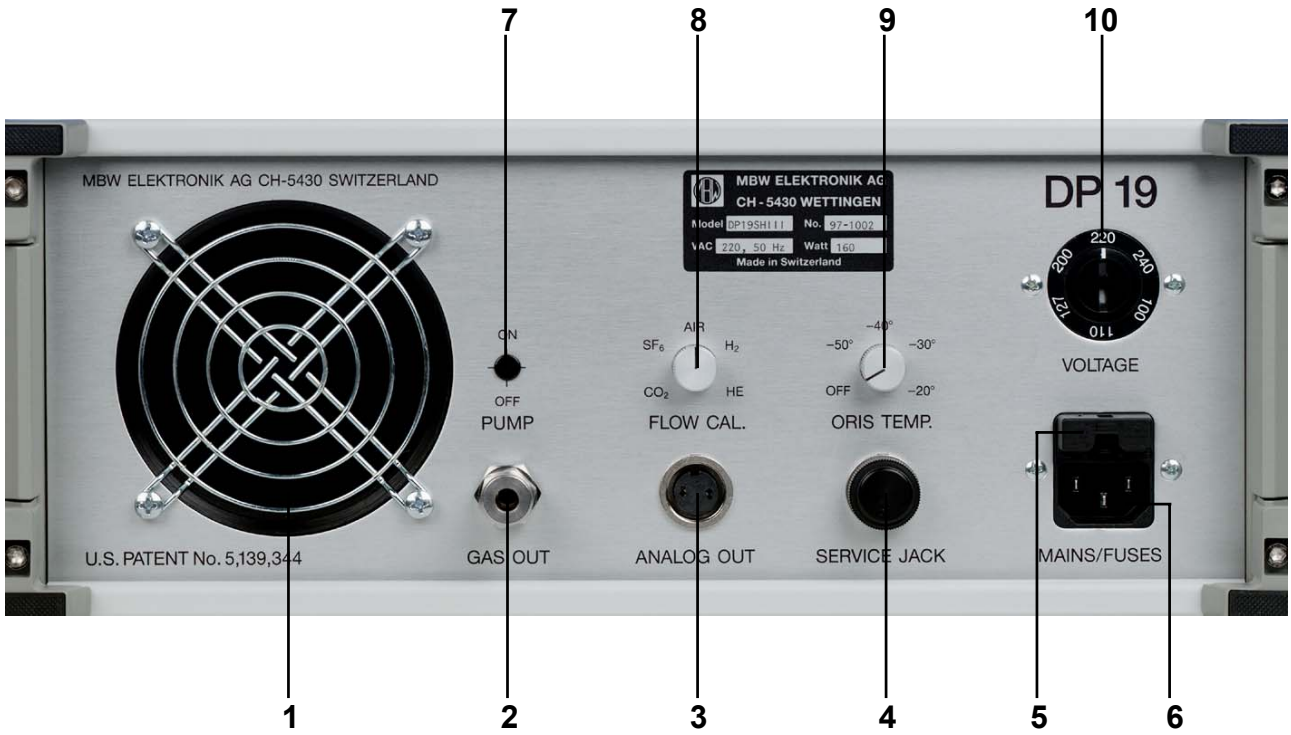
7 Dew Point Indicator (°C DEW POINT)
The digital display indicates the actual dew point directly in degrees Centigrade.

8 Test cooling Button (TEST COOLING)
This push button is used to check the instrument accuracy at 0°C (description see "Test Cooling" 4.5).

9 Light Intensity Potentiometer (LIGHT INTENSITY)
With this potentiometer the light intensity of the measuring head lamp can be adjusted (see also 5.1). When MIRROR CHECK mode is selected and the mirror is cleaned the needle of the Mirror Check Indicator must be set to the middle of the red field.

10 Flow Rate Indicator (L/HR)
This LED bar indicates the Flow rate in litres per hour (L/HR). With the FLOW CAL. selector switch on the instrument back panel the gas to be measured must be selected. If the flow rate is below 15 litres per hour LED 15 blinks. If the flow rate is above 60 litres per hour LED 60 blinks.

2.2 Back Panel



1 Fan
2 Measuring Gas Outlet
3 Analog Output
4 Service Jack
5 Mains Socket
6 Fuses
7 Pump-Switch
8 Flow Calibration Selector
9 ORIS Temp. Selector
10 Voltage Selector

1 Fan
The built-in fan serves to cool the measuring head. When the instrument is switched on, the fan is in continuous operation.

2 Measuring Gas Outlet (GAS OUT)
For the measurement of air and non-dangerous gases this outlet is normally open to the atmosphere. For the measurement of corrosive or toxic gases as well as for the measurement in a closed circuit, a corresponding gas line can be connected here.

3 Analog Output (ANALOG OUT)
The analog output supplies a voltage signal of ±10mV/°C, 0°C = 0mV for recording or remote indication purposes. The burden should not be less than 27 Ω.

4 Service Jack Socket (SERVICE JACK)
The service jack socket is used for temperature amplifier check. For normal operation of the instrument, the 8-pin connector must always be plugged in (description see 5.2).

5 Mains socket (MAINS)
The mains lead is plugged into this socket. The socket also contains the interference filter.

6 Instrument fuses (Fuses)
In the mains socket there are two fuses (∅ 5 x 20 mm). For 200, 220, 240 V operating voltage use 1,25 A fuses and for 100, 110, 127 V use 1,4 A fuses (both special types).

7 Gas Pump (PUMP)
This is the ON/OFF-switch for the optional built-in gas pump. If the pump is used the inlet needle valve must be removed because of the pressure drop. For standard SF_6 measurement this pump is not required.

8 Gas Selector (FLOW CAL)
For the correct function of the flowmeter, it is necessary to set the gas selector switch to the kind of gas to be measured. To avoid faulty results due to wrong manipulation, for all instruments model DP19-ABB the gas selector switch is blocked to the positions SF_6 and AIR.

9 ORIS-System (ORIS TEMP.)
This selector is used for the setting of the optimum working temperature of the optional ORIS injection system (description see 4.4).

10 Voltage Selector (VOLTAGE)
The operating voltage is set at the factory according to customer requirements. It may be changed by using an appropriate screwdriver.
(ATTENTION: Fuses must also be adjusted).

3. COMMISSIONING

3.1 Before Use

3.1.1 Internal Gas Circuit

If the instrument has not been in operation for some time, it must be conditioned before use. All tubes and couplings, which were not stored closed and filled with dry gas, must be flushed for 10 min. with dry N_2 or SF_6 (max. pressure 10 bar / 1 MPa). Open flowmeter valve completely and control valve slightly to attain the necessary gas flow of approx. 40 l/h. Damp couplings can be dried with a normal hot air fan.

3.1.2 Mirror Cleaning

Before use, the mirror should be cleaned with a neutral tissue or with cotton (do not use any solvents). Re-install front part of the measuring head, switch on the instrument and press MODE-button (MIRROR-CHECK). The indicator needle should now be in the middle of the red field. If necessary, adjust indicator needle with LIGHT INT. potentiometer (see 5.1).

3.2 Measuring Gas Supply

Sample Gas Lines

The selection of the gas tube material and the correct installation are of great importance. Inappropriate gas tube materials influence gas humidity and cause incorrect measurement results.

Sample Gas Lines Material

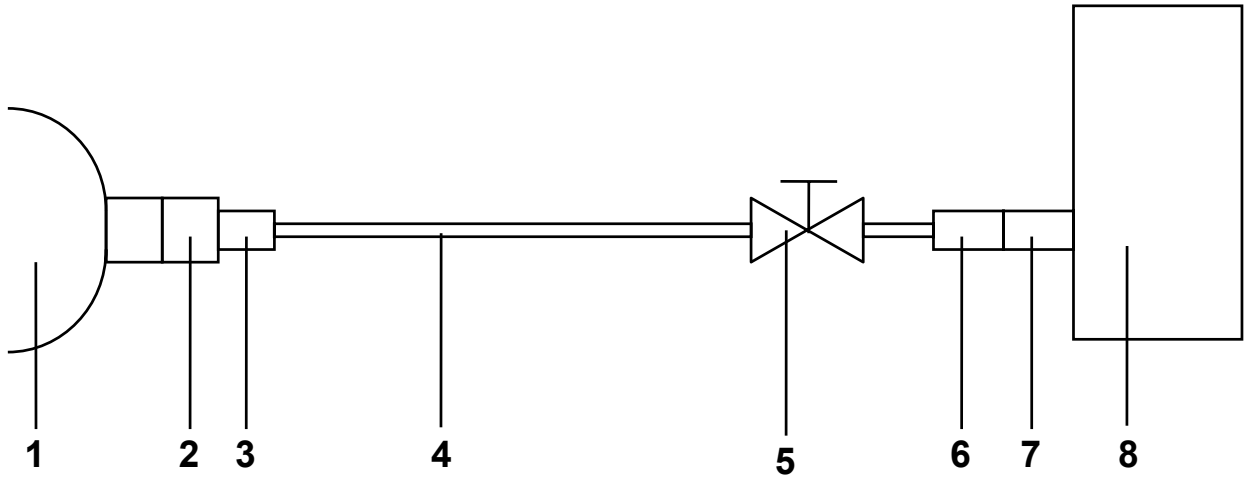
- Tubes made of rubber, nylon or PVC must not be used. They are permeable for water vapour and hygroscopic.
- To measure dew points down to -40°C, Polyethylene (PE) or copper tubes can be used.
- To measure dew points below -40°C, FEP, PTFE or stainless steel tubes must be used.
- The maximum operating pressure for PE, FEP and PTFE tubes (diameter 4 x 6 mm) is 10 bar (1 MPa).
- The maximum operating pressure for stainless steel tubes is 250 bar (25 MPa).

Installation

The sample gas tubes should be as short as possible. The tube temperature must never lie under the dew-point of the sample gas, even under extreme conditions (Danger of condensation in the lines = wrong measurement).

3.3 Assembly

Typical set up for the measurement of SF_6 gas.



1 Gas container (power switch, gas bottle etc.)
2 Sampling point coupling (DILO)
3 Conversion fitting
4 Sample gas line
5 SWAGELOK® control valve
6 WALTHER quick coupling 07-003, female part
7 WALTHER quick coupling 07-003, male self locking part
8 Dew Point Instrument DP19-ABB

4. MEASURING

4.1 Preparation

ATTENTION: Do not close the control valve and the flow meter by force! Both are needle valves and there is danger of deformation and leakage.

4.1.1 Connecting the Instrument

- First make the necessary connections between sampling point and instrument. Close control valve and flow meter completely.
- Plug in the mains lead and switch the instrument on (press the MAINS-button). Then press the MODE-button. Both buttons are now illuminated. After 5 min. warm-up mirror check indicator should be in the centre of the red zone.

There are two ways of measurement:

4.1.2 Measurement at System (Over-)Pressure

- Close flowmeter valve completely.
- Open control valve completely.
- Open flowmeter valve slowly until the required gas flow of 30 to 40 l/h is indicated.

4.1.3 Measurement at Atmospheric Pressure (100 kPa abs.)

- Close control valve completely.
- Open flow meter valve completely.
- Open control valve slowly until the required gas flow of 30 to 40 l/h is indicated.

4.2 Measurement

- Before releasing the MODE-button, check dew-point mirror condition. The indicator needle must be approx. in the middle of the red field.
- Release MODE-switch (light is off). Instrument starts cooling down to the dew point and the needle of mirror check indicator moves into the green field.
- Wait until the indication of the digital display is stable.
- Read dew point.

IMPORTANT:

When measuring more than on one point, change quickly (max. 2-3 min.), because open lines and the instrument will loose pressure and gas flow = danger of mirror freezing. It is not necessary to thaw off the instrument between measurements.

4.3 Terminating the Measurement

- Close control valve and flow meter completely.
- Press MODE-button (now illuminated).
- Switch instrument off (release MAINS-switch, light is off).
- Disconnect sample gas line from instrument and measuring point.

4.4 ORIS System

The patented optional ORIS-Device (Optimal Response Injection System) improves the response time when measuring low dew points. When the mirror temperature reaches the selected ORIS temperature, a small quantity of humidified gas is injected into the gas inlet tube. This injection speeds up the formation of the frost layer on the mirror and therefore shortens the response time.

For optimal results the ORIS TEMP selector-switch (see 2.2, back panel) should be set to the measuring range in which the instrument is used (for the measurement of SF_6-Gas at atmospheric pressure normally at -40°C).

NOTICE:

The setting of the ORIS-temperature can also be changed during the measurement. To switch off the ORIS device set the ORIS TEMP selector-switch to position OFF.

4.5 Accuracy Check

The measuring accuracy can be verified with a simple test. This is important if the measuring results do not correspond to expectation and fault is thought to lie with the instrument.

Procedure:

1. Disconnect sample gas lines or close control valve.
2. Open flowmeter valve completely.
3. Remove front part of measuring head.
4. Switch on instrument (MAINS ON), MODE-switch released (MEASUREMENT).
5. Press push-button contact TEST COOLING until dew point mirror temperature is approx. -25 to -30°C (watch digital display).
6. Breathe on mirror to form a frost layer.
7. Release push-button contact and let mirror temperature rise. When the mirror temperature rises too quickly, there will be a delay of the correct mirror temperature indication. Therefore, shortly before the temperature reaches 0°C, cool again by briefly pressing the TEST COOLING-button.
8. Carefully watch mirror and temperature indication. At exactly 0°C the frost layer must turn into water. If this happens, the temperature indication of the instrument is ok. If not, check tubing and fittings on tightness again.
9. After the check, clean and dry dew point mirror. Mount inner part of the measuring head and close with front. Close flowmeter completely. Push MODE-switch on position MIRROR CHECK (illuminated). Switch off instrument or continue measuring following 4.1 to 4.3.

5. MAINTENANCE

5.1 Mirror Cleaning and Adjustment of the Light Intensity

The mirror should be cleaned periodically. However cleaning is always necessary when the indicator needle shows contamination (press MODE switch for MIRROR CHECK). Paper tissue or cotton may be used to clean mirror. Do not use impregnated tissue. If necessary, use highly purified alcohol. To clean light source and photocell use loosened cotton tip (Q-tips).

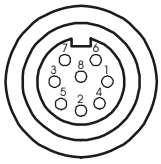
Procedure:

1. Instrument in operation (MODE switch released, mode MEASUREMENT; indicator needle is within green field, CORRECT).
2. Press MODE switch (MIRROR CHECK); indicator is now illuminated.
3. Temperature indication will show rising temperature; indicator needle moves toward red field but remains within green field (CONTAMINATED).
4. Wait until temperature indication shows approx. ambient temperature. (If mirror temperature is below ambient temperature when opening the measuring head, dew will form on the mirror).
5. Close control valve.
6. Open measuring head.
7. Clean mirror.
8. Re-install front part of measuring head and close measuring head.
9. If the indicator needle is now in the middle of the red field (CLEAN), the cleaning process is finished. If it remains within the green field or at the right edge of the red field, continue as described below (10).
10. Set indicator needle with LIGHT INTENSITY potentiometer to the middle of the red field.
11. If this is not possible (range of LIGHT INTENSITY potentiometer is not sufficient), lamp and photocell in front part of measuring head must be cleaned.

5.2 Service Jack

The Service Jack is a 8-pin socket which provides access to the temperature measuring circuit for accuracy checking with an external PRT-100 simulator and direct access to the mirror PRT-100 resistance thermometer for an external temperature measuring device.

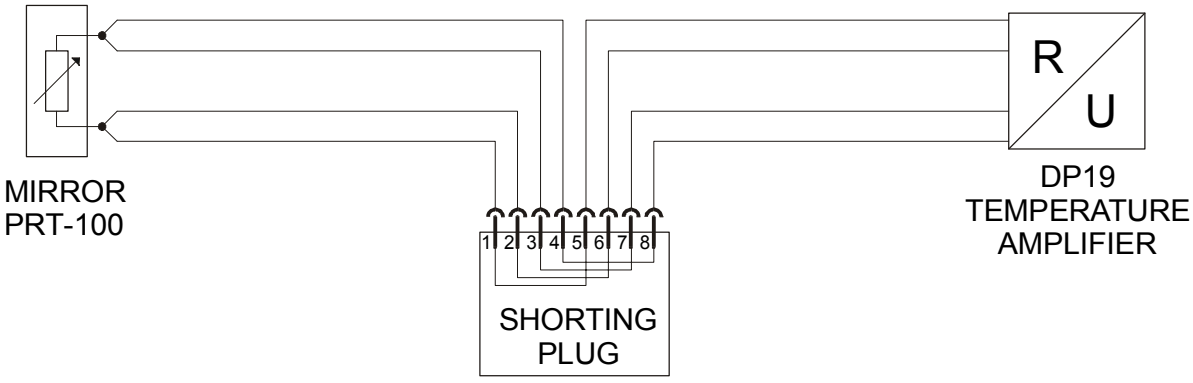
8-Pin Connector



Pin	Mirror PRT-100	Pin	Temp. Amplifier
1	Input LO	5	Input LO
2	Sense LO	6	Sense LO
3	Input HI	7	Input HI
4	Sense HI	8	Sense HI

5.2.1 Normal Operation

For normal operation the 8-pin shorting plug must be fitted. The shorting plug connects the dew point mirror PRT-100 temperature measuring sensor with the DP19-ABB mirror temperature amplifier.

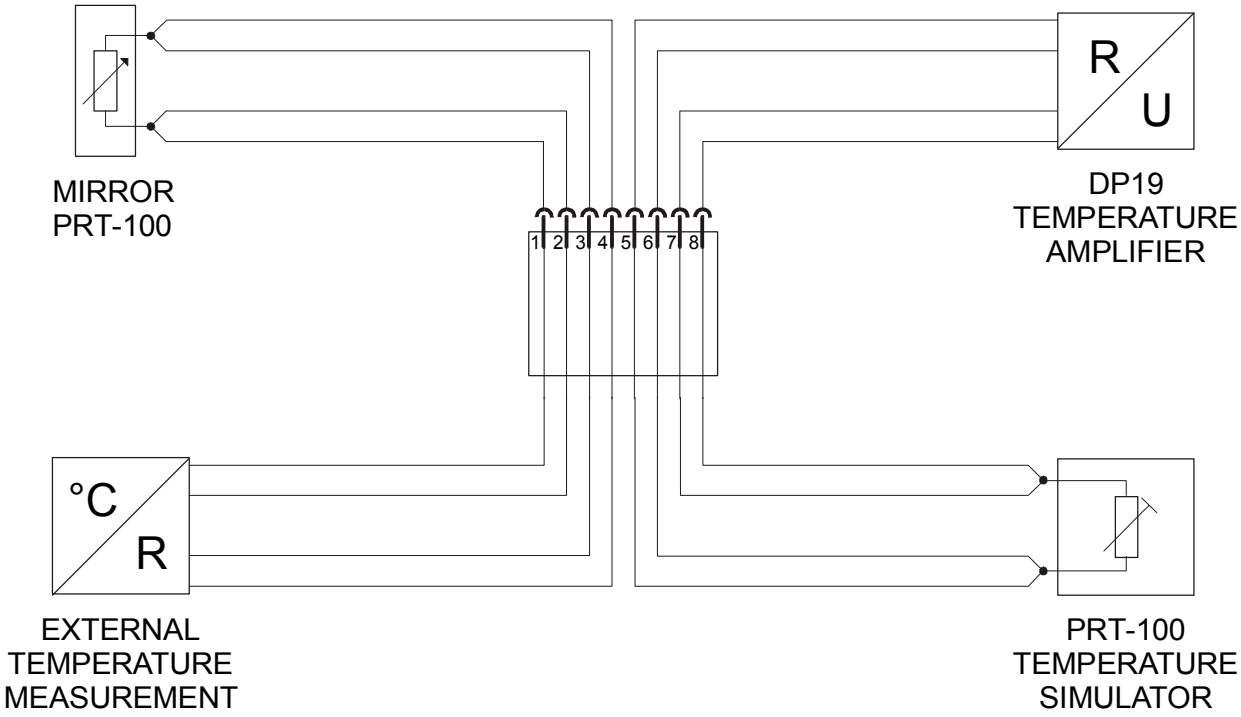


5.2.2 External Operation

The Service Jack connector provides access to the DP19-ABB mirror temperature amplifier.

The temperature amplifier can be checked with an external PRT-100 temperature simulator.

The Service Jack connector also provides access to the DP19-ABB mirror temperature PRT-100 temperature sensor. An external temperature measuring device can be connected to the dew point mirror PRT-100 temperature sensor. In this operation mode the DP19-ABB temperature amplifier is disconnected from the mirror temperature signal. For correct operation the approximate dew point temperature should be adjusted on the PRT-100 temperature simulator or with a resistant dummy. The DP19-ABB digital display indicates the simulator signal.



IMPORTANT:

If the shorting plug is removed the ORIS-function will not operate.

5.3 Trouble Shooting

Careful observation of the hints below will ensure fault-free measuring.

Potential sources of faulty measuring:	Remedy:
1. Condensation within the instrument, due to cold spots (below dew-point temperature) in the system.	Flush instrument with dry gas (instrument temp. **must not** be below ambient temperature as, e.g. after transport in cold weather).
2. Dampness of sample gas lines.	Before use flush sample gas lines for at least 10 minutes with dry gas.
3. Dampness of couplings.	Heat all couplings before connecting to at least 60°C, use hot air fan.
4. Oil or grease in sample gas lines or couplings.	Flush lines and couplings with a solvent (e.g. trichlorine, acetone) and dry with compressed air.
5. Permeability of ambient humidity in the gas measuring circuit.	Check tightness of system between sampling point and dew point mirror; use leak-detector, soap-solution etc. (see also 6 below).
6. Bad tubing quality.	Do not use tubing made of: rubber, nylon, PVC, they are permeable and hygroscopic. Polyethylene (PE) or copper (Cu) tubing can be used for measuring dew points down to -40°C. Extremely reliable within the entire measuring-range are : Fluorethylenepropylene (FEP), Polytetrafluorethylene (PTFE) and stainless steel (CrNi) tubing

7. Press Influence.	See diagram 6.2
8. Gas flow changes.	Gas flow may vary slightly (approx. 20-50 l/h) without effecting the measuring results. If gas flow is too high, a pressure drop will result and the measuring results will not be precise. If gas flow is too low, exact measuring will take a considerable amount of time.
9. Unstable indication (when measuring at excess pressure). Indicator needle wavers within the green field, dew point display alternates constantly (this may be the case when SF_6 liquefies).	If possible, conduct measuring at atmospheric pressure (see diagram 6.2).

6. APPENDIX

6.1 SF_6 Moisture in °C Dew Point <---> ppm by Weight

Symbols: DP = dew point
kPa = 1000 Pascal
100 kPa = 1 bar
°C = degree Celsius
ppm = parts per million
wt = by weight

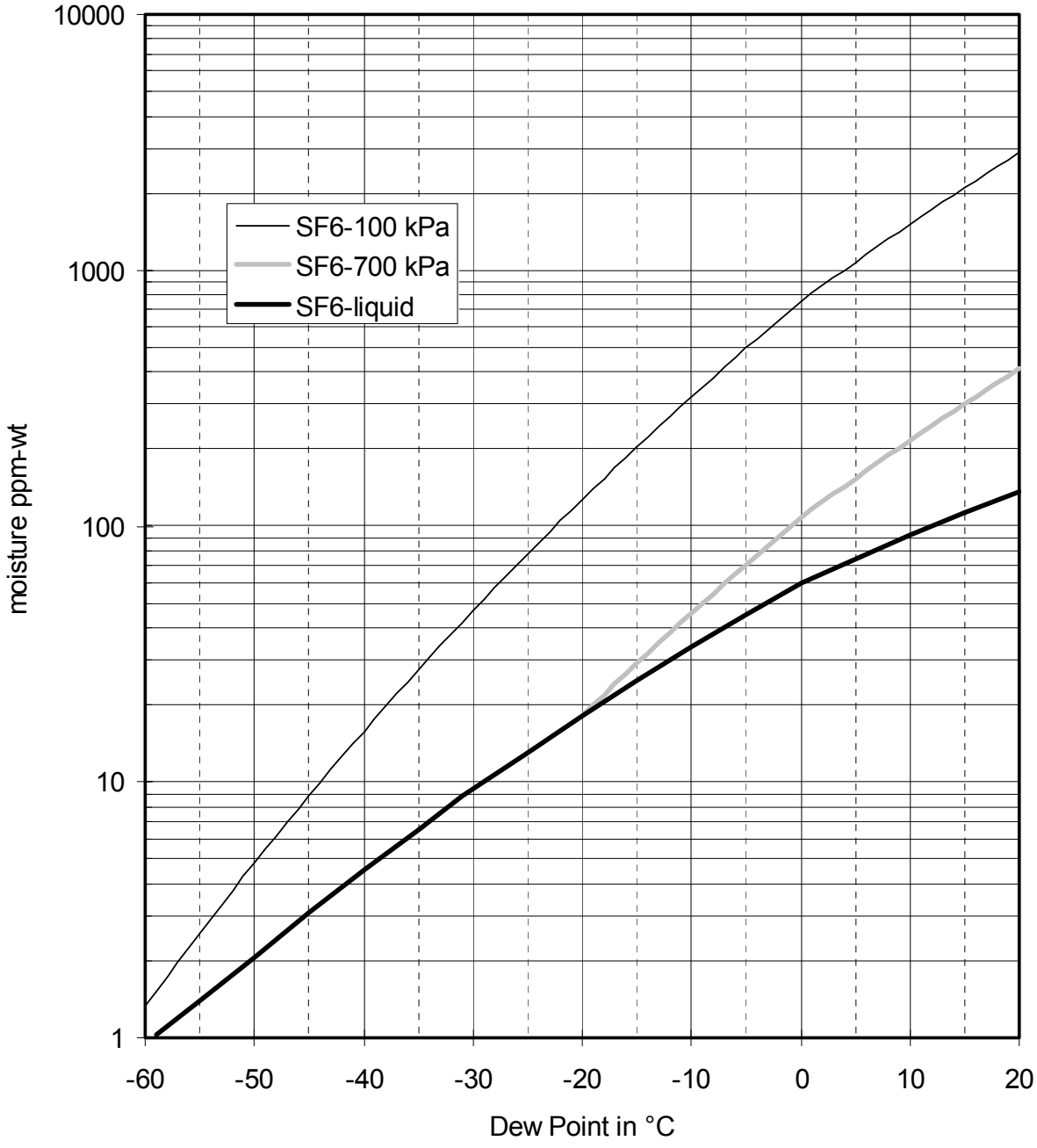
Dew Point °C	100 kPa SF_6 ppm-wt	700 kPa SF_6 ppm-wt
-60	1	
-59	2	
-58	2	
-57	2	
-56	2	
-55	3	
-54	3	
-53	3	
-52	4	
-51	4	
-50	5	
-49	5	
-48	6	
-47	7	
-46	8	
-45	9	
-44	10	
-43	11	
-42	13	
-41	14	
-40	16	
-39	18	
-38	20	
-37	22	
-36	25	
-35	27	
-34	31	
-33	34	
-32	38	
-31	42	
-30	47	
-29	52	
-28	57	
-27	64	
-26	70	
-25	78	
-24	86	
-23	95	
-22	105	
-21	115	
-20	127	**18.2**

Dew Point °C	100 kPa SF_6 ppm-wt	700 kPa SF_6 ppm-wt
-20	127	18
-19	140	20
-18	154	22
-17	169	24
-16	186	27
-15	204	29
-14	223	32
-13	245	35
-12	268	38
-11	293	42
-10	320	46
-9	350	50
-8	382	55
-7	417	60
-6	454	65
-5	495	71
-4	539	77
-3	587	84
-2	638	91
-1	694	99
0	754	108
1	810	116
2	871	124
3	935	134
4	1003	143
5	1076	154
6	1153	165
7	1235	176
8	1322	189
9	1415	202
10	1513	216
11	1618	231
12	1728	247
13	1845	264
14	1969	281
15	2101	300
16	2240	320
17	2387	341
18	2542	363
19	2706	387
20	2880	411

Conversion of 100 kPa into an other pressure i.e. 630 kPa:

ppm-wt {630} = ppm-wt {100} * 100 kPa / 630 kPa

6.2 SF_6 Moisture in Parts per Million by Weight



Important:

It is not possible to measure a dew point which is below the boiling point of the gas to be measured, because the gas condenses on the mirror. Above diagram shows the vapour pressure curve of SF_6 gas (——SF_6-liquid).

6.3 Manufactured & Serviced by

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